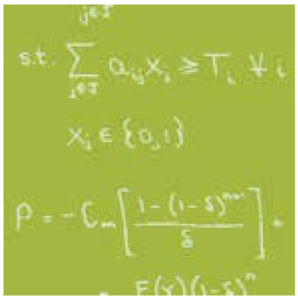
Annual Report
2012



ARC ceed

Centre of Excellence for Environmental Decisions

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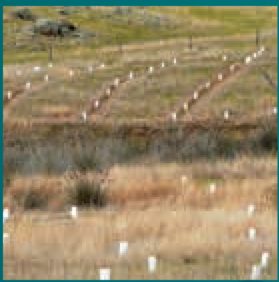


About CEED

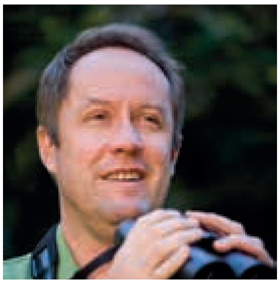
Our Vision

The vision of The ARC Centre of Excellence for Environmental Decisions (CEED) is to be the world's leading research centre for solving environmental management problems and for evaluating the outcomes of environmental actions.

Our Mission

Through our key researchers, already recognized as global leaders in fundamental environmental science, we will benefit environmental science, policy and management across Australia and around the world by tackling the complex problems of environmental management and monitoring in a rapidly changing and uncertain world.

Director's Report



Two thousand and twelve marks the second full year of operation of CEED. We've got over the excitement of our successful CoE application, we've set up our administrative systems and we're beginning to realise our potential.

It's been a year of consolidation in which the ideas in our application and our initial discussions have been translated into operational work plans and we've finalised the appointments of the scientists that form the research engine at the heart of CEED. While we've been settling in, the world around just seems to move and change faster and faster. Biodiversity continues to decline and the resources available to deal with this issue seem ever more inadequate. In light of this, the need for more effective environmental decision-making is greater than ever. The research being produced by our Centre speaks directly to this need and I hope the research case studies we present in this report demonstrate our value.

Looking over our research themes the key words emerging are **restoration, transformation, spatial** and **dynamic.** Of course, that's partly because these are the concepts that underpin our research but looking out at our rapidly changing world it's easy to see that these are the conceptual battlefields where our precious biodiversity can be lost or saved.

Restoration

The 2012 United Nations Rio+20 Conference on Sustainable Development endorsed a target to restore, by 2020, 150 million ha of disturbed and degraded land globally. CEED's research is all about framing what we mean by 'restoration', what knowledge and capacities will be needed to achieve it at scale, can carbon-focused restoration deliver for biodiversity, what options are available and how do we decide between them?

> *"Looking out at our rapidly changing world it's easy to see that these are the conceptual battlefields where our precious biodiversity can be lost or saved.*

Dynamic

So much of our decision-making is based on a static view of the world or the hope that we can return to some notional pristine pre-condition. In a world where accelerating change and growing uncertainty seem to be the only constant, we need better decision-making frameworks that can deal with change and effectively handle uncertainty.

Transformation

Following on from the notion of a dynamic world is the undeniable truth that we also live in a transformed world. Consider the urban sphere as just one example. The vast majority of Australia's population live in cities and their urban surrounds, and over 50% of threatened species occur within the urban fringe. It's within these transformed landscapes that we stand to lose thousands of species unless we can engage effectively with the nature of these spaces. CEED is developing research tools and methods designed specifically for application in the urban fringe. It's all well and good to work with the charismatic megafauna in remote national parks but the battle for biodiversity is invariably in the peri-urban fringe where powerful political and economical forces are at play.

CEED's research is making real contributions in all these areas, and it's doing it over multiple scales: international, national and regional. Internationally, biodiversity modelling and decision science has become increasingly topical. The finalisation of the program and processes for the new Intergovernmental Policy Platform on Biodiversity and Ecosystem Services (IPBES, www.ipbes.net) has lit a fire under our Centre's effort to project the consequences of policy on biodiversity.

From my perspective IPBES is exciting because it is a global attempt to place biodiversity and ecosystem service issues front and centre in global and national policy. In general, politicians and public servants make decisions based largely on economic metrics – how will this policy affect GDP, unemployment rates and interest rates? The IPBES will provide tools, processes and scenarios that enable us to put environmental issues into the decision-making mix by predicting the consequences of policies on biodiversity.

CEED is ideally placed to be a major player in IPBES research – from predicting the relative benefits of expanding the reserve system or managing it better, to deciding whether to grow cites by going up or spreading out. We create our art on an expansive canvas and we can only hope that our science inspires politicians and bureaucrats to reflect on their decisions.

Hugh Possingham
Director
ARC Centre of Excellence for Environmental Decisions

Overview

The Australian Research Council Centre of Excellence for Environmental Decisions (CEED) officially commenced its activities in July 2011, with ARC funding of $11.9m over seven 7 years from 2011 to 2017.

The need for the Centre is based on the premise that biodiversity problems have not been properly formulated and that mistakes have been made in allocating scarce resources. Despite facing the sixth global mass extinction of species, most conservation management is unevaluated and inefficient. It is intended that CEED will provide international leadership in tackling complex problems of environmental management and monitoring in an uncertain world. The Centre will be successful if its staff continue to produce papers in the top international scientific journals that also have impact policy and management and it continues to generate a new cohort of quantitatively skilled conservation researchers.

CEED is a partnership between five Australian and three international Universities and two international research centres:

- The University of Queensland (UQ)
- The University of Melbourne (UoM)
- RMIT University (RMIT)
- The University of Western Australia (UWA)
- The Australian National University (ANU)
- The Hebrew University of Jerusalem, Israel (HUJ)
- The Stellenbosch University, South Africa (Stell. U)
- Imperial College London, UK (Imperial)
- The US Geological Survey in the USA (USGS)
- The CSIRO in Australia (CSIRO).

Individually our key researchers are recognized as global leaders in fundamental environmental science. CEED will draw together this expertise to produce a centre of international scale and calibre to achieve our mission. While the goal of being the world leader in a research field seems lofty, our track record of publications in the world's top journals, and the fact that the disciplines of ecology and environmental science are amongst Australia's strongest research areas, make our mission ambitious but feasible.

Global Distribution of CEED's Key Researchers and Research Institutions

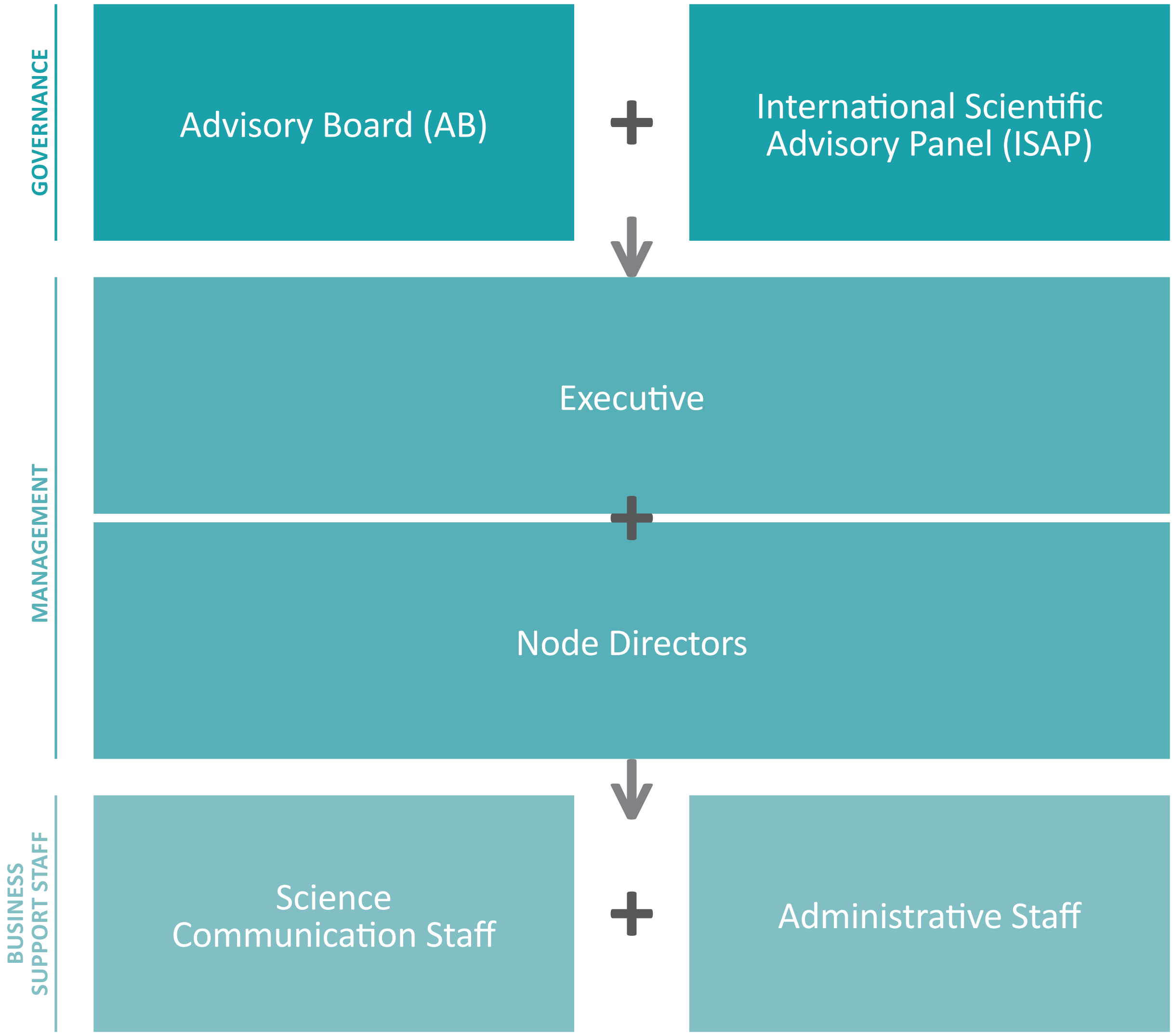
Management Structure

CEED's management and administrative structure aims to maximise collaborative synergies and the international impact of its work.

CEED is directed by a Management Executive, consisting of the Centre Director, Deputy Director, Chief Operations Officer (COO), and four Node Directors. Node Directors are responsible for within institution communication. This Management Executive meets monthly and jointly oversees CEED's research program.

Two important committees support the Centre's strategic, scientific and industry-related initiatives, our International Scientific Advisory Panel (ISAP) and Advisory Board.

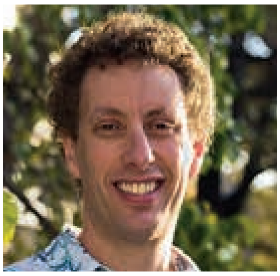
CEED's Management and Administrative Structure



Management

Executive

Prof. Hugh Possingham
Director
UQ



Assoc. Prof. Michael McCarthy
Deputy Director
UoM

Dr Alvin van Niekerk
Chief Operations Officer
UQ

Node Directors

Dr Kerrie Wilson
UQ

Prof. David Lindenmayer
ANU

Assoc. Prof. Brendan Wintle
UoM

Prof. David Pannell
UWA

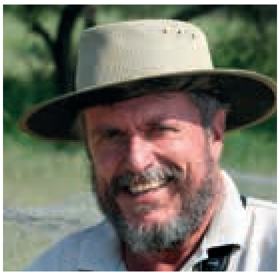
Dr Jonathan Rhodes
UQ

Advisory Board (AB)

The Advisory Board is comprised of eminent Australian Scientists. The function of the Advisory Board is to provide strategic advice to the Centre Management Committee and add value to the vision of CEED.

Prof. Stephen Walker, Chair
Dean of Science
UQ

Prof. Pauline Ladiges, FAA
UoM



Prof. Andrew Cockburn, FAA
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Prof. Alistar Robertson
PVC (Research)
UWA

Prof. Charlie Zammit
Dept. of Sustainability, Environment, Water, Population & Communities

International Scientific Advisory Panel (ISAP)

The ISAP are highly respected members of the international scientific community in fields of conservation and biodiversity. They provide valuable direction to CEED's research program.

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

Prof. Antoine Guisan
University of Lausanne

Prof. Claire Kremen
University of California, Berkeley

Prof. Bill Sutherland
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Membership

CEED Annual Conference

Chief Investigators

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Dr Eve McDonald-Madden, *CSIRO*
Professor Hugh Possingham
Dr Jonathan Rhodes
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The Australian National University

Professor David Lindenmayer

University of Melbourne

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University of Western Australia

Professor Richard Hobbs
Professor David Pannell

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Dr Salit Kark **(The Hebrew University of Jerusalem, Israel)**

Dr Andrew Knight **(Stellenbosch University, South Africa)**

Dr Tara Martin **(CSIRO Ecosystem Sciences, Australia)**

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

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

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The Australian National University

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Ben Cooke
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University of Western Australia

Katrina Davis
Christine Kershaw
Keren Raiter
Michael Wysong

ECRs and Cross Node Interaction

Early Career Researchers at a skills workshop on effective presentations at the University of Melbourne.

Empowering Early Career Researchers (ECRs) and encouraging interaction across the entire CEED network is partly about culture (what values are promoted within a group) and partly about structure (how the group is organised).

CEED takes its commitment to ECRs and network interactivity very seriously and we believe the way we work and the nature of our outputs reflect this. Theme leaders, for example, are deliberately drawn from different centres and organisations thereby necessitating cross-node communication and interaction. All Chief Investigators are expected to actively encourage their ECRs to participate in workshops and, if an ECR can mount a strong case for an idea of their own, CEED has funded workshops to support those new research questions. Following advice from the International Scientific Advisory Panel, we have explicitly set aside resources in 2013 for research working groups that are led by ECRs. Selection criteria include alignment with the CEED themes, innovation and cross node collaboration.

ECRs are encouraged and supported to attend national and international conferences, grow their own networks, and build their own profiles. They are tutored in a range of communication and life skill areas from social media bloggers (for example, consider the blogging activity of the Quantitative and Applied Ecology group at the University of Melbourne, the host of our Melbourne node – see http://qaeco.com/), dealing with the popular media, how to get a grant and how to deliver effective presentations. Several CEED ECRs have been very successful as presenters at conferences. For example CEED PhD candidates Kylie Soanes and Keren Raiter were awarded prizes for best student talks at the Ecological Society of Australia conference in Melbourne, while Abbey Camaclang and Tomas Bird, also CEED PhD candidates, were awarded prizes in the student presentation competition at the 2012 World Conference on Natural Resource Modeling. Through extra funding from the ARC, we have been able to send 5 of our own ECR researchers overseas for extended trips to places such as the USA, Canada, Germany, Chile and United Kingdom. Furthermore, this funding has enabled us to accommodate visits from 8 ECR researchers from overseas from places such as the USA, Canada, Greece, the United Kingdom and Sweden.

At workshops, ECRs are encouraged to take lead roles in developing research topics and projects, and are frequently first authors on significant papers. Consider, for example, the nine research highlights presented in this annual report. Of these, six were led by ECRs. Two of these (Jessica Walsh and Rebecca Runting) were honours students yet the research they were leading (Jessica evaluated fox control as a means of saving malleefowl while Rebecca determined the value of information for conservation planning around sea level rise) has the potential to transform current conservation practice.

An examination of the authorship of the papers produced by CEED also reflects on the wide involvement of researchers from across CEED's national network. Thirty-one, or 24%, of all CEED 2012 publications include a CEED PhD student or postdoctoral fellow. Of these, 22 (or 17% of all publications) have a CEED PhD student or postdoctoral fellow as the first author. And 14% of all publications have authors from more than one node.

Research

Research

A Theme A

Spatial planning for landscape restoration & management

Theme leaders: Richard Hobbs (UWA), Anthony Richardson (UQ), Peter Vesk (UoM), Tara Martin (CSIRO) and Salit Kark (Hebrew Uni).

How do we maintain and restore landscapes so that they retain their essential functions while conserving regional biodiversity? And how is this achieved in the face of rapid and ongoing changes in land-use, and in a changing climate?

Landscape management and restoration is a key challenge for landholders, policy and management agencies. While there have been considerable advances in our understanding of landscape patterns and processes over the past few decades, there is still much to do in terms of understanding how landscapes function to produce desired ecosystem services and maintain biodiversity. CEED research brings together researchers from the different nodes to provide new insights into many aspects of landscape management that are of key importance from a policy perspective but also at the cutting edge of landscape and restoration research.

The key foci of this theme are:

1. The implications of landscape-scale restoration on biodiversity, water and carbon balances.
2. The interplay between within-site management and landscape management.

Research produced in 2012 covered a variety of topics. A common thread running through much of the work is the focus on ensuring that good intentions result in good outcomes. Because ecological systems are complex and dynamic, apparently simple interventions can have unexpected or undesired outcomes. By unravelling the critical interactions we increase our ability to make effective decisions in landscape restoration and management. Following are examples of our research that have considered the likely impact of different types of management.

The opportunities and threats arising from the broad-scale uptake of plantations for carbon sequestration is becoming a hot-button issue. On one hand, such plantations offer a much-needed opportunity to conduct broad-scale restoration across agricultural regions of Australia. Done well, they would provide benefits in terms of carbon, biodiversity and an array of other ecosystem services. On the other hand, if carried out without considering broader system impacts, such 'restoration' could actually cause a range of adverse outcomes if, for example, the entire focus of such restoration was on fast-growing monocultures for rapid carbon accumulation. (Lindenmayer et al. 2012a; and see **Case Study #1).**

The question of the value of investments for protecting threatened species highlights the point that, without evaluation, the effectiveness of different conservation management actions is unknown. Jessica Walsh and colleagues examined the outcomes of fox baiting on malleefowl conservation in *Animal Conservation* (Walsh et al. 2012). Fox baiting is a standard management option where predation threatens rare and iconic species, but this study uncovered some unexpected results and concluded (counter-intuitively) that baiting is generally not a cost-effective management strategy for the recovery of malleefowl. (See **Case Study #2).**

In *Biological Conservation,* Martine Maron and colleagues considered the increasingly common practice of using restoration as an offset to compensate for damage to ecosystems resulting from development (Maron et al. 2012). In theory, restoration offers the opportunity to replace systems that have been damaged or completely removed during mining, urban development and the like. The goal is to restore a system that replaces all the key features of the target system. In practice, however, it is proving more difficult than expected to restore these features, and often effective restoration is difficult or impossible and the outcomes are time-lagged and highly uncertain. (See **Case Study #3).**

Site selection for protected areas is all about trade-offs too. The primary one is what natural values can be protected given different budget frameworks. Noam Levin led an international effort (working with Salit Kark's group) to devise a framework for systematic conservation planning and management of Mediterranean landscapes (Levin et al, 2012). The innovation they introduced, presented in *Biological Conservation,* was an allowance for spatio-temporal shifts of biodiversity features, threats and management options. Their aim was to demonstrate a novel approach for systematic conservation planning at a fine scale that incorporates dynamic ecological processes (e.g., succession), biodiversity targets and management costs. The approach they formulated can be applied to spatially prioritize conservation goals in the face of shifting environments and climates, allowing dynamic conservation planning at multiple spatial scales.

Revegetation is the central plank of most restoration efforts. The biodiversity value of regrowth vegetation is increasingly recognised worldwide. However, David Lindenmayer and colleagues have demonstrated in *PLoS ONE* that different kinds of revegetation have different values for bird diversity (Lindenmayer et al. 2012b). They examined the conservation value of different kinds of revegetation through a comparative study of birds in 193 sites surveyed over ten years in four growth types located in semi-cleared agricultural areas of south-eastern Australia. These growth types were resprout regrowth, seedling regrowth, plantings, and old growth. Their findings suggest a range of vegetation growth types are likely to be required in a given farmland area to support the diverse array of bird species of Australian temperate woodland ecosystems. These results also highlight the inherent conservation value of regrowth woodland and suggest that current policies that allow it to be cleared or thinned need to be carefully re-examined.

> *A common thread running through much of the work is the focus on ensuring that good intentions result in good outcomes.*

References

Lindenmayer, D.B., Hulvey, K.B., Hobbs, R.J., Colyvan, M., Felton, A., Possingham, H.P., Steffen, W., Wilson, K., Youngentob, K. and Gibbons, P. (2012a). Avoiding bio-perversity from carbon sequestration solutions. *Conservation Letters,* 5: 28-36

Lindenmayer, D.B., Northrop-Mackie, A.R., Montague-Drake, R., Crane, M., Michael, D., Okada, S., and Gibbons, P. (2012b) Not all kinds of revegation are created equal: Revegetation type influences bird assemblages in threatened Australian woodland ecosystems. *PLoS ONE,* 7.

Maron, M., Hobbs, R.J., Moilanen, A., Matthews, J.W., Christie, K., Gardner, T.A., Keith, D, Lindenmayer, D.B. and McAlpine, C.A. (2012). Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biological Conservation,* 155: 141-148.

Noam L., J.E.M. Watson, .LN. Joseph, H.S. Grantham, L. Hadar, N. Apel, A. Perevolotsky, N. DeMalach, H.P. Possingham and S. Kark. (accepted 2012). A framework for systematic conservation planning and management of Mediterranean landscapes. *Biological Conservation,* 158: 371–383

Walsh, J.C., Wilson, K.A., Benshemesh, J. and Possingham, H.P. (2012). Unexpected outcomes of invasive predator control: the importance of evaluating conservation management actions. *Animal Conservation,* 15: 319-328

Theme A

Case Study #1

Bio-perversity in the plantation

Minimizing poor outcomes from carbon plantings

Like it or not, the carbon economy is coming to town. No-one can predict exactly what it will look like but the bottom line is that one way or another emitting or capturing carbon is going to have a price. One of the expected consequences of this is that income from carbon offsetting will drive major land management changes. Land owners will be shifting land to higher carbon storage states by transforming the vegetation cover. Many people say this is a good thing with the potential to restore degraded land and better protect biodiversity. But a growing number of scientists are also advising caution, that a narrow focus on carbon storage has the potential to create significant negative environmental outcomes if the protection and enhancement of other values such as biodiversity are not explicitly considered. CEED researchers have even come up with a name for it – bio-perversity.

When it comes to locking up carbon, one popular strategy frequently put forward is the establishment of tree plantations – massive commercial-scale plantations transforming whole landscapes. Such ventures, it is proposed, lock up carbon while at the same time growing a valued commodity. The claim of other associated environmental benefits is also often thrown into the equation.

"Incentives to sequester carbon through establishing plantations are likely to increase as the impacts of climate change become more pronounced and intense," says Professor David Lindenmayer, the lead researcher on the CEED-led review of plantations for carbon sequestration and biodiversity.

"We argue that harmful outcomes for biodiversity – what we term 'bio-perversities' – can arise as unintended consequences from a range of efforts to enhance forest-based carbon sequestration. Perhaps the greatest of the associated potential bio-perversities are those which may arise from ill-conceived or inappropriate large-scale plantation projects.

"Our purpose in doing this review was twofold. First, we wanted to put up a red flag on the risks of rushing into plantation development with a narrow focus on carbon. Second, we're suggesting ways these risks can be avoided."

Broadly speaking, the researchers believe there are three areas of bio-perverse outcomes arising from carbon sequestration plantations:

- Land clearing to establish tree plantations.
- The risks of plantation trees becoming invasive plants.
- The potential for plantations to negatively affect key ecological processes and disturbance regimes.

Thorough, knowledge-based risk assessments of plantation projects and ecological monitoring will be essential for early detection and minimisation of potential bio-perverse outcomes such as altered hydrologic and geomorphic cycles and altered fire regimes. Some locations will be deemed unsuitable for plantation establishment as a result of these considerations. It is imperative that incentives schemes and reward systems have clear regulations to prevent the establishment of plantations in regions that are unsuitable.

"If the rush to plant trees and establish plantations for carbon sequestration results in a range of other environmental values being ignored, we expect big problems to follow," observes Lindenmayer. "A narrow focus on carbon may well exacerbate a range of existing environmental problems, contribute to further biodiversity loss, introduce additional obstacles to recovering or maintaining the ecological integrity of environments, and ultimately fail to mitigate the anthropogenic causes of climate change. And that would be a perverse outcome indeed of a venture that was intended to ameliorate the root cause of climate change."

Four strategies to mitigate plantation bio-perversity

1. **Ecological risk assessment**
   These would include:
   - An evaluation of the risks to existing ecosystems.
   - An assessment of uncertainties in understanding of ecosystem processes.
   - An evaluation of trade-offs between the ecosystem services gained and lost through plantation establishment.
2. **Full carbon accounting**
   This would involve quantifying the amount of carbon to be sequestered in plantations relative to the ecosystems they replace.
3. **Assessment of incentives**
   This includes anticipating the different strategies that might be adopted by plantation growers to a particular policy, and should involve collaboration with local and regional policy-makers as well as ecologists.
4. **Compliance & ecological monitoring programs**
   Such programs should include both local level 'participatory' monitoring as well as regional and national level 'expert-based' monitoring.

Case Study #2

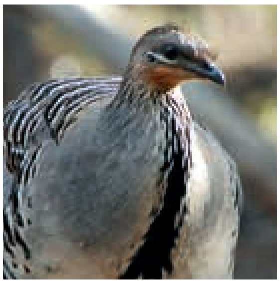
Does controlling foxes save malleefowl?

The importance of evaluating conservation management actions

How good are our investments in protecting threatened species? Without monitoring and evaluation, practitioners can only guess or assume the effectiveness of an action, thereby reducing their ability to make smart management choices in the future.

A case in point is the management of malleefowl *(Leipoa ocellata)*. This icon of the mallee is in trouble. Its distribution across Australia has declined dramatically in past decades due to habitat loss, fragmentation and degradation, predation by foxes, grazing by herbivores and frequent, intense fires. As described in the Malleefowl National Recovery Plan, current conservation management actions include predator control, habitat protection and restoration, fencing and community engagement.

> *"Our study provides a powerful example of why management decisions should be based on evidence, rather than ecological intuition and assumptions.*



Malleefowl.

The emphasis, however, is on fox baiting. That's because foxes are a known threat to the malleefowl through predation of eggs, chicks, juveniles and occasionally adults; and foxes are common in areas occupied by malleefowl.

But is fox management working? Often we'd have to say we simply don't have enough data to know, therefore we should do it anyway. But that's not the case with malleefowl because here there's a wealth of data. That's due to the dedicated efforts of hundreds of volunteers. Each year they record the number of active malleefowl mounds in monitoring sites across the species' distribution. Accompanying these data on breeding population size and growth are records of fox baiting regimes, a relative measure of fox presence and a record of environmental variables for over 25 years.

Jessica Walsh, an Early Career Researcher at the University of Queensland, evaluated this dataset and came to some very surprising conclusions.

"According to our models, an increase in fox baiting intensity did not significantly decrease the presence of foxes at a monitoring site," she says. "In addition, fox presence was positively correlated with the growth of malleefowl populations, which is quite unexpected. Increased investment in fox control did not result in higher malleefowl population growth, suggesting that baiting is generally not a cost-effective management strategy for the recovery of this species."

How could this be? Walsh and colleagues believe there are a number of factors at play here. First, the baiting intensities in most malleefowl monitoring sites are low, compared to the recommended effective baiting intensity. It's also possible malleefowl and foxes may be responding to an unknown environmental variable such as habitat quality or primary productivity, which had not been accounted for in the models.

"Whatever the reason behind our results, the basic point remains – there is limited quantitative evidence for the benefit of fox baiting to protect malleefowl," says Walsh. "Despite that, it's the main management action implemented across Australia for this species.

"Our study provides a powerful example of why management decisions should be based on evidence, rather than ecological intuition and assumptions," says Walsh. "There's an urgent need for conservation managers to carry out similar evaluations using the available evidence for management interventions that are being planned or already implemented."

The bottom line is that without evaluation, the effectiveness of different conservation management actions is unknown. And with very limited resources available to solve enormous challenges (often involving endangered species), that's simply not acceptable.

Case Study #3

Replacing lost ecosystems - the Devil is in the detail

Balancing biodiversity offsets with restoration reality

Biodiversity offsetting is a big and attractive idea. Indeed, it's one of the fastest-growing areas in conservation policy both here in Australia and overseas with more than 64 such programs currently underway around the world. The idea is that losses of biodiversity at an impact site are compensated by the generation of ecologically equivalent gains elsewhere. The result, in theory, is that there is 'no net loss' of biodiversity.

However, although this approach is being increasingly applied, when CEED researchers led by Martine Maron at the University of Queensland and Richard Hobbs at the University of Western Australia reviewed the literature on the effectiveness of restoration for biodiversity offsets, they found there is little evidence that it can work.

Most biodiversity offset activity falls into two categories. The first, called 'averted loss' offsetting, involves the protection and maintenance of sites that would otherwise be under threat of clearing or degradation. By definition, this approach doesn't avoid overall declines in biodiversity.

The second, which we refer to as 'restoration' offsetting, involves improving the quality or extent of habitat or vegetation through improved management or revegetation. In countries such as Australia, with relatively low deforestation rates and statutory vegetation clearing controls, the main offset opportunities arguably lie in restoration.

But how confidently can we use restoration and revegetation to replace lost biodiversity? CEED researchers found that many of the expectations set by current offset policy for ecological restoration remain unsupported by evidence.

The evidence base for different types of restoration offsets varies depending on the target biodiversity. There are very few – if any – situations in which an entire ecosystem can be reliably re-created. Similarly, old growth or late successional habitats can be considered effectively un-offsettable, due to the long lag times and large uncertainties involved.

The fact that restoration practice cannot recreate lost ecosystems is not an argument against doing restoration – it still generates benefits for elements of biodiversity, and

Restoration work near Canberra.

Restoration treeplanting in Gondwana Link in Western Australia.

The limitations of offsets

Acknowledging the limitations of what can be achieved through biodiversity offsetting is important. Otherwise we're accepting a policy that could result in the loss of effectively irreplaceable biodiversity. The researchers suggest that the main factors limiting the ability of ecological restoration to achieve a successful offset relate to:

1. **Poor measurability**

   Can we define and precisely measure the thing we are trying to offset?

2. **Uncertainty**

   Is there reasonable evidence we can re-create the thing we have lost?

3. **Time lags**

   Can the lost values be replaced with minimal delay?

If the answer is 'no' to any of these questions, then offsetting is unlikely to be an appropriate response to a potential biodiversity impact.

we are continually improving restoration practice. But in an offset context, the consequences of failure to restore are multiplied, since the promise of effective restoration may increase the chance that damage to biodiversity is permitted. Also, the criteria for success are much tougher – the aim is not simply to improve biodiversity in a site or a region, but to generate new biodiversity that is equivalent in both kind and amount to that which is lost from a natural system elsewhere.

The researchers recommend that restoration be used to deliver biodiversity offsets only when:

1. The impacted biodiversity and ecosystem values can be explicitly defined and measured.
2. There is an existing and sound evidence base that restoration of the values in question is feasible.
3. Time lags and uncertainties involved are explicitly accounted for in the calculation of loss and gain, and any time lags do not pose an interim threat to the persistence of the biodiversity value in question.

If we are to continue to destroy natural ecosystems – as we certainly will – it is better to offset part of the damage than none at all. However, without a transparent accounting framework that makes clear what losses are actually effectively compensated for through offsetting, and what residual damage is accumulating, it is difficult to judge the true costs of development.

> *"Without a transparent accounting framework that makes clear what losses are actually effectively compensated for through offsetting, it is difficult to judge the true costs of development.*

B

Theme B

Biodiversity decisions in dynamic systems

Theme leaders: Brendan Wintle (UoM), Jonathan Rhodes (UQ) and EJ Milner-Gulland (Imperial College, UK).

Change in the environment, society and economy is occurring at an accelerating rate. Given this, the need for making good environmental decisions is stronger than ever. However, the bulk of decision-making still ignores rapid change. CEED researchers have led the world in developing new tools and ways of thinking to make decisions in the context of rapid change and large uncertainty.

Climate change provides an excellent example of CEED's value in this area. Over the past five years, CEED researchers have led a transition from studies that identify climate-change impacts on biodiversity to studies that inform strategies for adaptation. CEED research on decision making in dynamic systems is now building on these significant achievements and covers a range of key topics. In addition to climate-change adaptation we are also working on characterizing and dealing with uncertainty, monitoring and learning, and analysing conservation cost-effectiveness. Below are some highlights.

CEED is making a significant contribution to the international effort to conserve biodiversity in a changing world through analysis and modelling of proposed policy and management responses. Examples include our work on REDD+ (see the section on climate change below) and engagement with the newly formed Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), an organisation that will become increasingly important for influencing how the international community responds to the challenge of conserving biodiversity. CEED is playing a key role in providing input into future IPBES biodiversity assessments and developing new ways for assessing the impact of global change on biodiversity and identifying appropriate policy responses (Nicholson et al. 2012).

Climate change

In the journal *Nature Climate Change,* Elizabeth Law and co-authors discussed the complex and variable ecological and social settings behind the global carbon emissions reduction program REDD+ (Law et al. 2012). They argue that the total value to society of each type of REDD+ outcome is dependent on the fundamentally different risk profiles of alternative forest-management approaches and their scope and potential for co-benefits. They describe a modular policy framework for REDD+ that distinguishes and differentially values the distinct outcomes. This represents a substantial improvement on current, ad-hoc approaches to promoting and managing incentives for effective forest-carbon initiatives, offers better scope to find common ground in policy negotiations and allows faster adaptation of policy to an uncertain future.

In the journal *Conservation Biology,* Melinda Moir and co-authors tackle a controversial management action that may become critical for the conservation of biodiversity under climate change; assisted migration (Moir et al. 2012). In a major advance in thinking about assisted migration, they consider what the implications are of moving species that have co-dependent species, such as parasites that are dependent on their hosts. In doing so, they develop a new framework for considering the implications that moving hosts will have on dependent species and what this means for decision making during assisted migration. (See **Case Study #1).**

Uncertainty

In the journal *Global Change Biology,* Rebecca Runting and CIs Jonathan Rhodes and Kerrie Wilson apply a novel approach to quantify the value of reducing uncertainty for the conservation of coastal wetlands under dynamic sea-level rise (Runting et al. 2012). In this pioneering work the authors present the first analysis of how much should be invested in the reduction of uncertainty through better predictive models of shifts in coastal ecosystems under sea-level rise. They make the surprising discovery that obtaining improved predictive models is so valuable for making more robust conservation decisions that, under some scenarios, even if we spend up to 90% of our conservation budget on improving predictions, we would still get better conservation outcomes. (See **Case Study #3).**

In the journal *Conservation Biology,* Yacov Salamon and CEED CIs Mick McCarthy and Brendan Wintle develop new mathematical methods to incorporate uncertainty into decision making in population-management problems (Salamon et al. 2012). Instead of maximizing the expected outcome, they maximized the probability of obtaining an outcome above a threshold of acceptability and demonstrated the value of this approach in case studies of managing koala and turtle populations.

And in the journal *Methods in Ecology and Evolution,* Georgia Garrard and co-authors develop a new general approach for estimating detectability of species (Garrard et al. 2012); a key cause of uncertainty in estimating species distributions. (See **Case Study #2).**

> *The bulk of decision-making still ignores rapid change. CEED researchers have led the world in developing new tools and ways of thinking to make decisions in the context of rapid change and large uncertainty.*

Cost-effective conservation investment

In the journal *Ecological Applications,* Carissa Klein and co-authors identify the problem that conservation planning for coral reefs focuses on removing threats in the sea, neglecting management actions on the land (Klein et al. 2012). They propose a more integrated approach to coral reef conservation, inclusive of land-sea connections, which requires an understanding of how and where terrestrial conservation actions influence reefs. They develop a land-sea planning approach to inform fine-scale spatial management decisions. They discover that protecting 2% of forest in one area is almost 500 times more beneficial than protecting 2% in another area, making prioritization essential.

In the journal *Conservation Letters,* Josie Carwadine and colleagues provide the first broad-scale, multi-species cost-effectiveness analysis of multiple management actions for the Kimberly region of Western Australia (Carwadine et al. 2012). Conducting broad-scale prioritisation of management actions is difficult, but CEED researchers have pioneered a robust approach to prioritising actions based on expert elicitation.

References

Carwardine, J., O'Connor, T., Legge, S., Mackey, B., Possingham, H.P. and Martin, T.G. (2012). Prioritizing threat management for biodiversity conservation. *Conservation Letters,* 5: 196-204

Garrard, G. E., McCarthy, M. A., Williams, N. S. G., Bekessy, S. A. and Wintle, B. A. (2012), A general model of detectability using species traits. *Methods in Ecology and Evolution,* DOI: 10.1111/j.2041-210x.2012.00257.x

Klein, C. J., Jupiter, S.D., Selig, E.R., Watts, M.E., Halpern, B.S., Kamal, M., Roelfsema, C. and Possingham, H.P. (2012). Forest conservation delivers highly variable coral reef conservation outcomes. *Ecological Applications,* 22: 1246-1256

Law, E.A., Dargusch, P.J., Thomas, S., Meijaard, E. and Wilson, K.A. (2012). A modular framework for management of complexity in international forest-carbon policy. *Nature Climate Change,* DOI: 10.1038/nclimate1376

Moir, M.L., Vesk, P.A., Brennan, K.E.C., Poulin, R., Hughes L., Keith, D.A, McCarthy, M.A. and Coats D.J. (2012). Considering extinction of dependent species during ex situ conservation and assisted migration of threatened hosts. *Conservation Biology,* 26: 199-207

Nicholson, E., Collen, B., Barausse, A., Blanchard, J.L., Costelloe, B.T., Sullivan, K.M.E., Underwood, F.M., Burn, R.W., Fritz, S., Jones, J.P.G., McRae, L., Possingham, H.P. and Milner-Gulland, E.J. (2012). Making Robust Policy Decisions Using Global Biodiversity Indicators. *PLoS ONE,* 7.

Runting, R., Wilson, K. and Rhodes, J.R. (2013). Does more mean less? The value of information for conservation planning under sea level rise. *Global Change Biology,* 19: 352-363

Salomon, Y., McCarthy, M.A., Taylor, P., and Wintle, B.A. (2013). Incorporating uncertainty of management costs in sensitivity analyses of matrix population models. *Conservation Biology,* 27: 134-144

Theme B

Case Study #1

Should we try to save parasites too?

Extinction of dependent species during translocation of threatened hosts

When we move a threatened plant species to a new site to improve its chances of survival, should we make a similar effort at moving the insects that live on that plant? And what should we do about parasites living on translocated animals?

To assist in determining whether the conservation of a host species benefits a dependent species (or the entire dependent assemblage), Melinda Moir and CEED CI Peter Vesk formulated a decision protocol for conservation managers. They used this protocol on a diversity of case studies including: New Zealand's iconic tuatara *(Sphenodon punctatus)* and a less-well-known host-specific tick species; the New Zealand Hihi bird and an internal coccidian parasite; a global database of native cat species and their assemblages of parasites; and three threatened plant species from southwest Western Australia and their insect assemblages.

As an example, consider the dragon-like tuatara and its host-specific tick *Amblyomma sphenodonti.* Despite occurring over much of New Zealand before the arrival of humans, tuatara are now restricted to 28 islands due to habitat modification and introduced rats, but the tick occurs on less than a third of these tuatara-inhabited islands. Conservation actions for the tuatara have included translocating populations to uninhabited islands. Early translocations of tuatara involved removing all ticks, but recently ticks have been translocated with the tuatara because they appeared not to affect the health or survival of host animals.

"Our decision protocol allowed us to assess whether the translocation of the tuatara to islands off New Zealand for conservation purposes also benefitted the tick," explains Moir. "Follow-up monitoring of two translocations found that despite the tuatara populations maintaining their numbers, the tick populations had crashed, in one case by over 98% of the original number of translocated ticks. Thus,

> *"Our decision protocol allowed us to assess whether the translocation of the tuatara for conservation purposes also benefitted the tick.*

Cothreatened ticks on the tail of the tuatara.

although initially it would have appeared that the survival of both tuatara and tick were assured through successful tuatara translocations, the reality is that further work is required to determine the requirements of the tick, such as host densities that promote successful transmission of the tick." These baseline ecological requirements must be uncovered and addressed. In this case, for example, it might involve experiments investigating the sustainability of tick populations on increasing densities of translocated tuatara populations. Only then will tick-with-tuatara translocations be successful. Furthermore, tick reintroductions onto island tuatara may be necessary to re-establish or sustain viable populations of the tick.

Unfortunately not every dependent species is lucky enough to receive as much attention from land managers and conservationists as the tuatara tick. In fact, most of the world's hyperdiverse fauna (including many dependent groups such as insects, arachnids, nematodes, etc) don't even have names yet. Unfortunately, the problem is compounded by the fact that even for described species, knowledge of their ecology and distribution is often not good enough for conservation assessment.

A practical way forward for the conservation of hyperdiverse assemblages may be to list them as a 'Threatened Ecological Community'. This would be beneficial as an assemblage may encompass multiple undescribed, but highly threatened taxa that could all be conserved through actions directed at the host. Members of listed threatened assemblages would also be protected from any forms of indirect extinction, such as through eradication programs to 'clean' threatened hosts of their 'parasite loads' before hosts are translocated.

"Conserving this huge proportion of the world's biodiversity is a monumental task," says Moir. "But rather than be overwhelmed, we can begin to address the problem with small steps. An initial step might be to include the decision protocol we've created to assist in managing dependent species."

Why worry about dependent species?

Does it really matter if we lose a few species of blood-sucking parasites when we move their host species around? A world without dependent species would be a world with limited pollination, cascades of secondary extinctions, and outbreaks of invasive plants and animals. Dependent species help maintain the genetic diversity of host species (promoting host diversification and evolution), and improve overall host health. So, even though parasites often get bad press, they all play some role in providing ecosystem services and maintaining the balance.

Case Study #2

Detecting species without species-specific guides

A new, trait-based model of detectability

Imperfect detectability of plants and animals during ecological surveys is a major issue. Get it wrong and you run the risk of endangered species being lost when development is permitted but the species was still present. Or, on the other hand, you risk an invasive species breaking out when control efforts are stopped too soon because the invading organism was considered no longer to be there. Imperfect detectability can lead to biased estimates of abundance or occupancy, impaired ability to detect change or response to management action and ultimately leads to poorly informed management decisions.

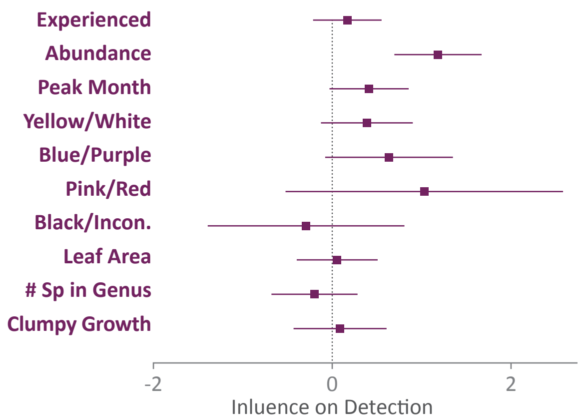
These days the problem of imperfect detectability is widely recognised. A range of methods exist for estimating detectability, including distance sampling, mark-recapture, and time-to-detection models. Each of these models has its own set of assumptions, data requirements and applications. Often, the data requirements of these models are heavy. Data, including abundance counts, presence-absence observations and times-to-detection, are variously required from multiple sites and multiple observers. What that adds up to is that, at this time, estimates of detection probability are available for relatively few species.

If you don't have a species-specific model to guide how much effort you need to expend to detect a species that is present (with confidence), what can you do? Maybe you could focus on some character trait of that species as a generic guide? For example, if you were aware that it took a certain amount of effort to detect a weed species with red flowers, maybe that knowledge could help you decide how much effort would be required to find an unrelated species that also had red flowers. Georgia Garrard and colleagues asked whether we can learn about the influence of species traits on detectability, and used trait-based models to predict the detectability of species for which no species-specific model exists.

Using a time-to-detection model, Garrard and colleagues investigated the influence of a range of species traits on the detectability of grassland plant species. Examples of the traits investigated were local abundance, height, likelihood of flowering at the time of survey, flower colour, leaf area, number of similar grassland species and whether the species grows in clumps.

"We found that local abundance has a clear influence on detectability, with species that occur in higher numbers having lower detection times (higher detection rates) than those occurring in small numbers," says Garrard (see **Figure B2).** "Species are also more likely to be detected if they are unique or in their peak flowering month at the time of survey, although these results are less definitive.

Figure B2



The relative size of the influence of traits on detection rate (mean and 95% credible intervals).

> *With more than 1300 nationally-listed threatened plant species and another 400 animal species in Australia alone, it's impossible to consider constructing a species-specific detectability model for every threatened species.*

"Our results also show that flower colour may have a large effect on detectability, with pink and red flowered species potentially more easily detected than those with inconspicuous or yellow flowers. This makes sense in native grasslands, where there are many yellow flowers and few pink or red flowers. The influence of flower colour is still very uncertain."

Using trait-based detectability models, the researchers were able to predict average times-to-detection reasonably well for new species. "Trait-based detectability models are an exciting development in the field of detectability research and have enormous potential to improve our environmental decision making," comments Garrard. "With more than 1300 nationally-listed threatened plant species and another 400 animal species in Australia alone, it's impossible to consider constructing a species-specific detectability model for every threatened species."

While they may not perfectly predict individual species' detection probabilities, trait-based models should provide sensible bounded estimates of detectability on which to base survey design and effort requirements.

Case Study #3

Beyond the bathtub

The value of information for conservation planning under sea level rise

If you were given the task of locating a reserve system to preserve coastal biodiversity, how much of your limited budget would you devote to acquiring high-quality data? Of course, collecting and using high-quality data is more expensive than using rougher, low-quality data. And the money you save in this step, which might be considerable, could be put towards acquiring more land so it's far from being an academic question. And it's especially important in a world experiencing a rapidly changing climate – consider coastal systems, where sea-level rise presents considerable challenges for developing cost-effective plans to preserve biodiversity.

So, what's the value of higher quality data for conservation planning relating to sea level rise? Rebecca Runting and CEED CIs Jonathan Rhodes and Kerrie Wilson explored this issue by determining the cost-effectiveness of investing in high-resolution elevation data and process-based models for predicting wetland shifts in a section of Moreton Bay in South East Queensland.

Coastal impact models are a useful tool for projecting the environmental responses to sea level rise and can inform plans for adaptation. The researchers examined two different impact models with two different datasets for elevation to predict the consequences of lower, mid-range, and upper sea level rise projections to 2100.

The first impact model is a simple inundation model. It works by simply projecting sea level rise onto a topographic map, and any area below the given contour is identified as being inundated. These models are sometimes referred to as bathtub inundation models. They're relatively quick and easy to use, can function with fairly basic data inputs but are somewhat simplistic in their projections. They don't take in to account, for example, sediment build-up and other key processes that remodel the landscape as sea level gradually rises.

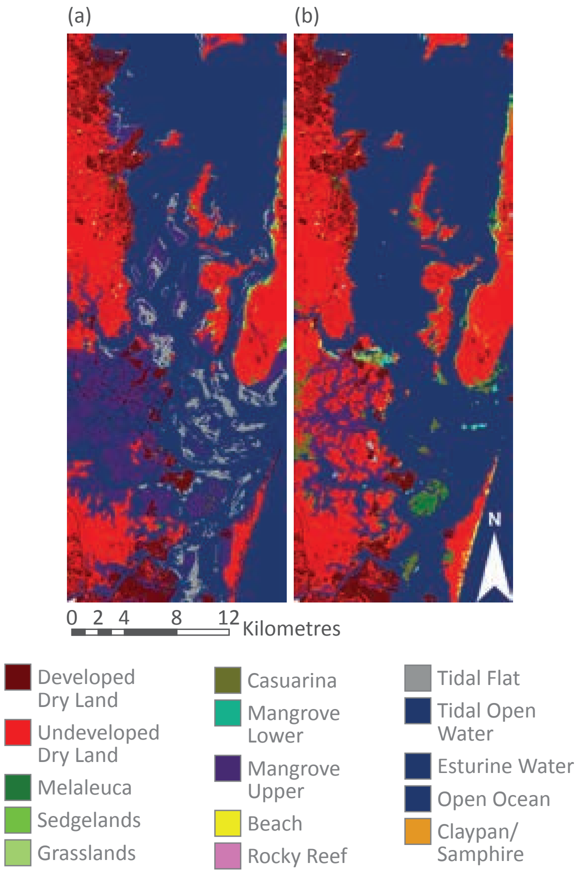
They also used the SLAMM modelling package (which stands for the Sea Level Affecting Marshes Model). It gives modellers the ability to account for many of the processes that get left out of the simpler bathtub model. For example, it can incorporate accretion, erosion and wetland shifts following changes in saline water conditions. While SLAMM offers many advantages over bathtub inundation models, it requires expert handling, high quality data inputs, and takes longer to run.

In addition to the type of model being used to estimate impacts of sea level rise, there's also the question of the quality of the elevation data that will be used in the model. Elevation data is a critical input into these models as minor changes in elevation (in the order of centimetres) can drive key processes. Their analysis compared a coarser (30m resolution) and finer (5m resolution) elevation dataset.

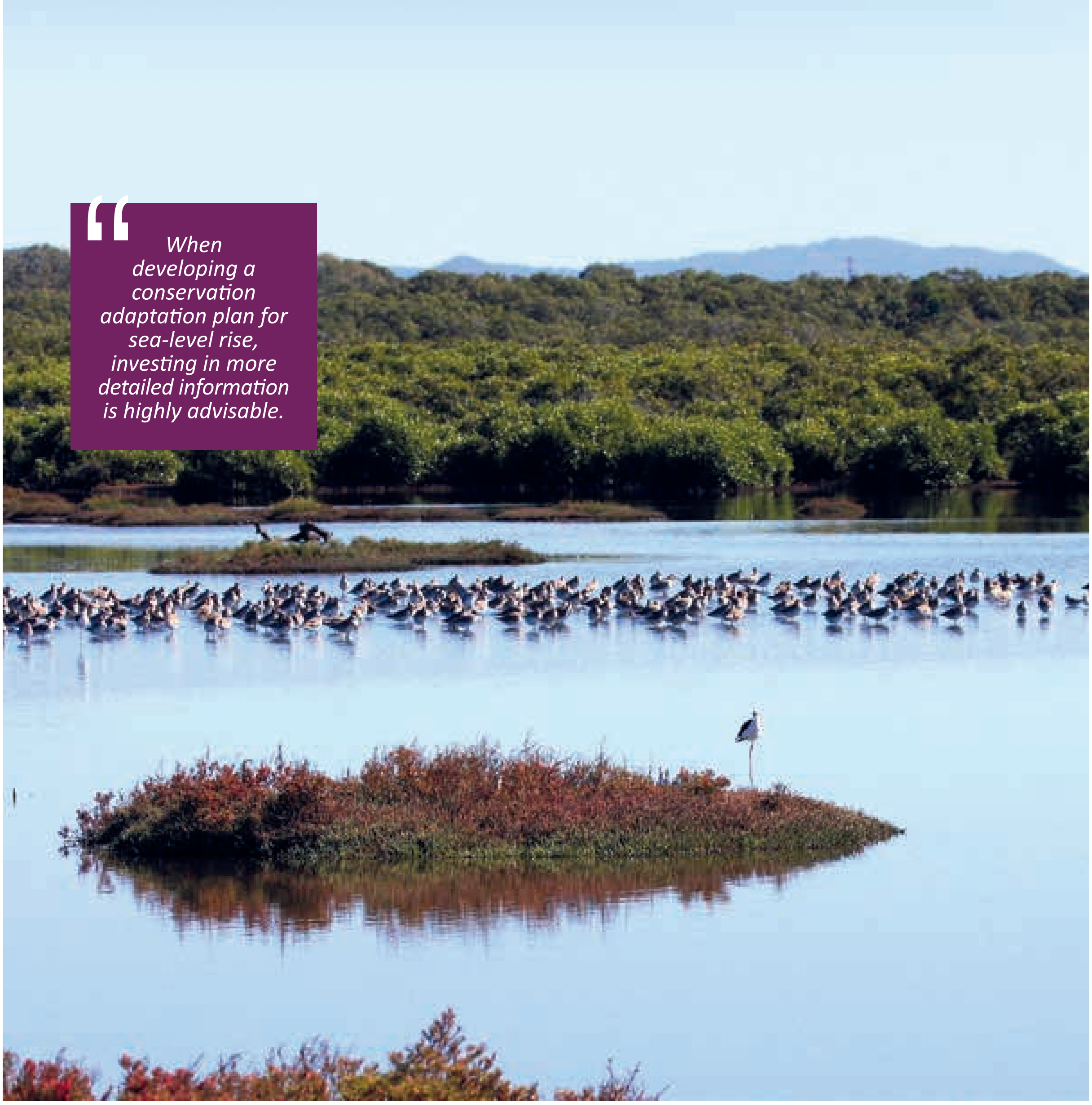
As might be expected, the fine resolution data and the more sophisticated SLAMM modelling approach both came at a significantly higher cost. The question then is what combination gives you the greatest conservation bang for your limited conservation buck. The benchmark for answering this question was the conservation value of the wetland distribution in 2100 mapped using the best available model and data (SLAMM + fine resolution data, see **Figure B3 A).**

They initially determined how much of this conservation value could be achieved by just using the simple bathtub model and coarse data (the cheapest option available) for

Figure B3 A



Wetland distribution produced from the (a) complex model with fine resolution elevation data and (b) the simplistic model with coarse elevation data for the mid-range sea-level rise scenario.



> *When developing a conservation adaptation plan for sea-level rise, investing in more detailed information is highly advisable.*

Wetlands are sensitive to changes in sea level.
Accurately modelling how sea-level rise will change these landscapes could be critical to saving them.

150 budget levels (up to $50 million). Conservation priority areas are selected using these modelled outputs. However, these outputs often miss the areas of high conservation value. This means that much more land must be purchased to get the same conservation value that could have been achieved if the best models and data were used instead.

Conservation priority areas were also selected using the more expensive modelling outputs (SLAMM + finer scale data). They then determined how much less it would cost (just in terms of land purchases) to achieve the same conservation value using these more accurate modelling outputs.

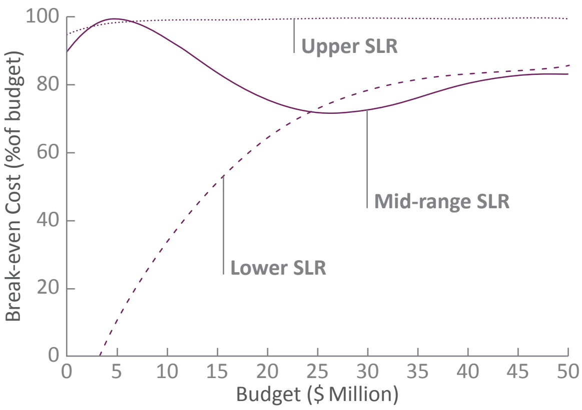
"The various model-dataset combinations produced quite different distributions of vegetation types by 2100," says Runting. "As the overall budget increased, so did the maximum amount that could be spent on acquiring the complex model and fine resolution elevation data without forgoing any conservation benefit relative to applying the simplistic model and coarse elevation data (see **Figure B3 B**).

"Our analysis suggests that for the upper sea-level rise scenario it was worth spending up to 99% of the budget on acquiring the high quality data! The break-even cost for the mid-range and lower sea-level rise scenarios was also a large proportion of the total budget.

"In other words, whilst adopting a more accurate approach may mean less land is acquired in terms of overall area, the land that is acquired would be of greater conservation value than the cheaper approaches."

Investing in detailed information doesn't always improve the conservation outcomes. However, when developing a conservation adaptation plan for sea-level rise, investing in more detailed information is a highly advisable action.

Figure B3 B



The maximum amount that could be spent on acquiring the complex model and fine resolution elevation data without forgoing any conservation benefit relative to the simplistic model and coarse elevation data (i.e., the break-even cost).

Research

C

Theme C

Rapidly-transforming landscapes

Theme leaders: Sarah Bekessy (RMIT), Yvonne Buckley (UQ/CSIRO), Tara Martin (CSIRO) and Martin Drechsler (UFZ).

Rapidly-transforming, human-dominated landscapes are a microcosm of the threats facing the environment. They provide a unique opportunity to develop and evaluate decision-making methods developed in CEED. Species invasions and land use changes (such as urbanisation) are transforming our landscapes and the species they hold faster than ever before in human history.

Undertaking conservation and management actions in multiple-use landscapes requires a clear understanding of the processes we are aiming to manage. It also needs planning tools that can take into account the pervasive trade-offs between economic, social and biodiversity benefits. Here are a few highlights of the cutting-edge environmental decision science being undertaken in two transforming landscapes – in and around expanding cities and approaches for managing invaded landscapes.

Invasiveness and invaded landscapes

Humans transform landscapes by moving species around for food and building materials, by accident, or just because we like to surround ourselves with the familiar or the exotic. Some of these non-native species have been responsible for declines in biodiversity, economic losses and disruption of the ecosystem services on which we depend for clean water and agriculture.

Making decisions about how to apportion budgets between prevention, monitoring and management, in order to minimise the impacts of invasive species in cost-effective ways, depends on understanding the relative risks and impacts of invasion in different kinds of ecosystems. Cost-effective management also depends on the coordination of management between decision makers and how they keep up with the often rapid spread of a new invader across the landscape.

CEED researchers have developed appropriate metrics for quantifying invasion that enable direct comparison between sites (Catford et al. 2012) and identified indicators of ecosystems at particular risk from the impacts of invasion (Walsh et al. 2012).

Some ecosystems and parts of the landscape are more invaded and more invasible than others. How should we prioritise management decisions in space to cost-effectively minimise the damage caused by invaders? Up until now this question has suffered from a lack of attention to appropriately quantifying the risk of invasion to different ecosystems and locations.

A prerequisite for characterizing invasibility is the ability to compare invasion level across ecosystems. In *Global Change*

Biology, Jane Catford and colleagues (2012) identified the best way to quantify the level of invasion by non-native animals and plants and recommended two invasion indices: relative non-native species richness and relative non-native species abundance. (See **Case Study #1).** The metrics are easy to measure, can be applied to various taxa, are independent of scale, and are comparable across regions and ecosystems.

Island ecosystems are particularly susceptible to invasion and to incurring biodiversity loss as a consequence of invasion. Research led by Jessica Walsh (Walsh et al. 2012) used data from 65 islands and archipelagos to determine which characteristics of an island influence the impact of non-native species on native birds, amphibians and mammals. The researchers found that the impact of non-native species is more severe on islands with more non-native species and a greater proportion of endemic native species.

Unexpectedly, the level of anthropogenic disturbance did not influence an island's susceptibility to the impacts of non-native species. This work identifies islands that are at risk of impact by non-natives and where investment should focus on preventing further invasions.

Conserving biodiversity in expanding cities

In Australia, over 50% of threatened species occur within the urban fringe and accelerating urbanization is now a key threat. Biodiversity near and within urban areas brings much social and ecological benefit but its maintenance involves complex trade-offs between competing land uses. Traditional approaches to conservation are challenging to implement in the urban arena for a number of reasons. Even our basic conceptions of what 'urban nature' is and how it should be 'restored' are being reassessed (Standish et al. 2012). Rachel Standish and CEED CI Richard Hobbs believe we have to look beyond preservation and repair (to some original state) if we are to meaningfully engage with the challenge of restoration in urban spaces. (See **Case Study #2).**

While most research in systematic conservation planning has focused on rural areas, conservation planning is becoming just as important in rapidly expanding urban areas. Yet, applying traditional conservation planning tools in this context is challenging given that managers are faced with the complexities of multiple stakeholders with different motives undertaking numerous actions in the presence of severe uncertainty.

Planning for biodiversity is made even more difficult by the rapid, spatially complex, non-linear manner in which contemporary cities are expanding. CEED has developed new theories and methodologies for the design and management of urban fringe landscapes, including transparently trading between competing values (Bekessy et al. 2012), prioritizing actions taken by multiple stakeholders (Gordon et al. 2012) and conceptualising the temporal dynamics of urban expansion (Ramalho & Hobbs 2012).

Urban design typically views biodiversity as a development constraint, not a value to be enhanced into the future. CEED CI Sarah Bekessy and colleagues (2012) argue in *Landscape and Urban Planning* that decisions could and should be more transparent and systematic. They demonstrate that efficient development solutions can be found that avoid areas important for biodiversity, and they present ways that these solutions can be presented in dynamic and visually compelling outputs. (See **Case Study #3).**

Part of the problem of prioritising conservation actions in an urban setting is that there can be multiple actors undertaking conservation actions, often with divergent or partially overlapping objectives. Gordon et al. (2012) explore this issue in *Ecological Modelling* with a simulation study involving two agents sequentially purchasing land for the conservation of multiple species using scenarios comprising either divergent or partially overlapping objectives between the agents. In each scenario the benefit is estimated for when an agent moves from acting in isolation to either sharing information or pooling resources with the other agent. The model demonstrates a method for determining conditions under which collaboration improves efficient use of scarce conservation resources.

The manner in which cities expand is another complexity that is rarely taken into account in the way that urbanization is classically assessed in ecological studies. An explicit consideration of the temporal dynamics, although frequently missing, is crucial in order to understand the effects of urbanization on biodiversity and ecosystem functioning in rapidly urbanizing landscapes. In particular, a temporal perspective highlights the importance of land-use legacies and transient dynamics in the response of biodiversity to environmental change. Ramalho & Hobbs (2012) outline the essential elements of an emerging framework for urban ecology in *Trends in Ecology and Evolution* that incorporates the characteristics of contemporary urbanization and thus empowers ecologists to understand and intervene in the planning and management of cities.

> *"Biodiversity near and within urban areas brings much social and ecological benefit but its maintenance involves complex trade-offs between competing land uses.*

References

Bekessy, S.A., White, M., Gordon, A., Moilanen, A., McCarthy, M.A. and Wintle, B.A. (2012). Transparent planning for biodiversity and development in the urban fringe. *Landscape and Urban Planning,* 108: 140-149

Catford, J.A., Vesk, P.A., Richardson, D.M. and Pysek, P. (2012). Quantifying levels of biological invasion: towards the objective classification of invaded and invasible ecosystems. *Global Change Biology,* 18: 44-62

Gordon, A., Bastin, L., Langford, W.T., Lechner, A.M. and Bekessy, S.A. (2012) Simulating the value of collaboration in multi-actor conservation planning. *Ecological Modelling,* DOI: 10.1016/j.ecolmodel.2012.07.009

Ramalho, C.E. & Hobbs, R.J. (2012). Time for a change: dynamic urban ecology. *Trends in Ecology and Evolution,* 27: 179-188

Walsh, J. C., Venter, O., Watson, E.M., Fuller, R.A., Blackburn, T.M. and Possingham, H.P. (2012). Exotic species richness and native species endemism increase the impact of exotic species on islands. *Global Ecology and Biogeography,* 21: 841-850

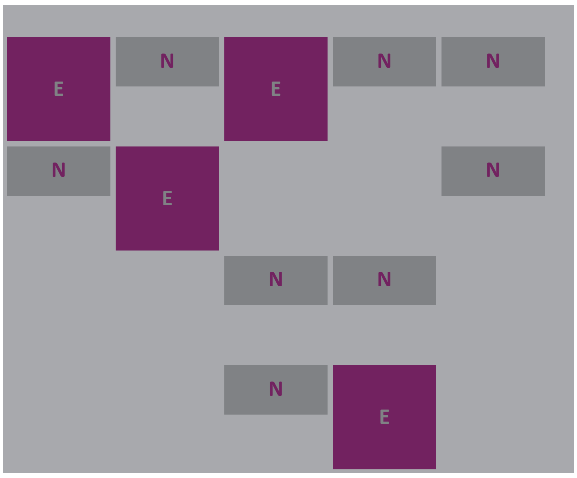
Case Study #1

Measuring invasion level to determine invasibility

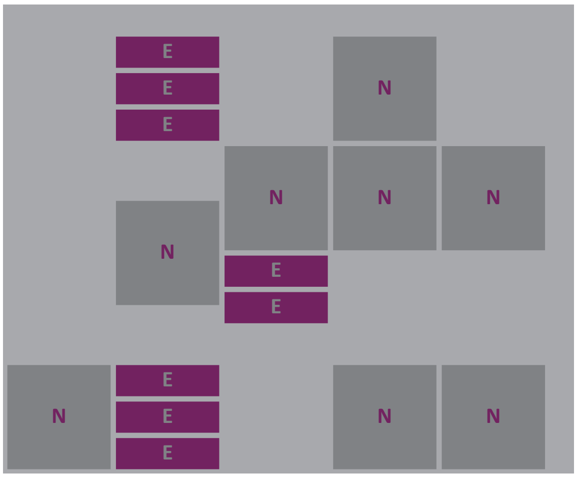
Assessing vulnerability to invasion

Biological invasions are a global phenomenon with multiple impacts. To date, research has primarily focused on the species that are doing the invading but CEED researcher Jane Catford believes there is much we can learn if we look at the properties of the systems that are being invaded. Invasibility is defined as the vulnerability of a habitat to invasion. Some ecosystems are considered more invasible than others but invasibility has rarely been quantified.

Figure C1 A: Two invaded ecosystems. Which is most invaded?



Ecosystem A *– Exotic species are 33% of total species. Exotics are 50% of total cover.*



Ecosystem B *– Exotic species are 50% of total species. Exotics are 25% of total cover.*

"A prerequisite for characterizing invasibility is the ability to compare levels of invasion across ecosystems," says Catford. "As simple as it may seem, there is no standard way to quantify the extent or severity of invasion: people use all sorts of different measures, which makes comparisons really difficult."

"Establishing a standard metric that indicates invasion level has many uses," says Catford. "Not only does it enable us to calculate invasibility, but it can help us assess ecological and economic risk and can be used to guide management.

"For example, if two ecosystems are invaded by a different suite of species, how can management resources be prioritized objectively if the net impact of invasion on the ecosystems is unknown? For example, in **Figure C1 A** which ecosystem, A or B, is most invaded? Ecosystem B contains more exotic species, but exotic species in Ecosystem A make up more cover.

A prerequisite for characterizing invasibility is the ability to compare levels of invasion across ecosystems. In this review we identified the best way to quantify the level of invasion by non-native animals and plants by assessing the advantages and disadvantages of different metrics."

Based on this review, Catford and colleagues recommended two invasion indices: relative alien species richness and relative alien species abundance. They then demonstrated how the indices can be used (see the box 'invasion of wetlands'). Relative alien species richness and relative alien species abundance indicate the contribution that alien species make to a community. They are easy to measure, can be applied to various taxa, are independent of scale and are comparable across regions and ecosystems. What's more, historical data are often available to feed into the analysis.

"The relationship between relative alien richness and abundance can indicate the presence of dominant alien species and the trajectory of invasion over time," says Catford. "It can highlight ecosystems and sites that are heavily invaded or especially susceptible to invasion. In so doing it can be used to inform spatial prioritisation of management decisions in a defensible and transparent way."

Establishing standard, transparent ways to define and quantify invasion level will facilitate meaningful comparisons among studies, ecosystem types and regions. It is essential for progress in ecology and will help guide ecosystem restoration and management.

A floodplain wetland in Victoria. The wetland here is covered by the invasive exotic *Sagittaria platyphylla* (arrowhead). How significant is the presence of this invader? Is this wetland more heavily invaded than other wetlands? Indices of invasion level provide us with a means to answer these questions regardless of the species in question.

> *"The relationship between relative alien richness and abundance can indicate the presence of dominant alien species and the trajectory of invasion over time.*

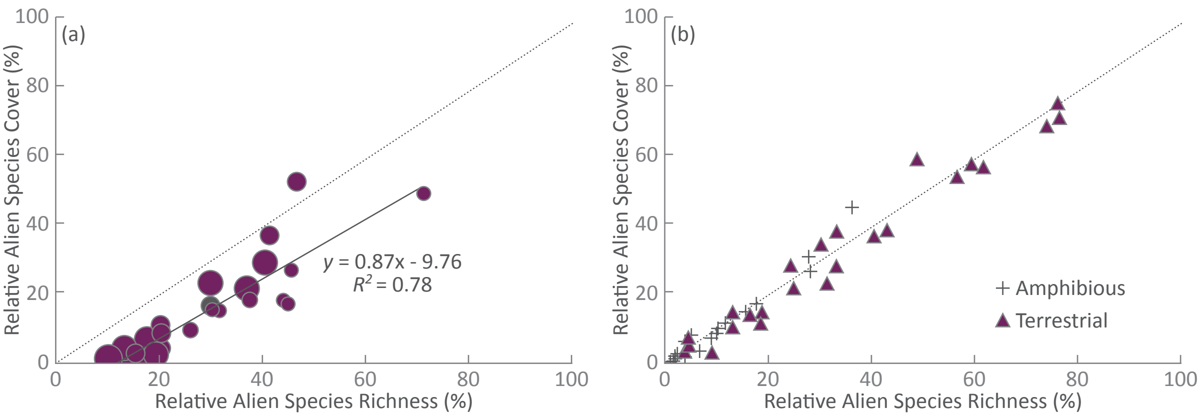
Invasion of wetlands

As an example of the utility of the invasibility index, the researchers applied it to 24 floodplain wetlands of the River Murray. The study used floristic data to calculate relative alien species richness and relative alien species abundance.

The line of best fit in **Figure C1 B** indicates that the relative contribution that alien species make to total vegetation cover is less than their contribution to total species richness. That is, in terms of cover, alien species 'punch below their weight' in all but one wetland.

Sites (or ecosystems) that are above the unity line should be of concern as the alien species present are contributing more cover than their native counterparts. Such an occurrence may indicate the presence of a strong, dominant invader in the community, which can be ascertained by examining specific information about species evenness.

Figure C1 B



Level of invasion in 24 riparian wetlands illustrated by (a) relative richness, cover and dominance of all alien species, and (b) relative richness and cover of two functional groups – amphibious and terrestrial alien species. (a) Size of the circles indicates Simpson's dominance index calculated using alien species only (range: 0.10–0.54; larger circles indicate wetlands where alien species cover is dominated by fewer species); black line is the line of best fit.

Theme C

Case Study #2

Restoration options for urban landscapes

Bringing together people and nature in the suburbs

Traditionally, the practice of ecological restoration in the suburbs has aimed to repair the 'altered nature' that exists in these landscapes. In a recent review of the options for ecological restoration led by CEED researcher Rachel Standish, it was proposed that there's a strong case for the broadening of restoration goals to better encompass the diversity of ecological as well as social values of urban nature. The hope is that restoration can serve a dual purpose in urban landscapes: to reconnect people with nature and to conserve biological diversity.

"The ecological values embedded within urban landscapes have received increasing attention from conservationists in recent decades," says Standish. "Ecological restoration emerged as a response to the need for biodiversity conservation in these spaces."

"Nature exists in many forms and people's responses to nature are similarly diverse. Goals for urban restoration can potentially reflect this variety of forms and responses. In our review, we focused on what we considered to be four broad options:

1. Conserve and restore nature at the fringes.
2. Restore remnant patches of urban nature.
3. Manage novel ecosystems.
4. Garden with iconic species for a sense of place.

"These options offer people multiple ways in which to engage with nature as well as providing opportunities for biodiversity conservation."

The first two options embody traditional approaches to conservation and restoration. They focus on 'repair' and 'preservation,' and are about returning historic ecosystems or setting some of these historic ecosystems aside in reserves.

Remnant patches of urban nature are the focus of most urban restoration efforts. In comparison to other cities of the world, Australian cities carry a high extinction debt and therefore restoration of remnant patches has a particularly important role to play in mitigating this debt. In some cases, the altered biophysical conditions of our cities may require high levels of management intervention to enable certain (relictual) species to persist. Such effort is likely to be deemed worthwhile if it were assessed on the basis of ecological as well as social values.

Managing novel ecosystems and gardening (options 3 and 4), represent strategies that are far from traditional (in terms of conservation) and are likely to be more controversial than the first two. Indeed, the idea that novel ecosystems – new combinations of species that arise due to environmental change, species invasion or both – might contribute to biodiversity conservation is likely to be unsettling to some people.

***Urban restoration** – Urban restoration gives people local opportunities to interact with nature. Proximity and 'cues to care', such as the plastic tree guards, are important determinants enabling people to derive benefits from nature.*

> *"There's a broadening of restoration goals to better encompass the diversity of ecological (as well as social) values of urban nature.*

Yet the increasing numbers of novel ecosystems in urban landscapes coupled with the challenge of pushing these systems back towards an historic-ecosystem target, are compelling reasons to re-think the options for their restoration.

Gardening is often considered separate from the practice of ecological restoration. However, in urban landscapes it is appropriate for gardening to be considered as a form of restoration given the potential for gardens to contribute to biodiversity conservation and for the activity to bring people into contact with nature.

"Urbanisation has undeniably resulted in the loss of native species worldwide," says Standish. "Yet cities are a space-efficient solution to meeting the needs of human society as well as being hotspots of human creativity. The challenge for the future is to design cities that optimise land use so as to meet the needs of people and nature.

"Ecological restoration can contribute to the sustainability of our cities and, at the same time, increase our understanding of the interactions between people and nature. And, with most of the world's human population now living in cities, the potential for urban nature to inspire people is perhaps greater than at any other time in history."

Case Study #3

The challenges of life on the fringe

Planning for biodiversity and development in the urban fringe

Biodiversity near and within urban areas brings many benefits but its maintenance involves complex trade-offs between competing land uses. That complexity can be challenging but CEED researchers are demonstrating how these trade-offs can be better described to facilitate more transparent, efficient and democratically derived urban planning.

"Conserving biodiversity in our urban fringes is not mission impossible," argues Sarah Bekessy, the CEED CI leading the research. "We have shown that efficient development solutions can be found that avoid areas important for biodiversity. And we have demonstrated how this can be done in the context of land use change across the city of Wyndham, a local government west of Melbourne."

The researchers used reserve design tools in a novel way to identify priority development sites. The approach is based on a synthesis of ecological, social and economic data. Then trade-offs between biodiversity conservation and other key development objectives were quantified. Other key development objectives included transport planning, flood risk and food production.

The process involves gathering data, identifying and weighting key values according to stakeholder preference, and modelling to produce visual representations of possible scenarios that have been optimized according to the chosen values.

"We're not saying this tool should be used to determine concrete planning outcomes," comments Bekessy. "However, our process can inform the decision-making process by generating options that satisfy a range of stated constraints. By explicitly identifying the biodiversity costs of particular urban planning options it's then possible to compare options in a transparent way.

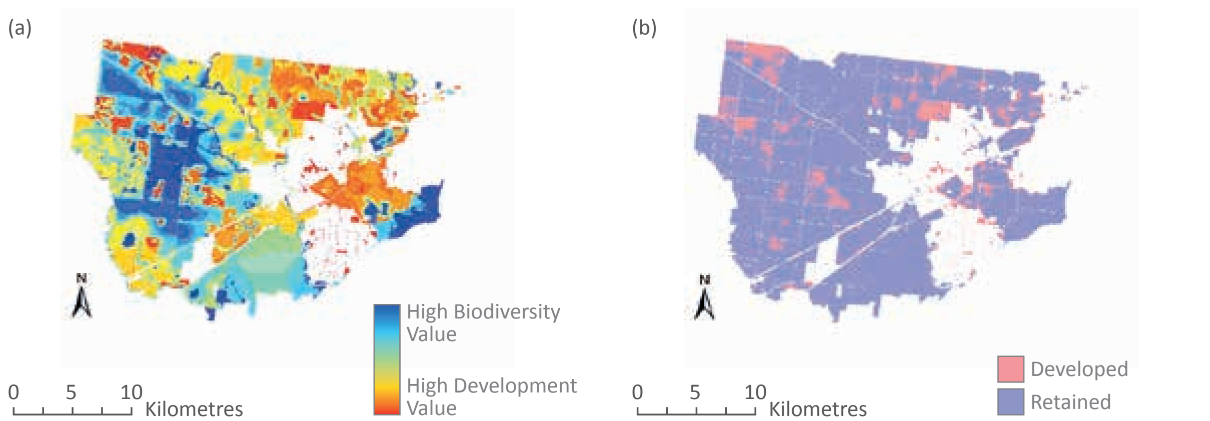
"By explicitly identifying the biodiversity costs of particular urban planning options it's then possible to compare options in a transparent way.

"Using our approach encourages decision-makers to rank priorities. The objective function for the optimization can be decided upon using a democratic process, whereby stakeholders openly debate and decide upon appropriate weightings for competing values.

"The tool provides powerful visual representations of the planning scenarios that can be used to integrate objectives and explore trade-offs (see **Figure C3).** The spatially explicit, visually compelling output from the model addresses an identified need in urban biodiversity planning."

While this tool provides a transparent mechanism for articulating trade-offs in urban planning, it does not indicate whether decisions are ultimately 'acceptable'. The decision to clear habitat to meet competing objectives is a social one, but should be made acknowledging the risks to environmental and other concerns.

Figure C3



A map of the study area showing its biodiversity value (a). Figure C3 (b) shows areas representing the lowest ranked 10% of the landscape in terms of biodiversity value. If biodiversity was your only consideration when it came to development then the areas in pink are places you would develop. Of course, in the urban zone there are many other considerations such as proximity to transport and flooding risk. The researchers explored multiple scenarios where these other considerations are also factored in to demonstrate it is possible optimise urban planning taking into account multiple considerations.

Communication

Publications

Books

1. Lindenmayer, DB, S Cunningham, and A Young (2012) Land Use Intensification: *Effects on Agriculture, Biodiversity, and Ecological Processes,* CSIRO Publishing, Melbourne & CRC Press, UK. p: 168.
2. Lindenmayer, DB, and P Gibbons (2012) *Biodiversity Monitoring in Australia,* CSIRO Publishing.,Melbourne. p: 210.

Book Chapters

3. Bode, M, and H Grantham (2012) Dynamic Programming IN: Hastings, A, and Louis Gross (Eds.), *Encyclopedia of Theoretical Ecology,* UC Press, Berkeley. p: 207-212.
4. Bode, M, and K A Wilson, and H P Possingham (2012) Biodiversity Hotspots IN: Craig, R K, and J C Nagle, and B Pardy, and O Scmitz, and W Smith (Eds.), *Encyclopedia of Sustainability: Ecosystem Management and Sustainability,* Berkshire Publishing Group, Barrington, USA.
5. Burgman, M, K Lowell, P Woodgate, S Jones, G Richards, and P Addison (2012) An endpoint hierarchy and process control charts for ecological monitoring IN: Lindenmayer, D, and P Gibbons (Eds.), *Biodiversity Monitoring in Australia,* CSIRO Publishing, Melbourne. p: 71-78.
6. Cunningham, SA, DH Duncan, and D Driscoll (2012) Land Use Intensification Impacts on Biodiversity in the mallee/wheat landscape of central NSW IN: Lindenmayer, DB, SA Cunningham, and A Young (Eds.), *Land Use Intensification: Effects on Agriculture, Biodiversity, and Ecological Processes,* CRC Press. http://www.publish.csiro.au/pid/6808.htm
7. Hobbs, RJ (2012) Cheerfulness and grumpiness in ecological monitoring in Australia IN: Lindenmayer, D, and P Gibbons (Eds.), Biodiversity Monitoring in Australia, CSIRO Publishing, Melbourne. p: 43-48.
8. Hobbs, RJ (2012) Environmental management and restoration in a changing climate IN: van Andel, J, and J Aronson (Eds.), Restoration Ecology: *The New Frontier,* 2nd edition, John Wiley & Sons Ltd. Chichester, UK. p: 23-29.
9. Lindenmayer, D (2012) Introduction: making monitoring happen - and then delivering on Australia's Biodiversity Conservation Strategy IN: Lindenmayer, D, and P Gibbons (Eds.), Biodiversity Monitoring in Australia, CSIRO Publishing, Melbourne. p: 1-4.
10. Lindenmayer, D (2012) Making monitoring up-front and centre in Australian biodiversity conservation IN: Lindenmayer, D, and P Gibbons (Eds.), *Biodiversity Monitoring in Australia,* CSIRO Publishing, Melbourne. p: 7-14.
11. Lindenmayer, D, and P Gibbons (2012) Can we make Biodiversity Monitoring happen in Australia? Moving beyond 'It's the thought that counts' IN: Lindenmayer, D, and P Gibbons (Eds.), *Biodiversity Monitoring in Australia,* CSIRO Publishing, Melbourne. p: 193-201.
12. Lindenmayer, DB (2012) Land use intensification in natural forest settings IN: Lindenmayer, DB, SA Cunningham, and A Young (Eds.), *Land Use Intensification: Effects on Agriculture, Biodiversity, and Ecological Processes,* CSIRO Publishing, Melbourne & CRC Press, UK. p: 113-122.
13. Lindenmayer, DB, S Cunningham, and A Young (2012) Land use intensification - a challenge for humanity IN: Lindenmayer, DB, SA Cunningham, and A Young (Eds.), *Land Use Intensification: Effects on Agriculture, Biodiversity, and Ecological Processes,* CSIRO Publishing, Melbourne & CRC Press, UK. p: 1-4.
14. Lindenmayer, DB, S Cunningham, and A Young (2012) Perspectives on land use intensification and biodiversity conservation IN: Lindenmayer, DB, SA Cunningham, and A Young (Eds.), *Land Use Intensification: Effects on Agriculture, Biodiversity, and Ecological Processes,* CSIRO Publishing, Melbourne & CRC Press, UK. p: 137-150.
15. McAlpine, CA, LM Seabrook, T Morrison, and JR Rhodes (2012) Chapter 2: Strengthening landscape ecology's contribution to a sustainable environment IN: Fu, B, and B Jones (Eds.), *Landscape Ecology for Sustainable Environment and Culture (Part I),* Springer, London.
16. McBride, MF, and MA Burgman (2012) What Is Expert Knowledge, How Is Such Knowledge Gathered, and How Do We Use It to Address Questions in Landscape Ecology? IN: Perera, AH, CA Drew, and CJ Johnson (Eds.), *Expert Knowledge and its Application in Landscape Ecology,* Springer, New York. p: 11-38.
17. Van Diggeln, R, RJ Hobbs, and L Miko (2012) Landscape ecology IN: van Andel, J, and J Aronson (Eds.), *Restoration Ecology: The New Frontier,* 2nd edition, John Wiley & Sons Ltd. Chichester, UK. p:45-58.

Journal Articles

Impact Factor greater than 15

18. Burrows, MT, DS Schoeman, CM Duarte, MI O'Connor, LB Buckley, CV Kappel, C Parmesan, BS Halpern, C Brown, KM Brander, JM Bruno, WJ Sydeman, P Moore, W Kiessling, AJ Richardson, and ES Poloczanska (2012) Invasive Species Unchecked by Climate Response. *Science,* 335 6068:538-539 - 2011 IF 31.201

19. Chow, SL, JE Lee, KA Hughes, J Barnes, PJ Barrett, DM Bergstrom, P Convey, DA Cowan, K Crosbie, G Dyer, Y Frenot, SM Grant, D Herr, MC II Kennicutt, M Lamers, A Murray, HP Possingham, K Reid, MJ Riddle, PG Ryan, L Sanson, JD Shaw, MD Sparrow, C Summerhayes, A Terauds and DH Wall (2012) Challenges to the Future Conservation of the Antarctic. *Science,* 337 6091:158-159 - 2011 IF 31.201

20. Hobbs, RJ (2012) Australia: better solutions to wildfires. *Nature,* 482 7386:471-471 - 2011 IF 36.280

21. Lindenmayer, DB, WF Laurance, and JF Franklin (2012) Global Decline in Large Old Trees. *Science,* 338 6112:1305-1306 - 2011 IF 31.201

22. Ramalho, CE, and RJ Hobbs (2012) Straw man or scaffolding? Building the foundations of urban ecology: a reply to McDonnell et al. T*rends in Ecology & Evolution,* 27 5:255-256 - 2011 IF 15.748

23. Ramalho, CE, and RJ Hobbs (2012) Time for a change: dynamic urban ecology. *Trends in Ecology & Evolution,* 27 3:179-188 - 2011 IF 15.748

24. Sutherland, WJ, R Aveling, L Bennun, E Chapman, M Clout, IM Cote, MH Depledge, LV Dicks, AP Dobson, L Fellman, E Fleishman, DW Gibbons, B Keim, F Lickorish, DB Lindenmayer, KA Monk, et al. (2012) A horizon scan of global conservation issues for 2012. T*rends in Ecology & Evolution,* 27 1:12-18 - 2011 IF 15.748

25. White, C, C Costello, BE Kendall, CJ Brown (2012) The value of coordinated management of interacting ecosystem services. *Ecology Letters,* 15 6:509-519 - 2011 IF 17.557

Impact Factor greater than 5 but less than 15

26. Barton, PS, SA Cunningham, AD Manning, H Gibb, DB Lindenmayer, and RK Didham (2012) The spatial scaling of beta diversity. *Global Ecology and Biogeography,* DOI: 10.1111/geb.12031

27. Biggs, R, M Schluter, D Biggs, EL Bohensky, S BurnSilver, G Cundill, V Dakos, TM Daw, LS Evens, K Kotschy, AM Leitch, C Meek, A Quinlan, C Raudsepp-Hearne, MD Robards, ML Schoon, L Schultz,and PC. West (2012) Toward Principles for Enhancing the Resilience of Ecosystem Services. *Annual Review of Environment and Resources,* 37:412-448

28. Brearley, G, J Rhodes, A Bradley, GL Baxter, Seabrook, D Lunney, Y Liu and C A McAlpine, (2012) Wildlife disease prevalence in human-modified landscapes. *Biological Reviews,* DOI: 10.1111/brv.12009

29. Brown, CJ, EA Fulton, HP Possingham, and AJ Richardson (2012) How long can fisheries management delay action in response to ecosystem and climate change? *Ecological Applications,* 22 1:298-310

30. Catford, JA, PA Vesk, DM Richardson, and P Pysek (2012) Quantifying levels of biological invasion: towards the objective classification of invaded and invasible ecosystems. *Global Change Biology,* 18 1:44-62

31. Chisholm, RA, and BA Wintle (2012) Choosing ecosystem service investments that are robust to uncertainty across multiple parameters. *Ecological Applications,* 22 2:697-704

32. Fordham, DA, HR Akcakaya, MB Araujo, J Elith, DA Keith, R Pearson, TD Auld, C Mellin, JW Morgan, TJ Regan, M Tozer, MJ Watts, M White, BA Wintle, C Yates, and BW Brook (2012) Plant extinction risk under climate change: are forecast range shifts alone a good indicator of species vulnerability to global warming? *Global Change Biology,* 18 4:1357-1371

33. Garrard, GE, MA McCarthy, NSG Williams, SA Bekessy, and BA Wintle (2012) A general model of detectability using species traits. *Methods in Ecology and Evolution,* 4 1:45-52

34. Kelly, LT, DG Nimmo, LM Spence-Bailey, RS Taylor, SJ Watson, MF Clarke, and AF Bennett (2012) Managing fire mosaics for small mammal conservation: a landscape perspective. *Journal of Applied Ecology,* 49 2:412-421

35. Klein, CJ, SD Jupiter, ER Selig, ME Watts, BS Halpern, M Kamal, C Roelfsema, and HP Possingham (2012) Forest conservation delivers highly variable coral reef conservation outcomes. E*cological Applications,* 22 4:1246-1256

36. Martinez, LM, RA Feagin, KM Yeager, J Day, R Costanza, JA Harris, RJ Hobbs, J Lopez-Portillo, IJ Walker, E Higgs, P Moreno-Casasola, J Sheinbaum, and A Yanez-Arancibia (2012) Artificial modifications of the coast in response to the Deepwater Horizon oil spill: quick solutions or long-term liabilities? *Frontiers in Ecology and the Environment,* 10 1:44-49

37. McBride, MF, ST Garnett, JK Szabo, AH Burbridge, SHM Butchart, L Christidis, G Dutson, HA Ford, RH Loyn, DM Watson, and MA Burgman (2012) Structured elicitation of expert judgments for threatened species assessment: a case study on a continental scale using email. *Methods in Ecology and Evolution,* DOI: 10.1111/j.2041-210X.2012.00221.x/full

38. Nimmo, DG, LT Kelly, LM Spence-Bailey, SJ Watson, A Haslem, JG White, MF Clarke, and AF Bennett (2012) Predicting the century-long post-fire responses of reptiles. *Global Ecology and Biogeography,* 21 11:1062-1073

39. Runting, R, KA Wilson, and JR Rhodes (2012) Does more mean less? The value of information for conservation planning under sea level rise. *Global Change Biology,* 19 2:352-363

40. Sutcliffe, PR, CR Pitcher, MJ Caley, and HP Possingham (2012) Biological surrogacy in tropical seabed assemblages fails. *Ecological Applications,* 22 6:1762-1771

41. Tscharntke, T, J.M. Tylianakis, T.A. Rand, R.K. Didham, L. Fahrig, B. Peter, J. Bengtsson, Y. Clough, T.O. Crist, C.F. Dormann, R.M. Ewers, J. Fruend, R.D. Holt, A. Holzschuh, A.M. Klein, D. Kleijn, C. Kremen, D.A. Landis, W. Laurance, D. Lindenmayer, C. Scherber, N. Sodhi, I. Steffan-Dewenter, C. Thies, W.H. Van der Putten, and C. Westphal (2012) Landscape moderation of biodiversity patterns and processes - eight hypotheses. *Biological Reviews,* 87 3:661-685

42. Walsh, JC, O Venter, JEM Watson, RA Fuller, TM Blackburn, and HP Possingham (2012) Exotic species richness and native species endemism increase the impact of exotic species on islands. *Global Ecology and Biogeography,* 21 8:841-850

43. Watson, SJ, RS Taylor, DG Nimmo, LT Kelly, A Haslem, MF Clarke, and AF Bennett (2012) Effects of time-since-fire on bird species: how informative are generalized fire-response curves for conservation management? *Ecological Applications,* 22 2:685-696

Impact Factor greater than 3 but less than 5

44. Barton, PS, SA Cunningham, DB Lindenmayer, and AD Manning (2012) The role of carrion in maintaining biodiversity and ecological processes in terrestrial ecosystems. *Oecologia,* DOI: 10.1007/s00442-012-2460-3

45. Bennett, JR, and P Arcese (2012) Human Influence and Classical Biogeographic Predictors of Rare Species Occurrence. *Conservation Biology,* DOI: 10.1111/cobi.12015

46. Bode, M, SR Connolly, JM Pandolfi (2012) Species Differences Drive Nonneutral Structure in Pleistocene Coral Communities. *American Naturalist,* 180 5:577-588

47. Bradstock, RA, GJ Cary, DB Lindenmayer, OF Price, and RJ Williams (2012) Wildfires, fuel treatment and risk mitigation in Australian eucalypt forests: Insights from landscape-scale simulation. *Journal of Environmental Management,* 10566-75

48. Brearley, G, CA McAlpine, S Bell, and A Bradley (2012) Influence of urban edges on stress in an arboreal mammal: a case study of squirrel gliders in southeast Queensland, Australia. *Landscape Ecology,* 27:1407-1419

49. Carwardine, J, T O'Connor, S Legge, B Mackey, HP Possingham, and TG Martin (2012) Prioritizing threat management for biodiversity conservation. *Conservation Letters,* 5 3:196-204

50. Crase, B, AC Liedloff, and BA Wintle (2012) A new method for dealing with residual spatial autocorrelation in species distribution models. *Ecography,* 35 10:879-888

51. Dexter, N, DSL Ramsey, C MacGregor, and DB Lindenmayer (2012) Predicting Ecosystem Wide Impacts of Wallaby Management Using a Fuzzy Cognitive Map. *Ecosystems,* 15 8:1363-1379

52. Di Marco, M, M Cardillo, HP Possingham, KA Wilson, SP Blomberg, L Boitani, and C Rondinini (2012) A novel approach for global mammal extinction risk reduction. *Conservation Letters,* 5 2:134-141

53. Driscoll, D, A Felton, P Gibbons, A Felton, N Munro, and DB Lindenmayer (2012) Priorities in policy and management when existing biodiversity stressors interact with climate-change. *Climatic Change,* 111 3:533-557

54. Elliott, CP, DB Lindenmayer, SA Cunningham, and AG Young (2012) Landscape context affects honeyeater communities and their foraging behaviour in Australia: implications for plant pollination. *Landscape Ecology,* 27 3:393-404

55. Garrard, GE, MA McCarthy, PA Vesk, JQ Radford, and AF Bennett (2012) A predictive model of avian natal dispersal distance provides prior information for investigating response to landscape change. *Journal of Animal Ecology,* 81 1:14-23

56. George, SJ, RJ Harper, RJ Hobbs, and M Tibbett (2012) A sustainable agricultural landscape for Australia: A review of interlacing carbon sequestration, biodiversity and salinity management in agroforestry systems. *Agriculture Ecosystems & Environment,* 163:28-36

57. Gustafsson, L, SC Baker, J Bauhus, WJ Beese, A Brosie, J Kouki, DB Lindenmayer, A Lohmus, G Martinez Pastur, C Messier, M Neyland, P Palik, A Sverdrup-Thygeson, WJA Volney, A Wayne, and JF Franklin (2012) Retention Forestry to Maintain Multifunctional Forests: A World Perspective. *BioScience,* 62 7:633-645

58. Haslem, A, SC Avitabile, RS Taylor, LT Kelly, SJ Watson, DG Nimmo, SA Kenny, KE Callister, LM Spence-Bailey, AF Bennett, and MF Clarke (2012) Time-since-fire and inter-fire interval influence hollow availability for fauna in a fire-prone system. *Biological Conservation,* 152:212-221

59. Ikin, K, E Knight, DB Lindenmayer, J Fischer, and AD Manning (2012) The influence of native versus exotic streetscape vegetation on the spatial distribution of birds in suburbs and reserves. *Diversity and Distributions,* DOI: 10.1111/j.1472-4642.2012.00937.x

60. Lechner, AM, WT Langford, SA Bekessy, and SD Jones (2012) Are landscape ecologists addressing uncertainty in their remote sensing data? *Landscape Ecology,* 27 9:1249-1261

61. Lindenmayer, DB, and SA Cunningham (2012) Six principles for managing forests as ecologically sustainable ecosystems. *Landscape Ecology,* DOI: 10.1007/s10980-012-9720-9

62. Lindenmayer, DB, AR Northrop-Mackie, R Montague-Drake, M Crane, D Michael, S Okada, and P Gibbons (2012) Not All Kinds of Revegetation Are Created Equal: Revegetation Type Influences Bird Assemblages in Threatened Australian Woodland Ecosystems. *PLoS ONE,* 7 4:e34527. DOI: 10.1371/journal.pone.0034527

63. Lindenmayer, DB, C Zammit, SJ Attwood, E Burns, CL Shepherd, G Kay, and J Wood (2012) A Novel and Cost-Effective Monitoring Approach for Outcomes in an Australian Biodiversity Conservation Incentive Program. *PLoS ONE,* 7 12:e50872. DOI: 10.1371/journal.pone.0050872

64. Lindenmayer, DB, J Wood, R Montague-Drake, D Michael, M Crane, S Okada, C MacGregor, and P Gibbons (2012) Is biodiversity management effective? Cross-sectional relationships between management, bird response and vegetation attributes in an Australian agri-environment scheme. *Biological Conservation,* 152:62-73

65. Lindenmayer, DB, JF Franklin, A Lohmas, SC Baker, J Bauhaus, W Beese, A Brodie, B Kiehl, J Kouki, G Martinez Pastur, C Messier, M Neyland, B Palik, A Sverdrup-Thygeson, J Volney, A Wayne, and L Gustafsson (2012) A major shift to the retention approach for forestry can help resolve some global forest sustainability issues. *Conservation Letters,* 5 6:421-431

66. Lindenmayer, DB, KB Hulvey, RJ Hobbs, M Colyvan, A Felton, HP Possingham, W Steffen, KA Wilson, K Youngentob, and P Gibbons (2012) Avoiding bio-perversity from carbon sequestration solutions. *Conservation Letters,* 5 1:28-36

67. Lindenmayer, DB, W Blanchard, L McBurney, D Blair, S Banks, GE Likens, JF Franklin, WF Laurance, JAR Stein, and P Gibbons (2012) Interacting Factors Driving a Major Loss of Large Trees with Cavities in a Forest Ecosystem. *PLoS ONE,* 7 10:e41864. DOI: 10.1371/journal.pone.0041864

68. Maron, M, RJ Hobbs, A Moilanen, JW Matthews, C Christie, TA Gardener, DA Keith, DB Lindenmayer, and CA McAlpine (2012) Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biological Conservation,* 155:141-148

69. Martin, TG, MA Burgman, F Fidler, PM Kuhnert, S Low-Choy, M McBride, and K Mengersen (2012) Eliciting Expert Knowledge in Conservation Science. *Conservation Biology,* 26 1:29-38

70. Martin, TG, S Nally, AA Burbidge, S Arnall, ST Garnett, MW Hayward, LF Lumsden, P Menkhorst, E McDonald-Madden, and HP Possingham (2012) Acting fast helps avoid extinction. *Conservation Letters,* 5 4:274-280

71. Moir, ML, PA Vesk, KEC Brennan, R Poulin, L Hughes, DA Keith, MA McCarthy, and DJ Coates (2012) Considering Extinction of Dependent Species during Translocation, Ex Situ Conservation, and Assisted Migration of Threatened Hosts. *Conservation Biology,* 26 2:199-207

72. Nicholson, E, B Collen, A Barausse, JL Blanchard, BT Costelloe, KME Sullivan, FM Underwood, RW Burn, S Fritz, JPG Jones, L McRae, HP Possingham, and EJ Milner-Gulland (2012) Making Robust Policy Decisions Using Global Biodiversity Indicators. *PLoS ONE,* 7 7:e41128. DOI: 10.1371/journal.pone.0041128

73. Perringa, MP, RJ Standish, KB Hulvey, L Lacha, TK Moralda, R Parsons, RK Didham, and RJ Hobbs (2012) The Ridgefield Multiple Ecosystem Services Experiment: Can restoration of former agricultural land achieve multiple outcomes? *Agriculture Ecosystems & Environment,* 163 1:14-27

74. Pollock, LJ, WK Morris, and PA Vesk (2012) The role of functional traits in species distributions revealed through a hierarchical model. *Ecography,* 35 8:716-725

75. Smith, AL, CM Bull, and DA Driscoll (2012) Post-fire succession affects abundance and survival but not detectability in a knob-tailed gecko. *Biological Conservation,* 145 1:139-147

76. Solow, A, W Smith, M Burgman, T Rout, BA Wintle, and D Roberts (2012) Uncertain Sightings and the Extinction of the Ivory-Billed Woodpecker. *Conservation Biology,* 26 1:180-184

77. Thompson, CJ, RM Cannon, and MA Burgman (2012) Surveillance for threatened and invasive species when uncertainty is severe. *Diversity and Distributions,* 18 4:410-416

78. Tingley, R, and S Dubey (2012) Disparity in the timing of vertebrate diversification events between the northern and southern hemispheres. *BMC Evolutionary Biology,* 12:244. DOI: 10.1186/1471-2148-12-244

79. Venter, O, HP Possingham, L Hovani, S Dewi, B Griscom, G Paoli, P Wells, and KA Wilson (2012) Using systematic conservation planning to minimize REDD+ conflict with agriculture and logging in the tropics. *Conservation Letters,* DOI: 10.1111/j.1755-263X.2012.00287.x

80. Westgate, M, DA Driscoll, and DB Lindenmayer (2012) Limited influence of stream networks on the terrestrial movements of three wetland-dependent frog species. *Biological Conservation,* 153169-176

81. Wintle, BA, TV Walshe, KM Parris, and MA McCarthy (2012) Designing occupancy surveys and interpreting non-detection when observations are imperfect. *Diversity and Distributions,* 18 4:417-424

Impact Factor less than 3

82. Bekessy, SA, M White, A Gordon, A Moilanen, MA McCarthy, and BA Wintle (2012) Transparent planning for biodiversity and development in the urban fringe. *Landscape and Urban Planning,* 108 2-4:140-149

83. Bennett, VA, VA Doerr, ED Doerr, AD Manning, and DB Lindenmayer (2012) The anatomy of a failed reintroduction: a case study with the Brown Treecreeper. *Emu,* 112 4:298-312

84. Biggs, D, NC Ban, and CM Hall (2012) Lifestyle values, resilience, and nature-based tourism's contribution to conservation on Australia's Great Barrier Reef. *Environmental Conservation,* 39 4:1-10

85. Bode, M, PR Armsworth, HE Fox, and L Bode (2012) Surrogates for reef fish connectivity when designing marine protected area networks. *Marine Ecology-Progress Series,* 466:155-166

86. Boyce, MS, PWJ Baxter, and HP Possingham (2012) Managing moose harvests by the seat of your pants. *Theoretical Population Biology,* 82 4:340-347

87. Canessa, S, GW Heard, KM Parris, and MA McCarthy (2012) Integrating variability in detection probabilities when designing wildlife surveys: a case study of amphibians from south-eastern Australia. *Biodiversity and Conservation,* 21 3:729-744

88. Chalak, M, and DJ Pannell (2012) Optimising control of an agricultural weed in sheep-production pastures. *Agricultural Systems,* 109:1-8

89. Clements, GR, DM Rayan, SA AZIZ, K Kawanishi, C Traeholt, D Magintian, MFA Yazi, and R Tingley (2012) Predicting the distribution of the Asian tapir in Peninsular Malaysia using maximum entropy modeling. *Integrative Zoology,* 7 4:400-406

90. Driscoll, D, AL Smith, S Blight, and J MainDonald (2012) Reptile responses to fire and the risk of post-disturbance sampling bias. *Biodiversity and Conservation,* 21 6:1607-1625

91. Giakoumi, S, T Mazor, S Fraschetti, S Kark, M Portman, M Collen, J Steenbeck, and HP Possingham (2012) Advancing marine conservation planning in the Mediterranean Sea. *Reviews in Fish Biology and Fisheries,* 22 4:943-949

92. Gordon, A, BA Wintle, SA Bekessy, JL Pearce, LA Venier, and JN Wilson (2012) The use of dynamic landscape metapopulation models for forest management: a case study of the red-backed salamander. *Canadian Journal of Forest Research-Revue Canadienne de Recherche Forestière,* 42 6:1091-1106

93. Grantham, ME, DA Newburn, MA McCarthy, and AM Merenlender (2012) The role of stream flow and land use in limiting oversummer survival of juvenile steelhead trout in California streams. *Transactions of the American Fisheries Society,* 141:585-598

94. Gustavo, SMA, and JR Rhodes (2012) Protected Areas and Local Communities: an Inevitable Partnership Successful Conservation Strategies? *Ecology and Society,* 17 4:14-

95. Jarrad, FC, T Walshe, YE Chee, and MA Burgman (2012) A test of biotic interactions among two alpine plant species in Australia. *Austral Ecology,* 37 1:90-96

96. Kragt, ME, DJ Pannell, MJ Robertson, and T Thamo (2012) Assessing costs of soil carbon sequestration by crop-livestock farmers in Western Australia. *Agricultural Systems,* 112:27-37

97. Lechner, AM, WT Langford, SD Jones, SA Bekessy, and A Gordon (2012) Investigating species-environment relationships at multiple scales: Differentiating between intrinsic scale and the modifiable areal unit problem. *Ecological Complexity,* 11:91-102

98. Likens, GE, and DB Lindenmayer (2012) Integrating approaches leads to more effective conservation of biodiversity. *Biodiversity and Conservation,* 21 13:3323-3341

99. Lindenmayer, DB, GE Likens, A Andersen, B Bowman, CM Bull, E Burns, CR Dickman, AA Hoffmann, DA Keith, MJ Liddell (2012) Value of long-term ecological studies. *Austral Ecology,* 37 7:745-757

100. Manning, AD, P Gibbons, J Fischer, DL Oliver, and DB Lindenmayer (2012) Hollow futures? Tree decline, lag effects and hollow-dependent species. *Animal Conservation,* DOI: 10.1007/s10980-012-9720-9

101. Miyake, S, M Renouf, A Peterson, CA McAlpine, and C Smith (2012) Land-use and environmental pressures resulting from current and future bioenergy crop expansion: A review. *Journal of Rural Studies,* 28 4:650-658

102. Moir, ML, and E Guilbert (2012) *Swaustraltingis Isobellae,* a new genus and new species of Australian lacebug (Insecta: Heteroptera: Tingidae), with a redescription of *Cysteochila cracentis Drake,* and notes on the lacebug fauna of south-west Australia. *Australian Journal of Entomology,* 51 4:258-265

103. Moir, ML, PA Vesk, KEC Brennan, L Hughes, DA Keith, MA McCarthy, DJ Coates, and S Barrett (2012) A preliminary assessment of changes in plant-dwelling insects when threatened plants are translocated. *Journal of Insect Conservation,* 16 3:367-377

104. Munro, NT, J Fischer, J Wood, and DB Lindenmayer (2012) Assessing ecosystem function of restoration plantings in south-eastern Australia. *Forest Ecology and Management,* 282:36-45

105. Pannell, DJ (2012) Environment protection: challenges for future farming. *Agricultural Economics,* 8 2:19-26

106. Qiu, S, W Bell, RJ Hobbs, and AJ McComb (2012) Estimating nutrient budgets for prescribed thinning in a regrowth eucalyptus forest in south-west Australia. *Forestry,* 85 1:51-61

107. Sharafi, SM, M White, and M Burgman (2012) Implementing comprehensiveness, adequacy and representativeness criteria (CAR) to indicate gaps in an existing reserve system: A case study from Victoria, Australia. *Ecological Indicators,* 18 July:342-352

108. Walsh, JC, KA Wilson, J Benshemesh, and HP Possingham (2012) Integrating research, monitoring and management into an adaptive management framework to achieve effective conservation outcomes. *Animal Conservation,* 15 4:334-336

109. Watson, SJ, RS Taylor, DG Nimmo, LT Kelly, MF Clarke, and AF Bennett (2012) The influence of unburnt patches and distance from refuges on post-fire bird communities. *Animal Conservation,* 15 5:499-507

110. Williams, JR, DA Driscoll, and CM Bull (2012) Roadside connectivity does not increase reptile abundance or richness in a fragmented mallee landscape. *Austral Ecology,* 37 3:383-391

No Impact Factor currently registered with ISI Web of Science

111. Grafton, QR, J Pittock, R Richard, J Williams, G Fu, M Warburton, B Udall, R McKenzie, X Yu, N Che, D Connell, Q Jiang, T Kompas, A Lynch, R Norris, HP Possingham, and J Quiggin (2012) Global insights into water resources, climate change and governance. *Nature Climate Change,* DOI: 10.1038/nclimate1746

112. Grantham, HS, VN Agostini, J Wilson, S Mungubhai, N Nidayat, A Muljadi, C Rotinsulu, M Mongdong, MW Beck, and HP Possingham (2012) A comparison of zoning analyses to inform the planning of a marine protected area network in Raja Ampat, Indonesia. *Marine Policy,* 38 38:184-194

113. Ikin, K, E Knight, DB Lindenmayer, J Fischer, and AD Manning (2012) Linking bird species traits to vegetation characteristics in a future urban development zone: implications for urban planning. *Urban Ecosystems,* 15 4:961-977

114. Law, EA, S Thomas, E Meijaard, PJ Dargusch, and KA Wilson (2012) A modular framework for management of complexity in international forest-carbon policy. *Nature Climate Change,* 2 3:155-160

115. Michael, DR, and DB Lindenmayer (2012) Vegetation structure and floristics of granite landforms in the South-west Slopes of New South Wales. *Cunninghamia,* 12 4:309-323

116. Moir, ML, and B Lis (2012) Description of three new species of *Ceratocader* (Hemiptera: Heteroptera: Tingidae) from Western Australia. *Records of the Western Australian Museum,* 27 2:148-155

117. Ponce-Reyes, R, VH Reynoso-Rosales, JEM Watson, J Van Der Wal, RA Fuller, RL Pressey, and HP Possingham (2012) Vulnerability of cloud forest reserves in Mexico to climate change. *Nature Climate Change,* 2:448-452

118. Rodríguez, JP, KM Rodríguez-Clark, DA Keith, EG Barrow, J Benson, E Nicholson, and P Wit (2012) IUCN Red List of Ecosystems. *SAPIENS* [online], 5 2:http://sapiens.revues.org/1286

119. Watson, SJ, RS Taylor, L Spence-Bailey, DG Nimmo, S Kenny, LT Kelly, A Haslem, P Griffioen, K Callister, L Brown, S Avitabile, AF Bennett, and MF Clarke (2012) The Mallee Fire And Biodiversity Project. *Proceedings of the Royal Society of Victoria,* 124 1:38-46

120. Williams, RJ, CH Wahren, JM Shannon, WA Papst, DA Heinze, and JS Camac (2012) Fire Regimes and Biodiversity in Victoria's Alpine Ecosystems. *Proceedings of the Royal Society of Victoria,* 124 1:101-109

Report

121. Fernandes, L, A Green, J Tanzer, A White, PM Alino, J Jompa, P Lokani, A Soemodinoto, M Knight, B Pomeroy, HP Possingham, and B Pressey (2012) Biophysical principles for designing resilient networks of marine protected areas to integrate fisheries, biodiversity and climate change objectives in the Coral Triangle. *Report prepared by The Nature Conservancy for the Coral Triangle Support Partnership,* 152 pp.

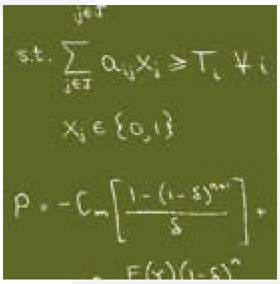
Events

Hugh Possingham opens an 'Introduction-to-Marxan' course at the University of Queensland.

A Red List of Ecosystems

CEED Workshop, The University of Melbourne, May 2012

CEED workshop participants at The University of Melbourne



In May, some 32 people from around the world met at the School of Botany, University of Melbourne, at a CEED-sponsored workshop on the IUCN Red List of Ecosystems.

> *It was a very successful workshop, with many fruitful and constructive discussions.*

The focus of the workshop was on applying the draft IUCN criteria to marine systems, defining collapse (analogous to extinction for species), and developing ways of assessing change in ecological function as they move towards collapse.

Outputs will include new collaborations and papers reviewing conceptual and quantitative models for understanding change in function and framing assessment, and exploring the definition of collapse.

This research will help underpin further development of criteria for the IUCN Red List of Ecosystems.

Integrating land-sea conservation planning

CEED Workshop, Lady Elliot Island, June 2012

What are the trade-offs between equity and conservation? How are ecosystem services and marine biodiversity impacted by coastal road developments? What are the impacts of land-use plans on fisheries?

These are all issues connecting land-based activity with marine conservation, and they are all challenges currently being confronted by the countries in the Coral Triangle.

These issues and more were the focus of a small CEED workshop in June held on Lady Elliot Island on integrating terrestrial processes into marine conservation planning.

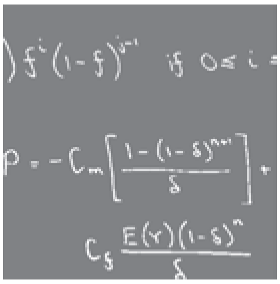
The workshop was exceptionally productive with the discussions and planning driven by real-world conservation problems relevant to the Coral Triangle. For example, the researchers discussed how to help prioritise land-uses that cost-effectively benefit marine ecosystems in Indonesia (in collaboration with Conservation International) and Papua New Guinea (in collaboration with the Wildlife Conservation Society and The Nature Conservancy).

Tackling the land-sea interface at the workshop were (from left to right) back row: Ben Halpern (NCEAS, UCSB), Mary Ruckelshaus (Stanford), Chris Brown (UQ), Viv Tulloch (UQ), Hedley Grantham (CI); front row: Hugh Possingham (UQ), Crow White (UCSB), Maria Beger (UQ) and Carissa Klein (UQ).

Mathematical & Computational Biology - Winter School

University of Queensland, 2 – 6 July 2012

> *This cross-centre cooperation highlights the significance of CEED and its willingness to collaborate with people and organisations in fields of common interest.*



Four CEED personnel participated in a winter school hosted by the ARC Centre of Excellence in Bioinformatics at the University of Queensland from the 2nd to the 6th of July 2012.

The five-day symposium was attended by 280 people (including 145 students) plus 30 Speakers. CEED speakers, coordinated by CEED CI Eve McDonald-Madden, presented a day introducing the mathematics and ecology of environmental modeling and decision-making.

CEED-related presentations received very positive quantitative feedback so we have been invited to coordinate another day for July 2013.

2012 World Conference on Natural Resource Modeling

University of Queensland, 9 – 12 July 2012

CEED co-hosted this annual international conference in Brisbane where eighteen CEED Researchers gave presentations. CEED Chief Investigator Dr Michael Bode and Partner Investigator Professor E.J. Milner-Gulland (Imperial College) both delivered keynote presentations. Sixty-eight delegates from 12 institutions (from Australia and overseas) participated in the conference, and the event was rated as extremely successful. CEED PhD candidates Abbey Camaclang and Tomas Bird were awarded prizes in the student presentation competition.

Matt Watt goes over an exercise with Azusa Makino during the 'Train the Trainer' course.

Marxan Training Courses

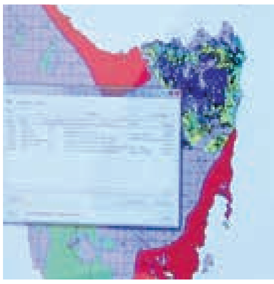
University of Queensland, July 2012

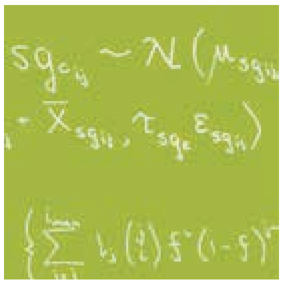
In July CEED co-sponsored two Marxan courses at UQ's St Lucia campus – one for beginners and one for experienced users wanting to achieve more with Marxan by becoming a trainer.

Marxan is the primary tool that governments and non-government organisations use to prioritise the location of reserves and national parks - with over 2,000 users from more than 100 countries (and at least 1,200 organisations).

A big part of Marxan's success is its committed community of users, which provides technical support for Marxan users and generates a constant stream of innovative new ways of using Marxan. This generates new theory and leads to software modification.

CEED invests in that community by training people to train others in how to use Marxan. At the University of Queensland a 'Train the Trainer' course is run every time an 'Introduction to Marxan' workshop is held.





Workshop Summary

A summary of workshops conducted throughout 2012.

2012 Workshops

Workshop Name	Convenor(s)	Location of Workshop
Borneo futures project workshop	Kerrie Wilson	University of Queensland
Collaboration in conservation	Salit Kark	The Hebrew University of Jerusalem
Advancing conservation planning in the Mediterranean Sea	Sylvaine Giakoumi	Santorini, Greece
Woody plant regeneration and thinning	Peter Vesk	Glen Erin Retreat Victoria
What are species distribution models for? (workshop 2)	Antoine Guisan	Dockside Hotel, Brisbane
Red list criteria for ecosystems	Emily Nicholson	University of Melbourne
What are species distribution models for? (workshop 3)	Antoine Guisan	UQ Business School, Brisbane
Conserving migratory species	Richard Fuller	Powerhouse Museum, Brisbane
Marine planning in the Coral Triangle	Carissa Klein	Lady Elliot Island, Queensland
Threat mapping and conservation decision-making	Ayesha Tulloch	University of Queensland
Community modelling in conservation planning (workshop 1)	Patricia Sutcliffe	University of Queensland
Scoping workshop metapopulation management	Eve McDonald-Madden	University of Queensland
Marxan train the trainer course	Matthew Watts	University of Queensland St Lucia
Introduction to Marxan course	Matthew Watts	University of Queensland St Lucia
CEED collaboration workshop	Salit Kark	Stradbroke Island, Queensland
Community modelling in conservation planning (workshop 2)	Patricia Sutcliffe	University of Queensland
Adaptive management workshop	Eve McDonald-Madden/ Brendan Wintle	UQ Business School, Brisbane
Species' intrinsic life history traits and how they relate to climate change vulnerability	Nathalie Butt	University of Queensland
Inserting functional connectivity into systematic conservation planning	Renato Crouzeilles	University of Queensland
CEED project prioritisation protocol analysis	Ayesha Tulloch	Stradbroke Island, Queensland
Dynamic social, economic and institutional feedbacks and biodiversity conservation	Jonathan Rhodes	Hotel Urban, Brisbane
Marxan train the trainer course	Matthew Watts	University of Queensland
Introduction to Marxan course	Matthew Watts	University of Queensland
Innovative Modelling methods for resource management in rural areas	Graeme Doole	Hamilton New Zealand

Media

The Centre has had a substantial media presence in radio, TV and print media with increases in coverage across all media outlet types, and an increased presence in web-based media.

CEED chief investigators featured in 350 different stories relevant to environmental decision-making. A "story" is defined as a unique report in any media, even if it relates to previous reports. This is a large increase from 56 stories in 2011, even considering that the 2011 Annual Report only covered 6 months. Because many of these reports were in syndicated media, where the same story is reported across subsidiaries of a media outlet, stories in 2012 were reported around 1,654 times.

This has been partly due to the appointment of Julian Cribb & Associates to assist us in creating and distributing media releases. As well as ensuring our research was well reported, we focused on getting a greater breadth of our researchers into the media, in particular students and early-career researchers. Some media highlights are presented below.

CEED Researcher(s)	Media Article Brief	Report coverage	Audience circulation (approx.)
19 January			
Dr Phil Gibbons (ECR)	"Prescribed burning is not the best way to protect homes from the ravages of severe bushfires as is widely believed. Reducing fuel near houses is more effective, say Australian and US bushfire experts who analysed the impact on 499 homes of Victoria's devastating bush fires."	*The Australian*	133,000
1 March			
Dr Michael Bode (ECR)	"Dr Bode explains how computers can be used to model reef-fish populations. Computer modeling is used to transfer numerological data into visual patterns that can be more easily understood."	City and regional TV coverage in all states; reported 31 times.	231,000
April & August			
Dr Clive McAlpine	"Koala populations in Australia have crashed and many experts believe they will all but vanish within 50 years. "There'll be small remnants hanging on," says Clive McAlpine, University of Queensland ecologist and spokesman for the Koala Research Network."	45 reports including ABC's *Four Corners* & Ten TV syndicate.	958,700
27 April			
Prof. David Lindenmayer	"Professor David Lindenmayer from Australian National University (ANU) says farmers should support the regrowth and planting of native trees on their properties to encourage the return of native woodland bird species."	156 radio stations around Australia reported this.	Radio circulation not specified. Print: 230,000
8 May			
Prof. Hugh Possingham	"The ARC Centre for Excellence for Environmental Decisions has called for all levels of government to prioritise national parks. Hugh Possingham from the Centre says parks are suffering as authorities cannot maintain them all."	144 reports; radio & print.	1,034,800

CEED Researcher(s)	Media Article Brief	Report coverage	Audience circulation (approx.)
18 August			
Dr Anthony Richardson	"Scientists claim to have solid proof that climate change is causing havoc with our oceans and fragile marine life. A rise in ocean temperature is causing tropical fish to head south. Experts agree it is time for Australia to adapt."	Reported via TV, radio & digital media 194 times.	1,422,000
5 September			
Dr Maria Beger (ECR & CEED ECR funding recipient)	"A team of marine scientists from the country [Indonesia], Netherlands and Australia will begin an expedition in the proposed Tun Mustapha Park, of Kudat, to assess aspects of marine biodiversity and ecology, as well as the socio-economic benefits of the marine ecosystems to local communities in the proposed park."	International news; reported in the *Daily Express, Borneo Post* and *See Hua Daily News*, Indonesia.	337,800
28 November			
Kate Grarock (PhD student)	"New research by the ARC Centre of Excellence for Environmental Decisions into the mynor bird shows the pest thrives in habitats that are far from hospitable."	Reported across 6 different radio stations on prime time news.	30,600
8 December			
Prof. David Lindenmayer	"Giant old trees are dying at an alarming rate due to human activity, fire and climate change, an ecologist says. The accelerated death rate of trees aged between 100 and 300 years seems to be a global problem in all types of forest (note – press release by Jullian Cribb & Assoc.)."	53, radio, printed & online.	1,774,600
26 December			
Prof. Hugh Possingham & Assoc. Prof. Michael McCarthy	"Making decisions about which species to save from extinction – discussions of triage."	Reported 9 times via ABC Radio, *Courier Mail* & local print media.	429,123

Decision Point

Decision Point: Australia's leading magazine on environmental decision science.

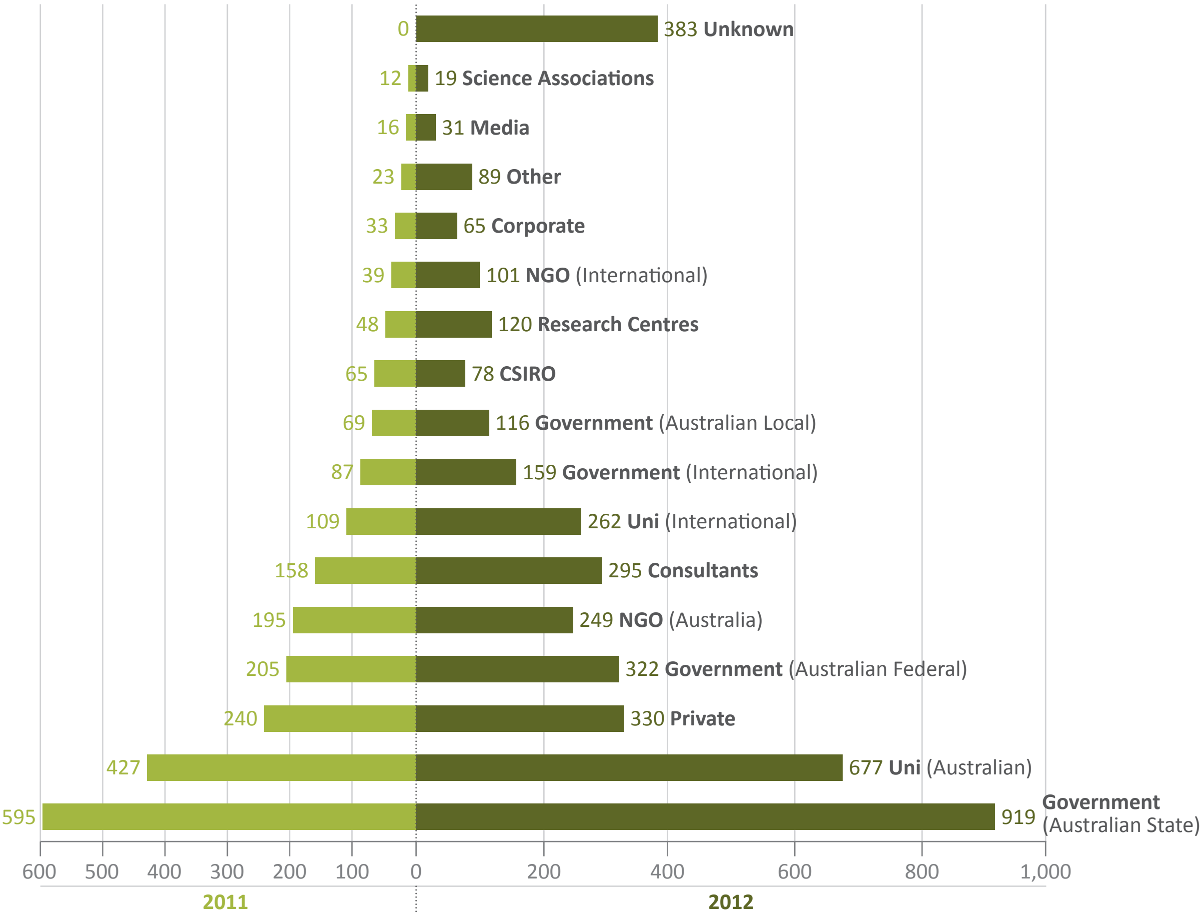
Effective decision making and the science that unpins it is crucial to conservation efforts. However, that science can often be complex, technical and even dry to engage with. CEED has overcome this through co-sponsoring our monthly magazine *Decision Point.* In 2012, we published another 10 issues, which are all available free to download via our web site **(www.decision-point.com.au).**

Our subscription increased from around 2,500 at the end of 2011, to just over 4,200 by the end of 2012 (with less than 20 unsubscribe requests). Our web site was viewed

> *Just a brief note to compliment the editors for putting together a fantastic edition of Decision Point.*
>
> Jamie, private subscriber, South Hobart

> *What would we do without our regular dose of challenging articles from Decision Point? I love it.*
>
> Judy, Community Solutions

Decision Point Subscribers by Sector



Number of Subscribers by Sector (years ending December)

43,092 times, with 24,758 of these views being directed from our home page. Whilst the majority of downloads were within Australia, 23% of our readership is from elsewhere around the globe .

> *Decision Point would have to be the most relevant and insightful publication I receive. The coverage of issues is excellent, the content innovative and the research findings are incredibly useful in my everyday work.*
>
> Kirsti, Southern Rivers CMA

We love creating *Decision Point* and have made modifications to the web site to facilitate download of all our past issues, and easy access to all stories through a full-content search engine.

We feel *Decision Point* is crucial in bringing CEED's research to other researchers, environmental managers and decision makers in Australia and internationally, and are delighted that our readers feel the same way.

> *A lot of research centres have on-line newsletters and feeds that synthesise and break-down their research into useable and digestible chunks – an absolutely essential function given how time poor us readers and end users are.*
>
> *That said, Decision Point does this in a captivating and enticing format and manner that is head and shoulders above the rest.*
>
> *Frankly, Decision Point is one of the only newsletters I receive that I prioritise reading, and I do this because the content is captivating, and the format makes it easy to understand and digest the huge amount of information.*
>
> *Cross referencing to past issues and the thematic focus of each issue is very reader-friendly.*
>
> *You and your team are to be congratulated on what is truly an exceptional product.*
>
> Andrew, Great Barrier Reef Marine Park Authority

Decision Point, Issue #65, November 2012.

> *Decision Point seems to be a place to find quick answers for everyday questions for managers. That will be very useful!*
>
> Giselda, Projeto Manejar è Preciso, Instituto Florestal, Brazil

Performance Indicators

Selected Performance Indicators

The performance indicators listed below are specific to CEED and are indicative of the progress of the Centre during its first full year in operation.

Research Findings

Performance Measure	Reporting Frequency	2011 Target	2012 Target	Achieved 2012
Number of research outputs – peer reviewed publications	Annually	45	55	122

Research Training and Professional Education

Performance Measure	Reporting Frequency	2011 Target	2012 Target	Achieved 2012
Number of attended professional training courses for staff and students	Annually	12	15	19
Number of Centre attendees at all professional training courses	Annually	40	60	50
Number of new postdoctoral researchers recruited to the Centre working on core Centre research	Annually	12	6	20
Number of Early Career Researchers (within five years of completing PhD) **working on core Centre research**	Annually	10	15	40
Number of students mentored	Annually	50	50	114
Number of mentoring programs	Annually	1	1	5

International, National and Regional Links and Networks

Performance Measure	Reporting Frequency	2011 Target	2012 Target	Achieved 2012
Number of international visitors and visiting fellows (for more than 10 days)	Annually	10	10	19
Number of other international visitors and visiting fellows	Annually	20	20	46
Number of national and international workshops held/organised by the Centre	Annually	8	10	38
Number of visits to overseas laboratories and facilities (for 10 days or more)	Annually	10	15	31
Number of short visits to overseas laboratories and facilities	Annually	20	30	46

End-user Links

Performance Measure	Reporting Frequency	2011 Target	2012 Target	Achieved 2012
Memberships of national and international boards and advisory committees	Annually	20	20	53
Number of government, industry and business community briefings	Annually	20	20	83

Centre-specific Performance (End-user Links)

Performance Measure	Reporting Frequency	2011 Target	2012 Target	Achieved 2012
Internally produced Magazine, issues	Annual	10	10	10 editions of *Decision Point* & 47 of *Dbyte* News
Separate media stories	Annual	5	10	350 stories
Media outputs, articles, radio (see Media, pages 48-49, for full explanation)	Annual	50	100	1,654 individual reports

Finance

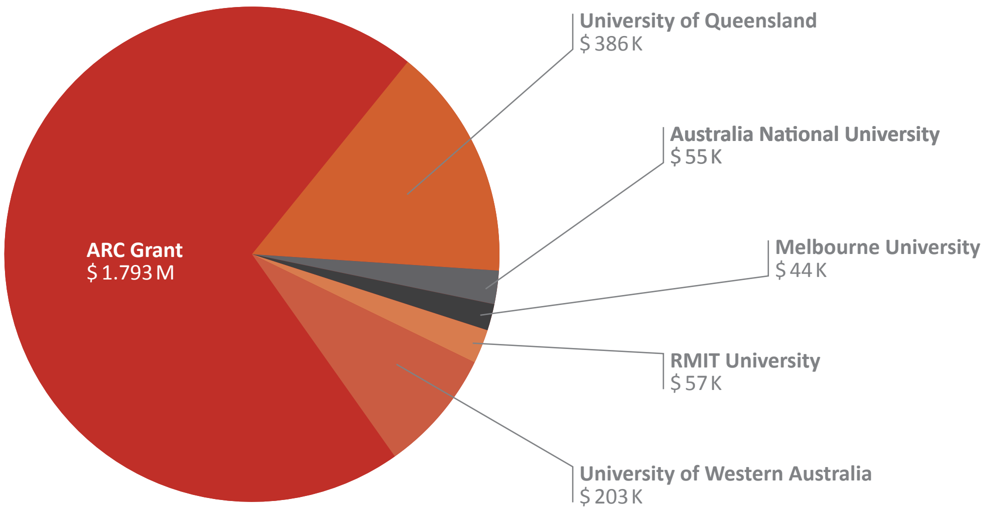
Income

Income (in $AUD)

	2011 (15 July to 31 December)	2012 (1 January to 31 December)
ARC Grant		
University of Queensland	636,600	729,813
Australia National University	184,861	184,861
Melbourne University	433,830	433,830
RMIT University	109,994	109,994
University of Western Australia	334,715	334,715
Total ARC Grant	1,700,000	1,793,213
Host Institution support		
University of Queensland	386,439	386,439
Australia National University	55,458	55,458
Melbourne University	220,433*	43,892**
RMIT University	56,630	56,630
University of Western Australia	203,184	203,184
Total Host Institution support	922,144	745,603
Total Income	2,622,144	2,538,816

*Note: *Includes $88,192 for 2012. **Excludes $88,192 paid in 2011.*

2012 Cash-operating Budget (in $AUD)



Expenditure

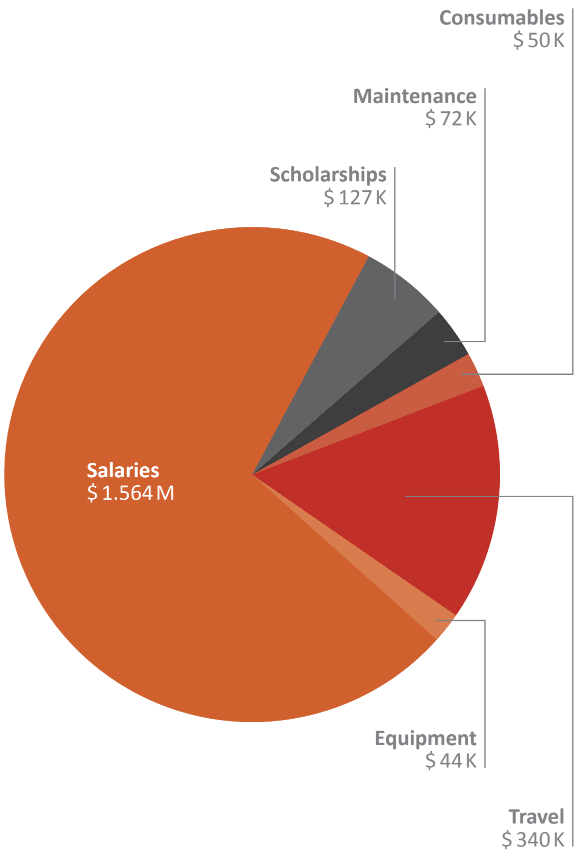
Expenditure (in $AUD)

	2011 (15 July to 31 December)	2012 (1 January to 31 December)
Salaries		
University of Queensland	109,537	540,321
Australia National University	153,131	117,028
Melbourne University	10,818	428,369
RMIT University	80,931	127,624
University of Western Australia	3,565	351,068
Total Salaries	357,982	1,564,410
Equipment		
University of Queensland	36,292	15,231
Australia National University	0	0
Melbourne University	0	17,210
RMIT University	348	2,150
University of Western Australia	0	9,331
Total Equipment	36,640	43,922
Travel		
University of Queensland	112,101	208,187
Australia National University	864	3,229
Melbourne University	18,438	92,521
RMIT University	22,685	19,752
University of Western Australia	16,188	16,345
Total Travel	170,276	340,034
Consumables		
University of Queensland	36,740	35,956
Australia National University	120	183
Melbourne University	4,031	10,128
RMIT University	2,241	923
University of Western Australia	4,075	2,664
Total Consumables	47,207	49,854

Expenditure (in $AUD) - continued

	2011 (15 July to 31 December)	2012 (1 January to 31 December)
Maintenance		
University of Queensland	0	52,055
Australia National University	0	0
Melbourne University	0	14,339
RMIT University	0	0
University of Western Australia	1,500	6,050
Total Maintenance	1,500	72,444
Scholarships		
University of Queensland	6,895	51,761
Australia National University	0	0
Melbourne University	0	28,646
RMIT University	0	21,590
University of Western Australia	0	25,389
Total Scholarships	6,895	127,386
Total Income	2,622,144	2,538,816
Total Expenditure	620,500	2,198,050
Surplus/Deficit	2,001,644	340,766

2012 Expenditure (in $AUD)



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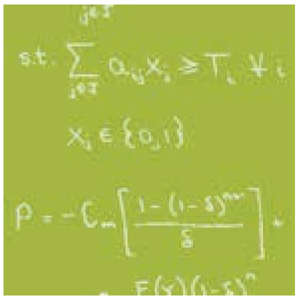

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