DECISION POINT

Connecting conservation policy makers, researchers and practitioners

Issue #95 / April 2016

Restoring marine ecosystems

What's the cost and is it feasible?

Scanning the horizon for threats and opportunities

Restoration: the case of the grey-crowned babbler

Tracking seabirds for conservation

Decision Point

Decision Point is the bimonthly magazine of the ARC Centre of Excellence for Environmental Decisions (CEED). It presents news and views on environmental decision making, biodiversity, conservation planning and monitoring. ***Decision Point*** is available free from http://www.decision-point.com.au/

Plus

DECISION POINT

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A coral nursery in the Florida Keys. Restoration efforts can get incredibly expensive and even then they can be quite risky. See our story on page 4. (Photo XL Catlin Seaview Survey)

On the point

Decisions, decisions, decisions

In this bumper issue* of *Decision Point* we explore a wide range of topics surrounding good environmental decision making – from the many trade-offs we need to consider when making a good decision to the ingredients that go into a good decision-making process.

The trade-offs include whether it's better to go for high target-persistence (aiming for high probabilities for a species to persist into the future) for a few species or setting lower target-persistence for many species (see page 14); considering the properties of irreplaceability vs importance when planning biodiversity areas (page 11); and incorporating cost and feasibility into decisions about coastal restoration (page 4).

The theme of a good decision-making process include stories on learning from past restoration efforts (page 10); appreciating the value of model-based algorithms in management decisions (page 8); and mapping an argument to draw out hidden assumptions (page 9).

And then there are a crop of stories that tell us a little about environmental decision science itself. These include the process by which we highlight emerging conservation issues through horizon scanning (page 6) and the unconscious gender bias that permeates science (page 12, and we outline what CEED has been doing to address this issue).

*So, it's a bumper issue indeed; more so because this issue runs for 20 pages (instead of 16) in order to incorporate a few hang-over stories from last year. And while pointing out this difference, it's worth telling our readers that because of changed funding, *Decision Point* will only be coming out every second month (five times a year instead of ten: February, April, June, August and October). The other months will see the publication of a new magazine called *Science for Saving Species*. It's the magazine of the new National Environmental Science Programme (NESP) Threatened Species Recovery Hub. Some of the NESP TSR researchers are involved in CEED so there are many connections between the two networks.

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DECISION POINT

Decision Point is the bimonthly magazine of the ARC Centre of Excellence for Environmental Decisions (CEED). CEED is a network of conservation researchers working on the science of effective decision making to better conserve biodiversity. Our members are largely based at the University of Queensland, the Australian National University, the University of Melbourne, the University of Western Australia and RMIT.

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'Degraded', or is it just different?

One of the world's leading restoration ecologists has questioned the way we use the term 'degraded'. According to CEED Chief Investigator Professor Richard Hobbs this is far more than simple semantics. How we assess whether a system is degraded has major implications for whether restoration is required.

In a paper just published in *Restoration Ecology*, Richard Hobbs examines the perceptions and values that are associated with term 'degraded' and how this affects the decisions we make on whether intervention is appropriate.

"An underlying premise of ecological restoration is that it focuses on the recovery of degraded systems," says Richard Hobbs, Director of the Ecosystem Restoration and Intervention Ecology (ERIE) Centre at the University of Western Australia. "While this is an apparently straightforward aim, there is in fact considerable variation in how the term 'degraded' is defined, used and assessed."

Hobbs points out that there is a notable subjective component to decisions regarding what is degraded and what isn't, and this often relates to the values and goals being considered.

Reference

Hobbs RJ (2016). Degraded or just different? Perceptions and value judgements in restoration decisions. *Restoration Ecology* 24: 153-158. doi: 10.1111/rec.12336 http://onlinelibrary.wiley.com/doi/10.1111/rec.12336/abstract

Intact ecosystems provide best defence against climate change

With climate change now posing a clear and present danger all around the planet, scientists are calling for more intelligence in the decisions we make about how we adapt, especially in relation to our ecosystems. In many cases, leaving these ecosystems intact would be the smartest and most cost-effective insurance policy we could have. That's the message in a paper just published in *Nature Climate Change* by two CEED researchers Tara Martin and James Watson.

The paper discusses how adaptation strategies that have negative impacts on natural systems may come back to sting us in the long-term. On the other hand, strategies that maintain the ecological integrity of our ecosystems hold real potential to soften the many blows that come with climate change. The scientists cite as examples conservation reserves being used as drought relief to feed livestock, while forests in the Congo Basin in Africa are being cleared for agriculture in response to drought, and coral reefs are being destroyed to build sea walls from the low-lying islands in Melanesia.

"These are just a few of the human responses to climate change that, if left unchallenged, may leave us worse off in the future due to their impacts on nature," says CSIRO's Dr Tara Martin. "And yet, functioning and intact forests, grasslands, wetlands and coral reefs represent our greatest protection against floods and storms."

Reference

Martin TG & JEM Watson (2016). Intact ecosystems provide best defence against climate change. *Nature Climate Change* 6: 122–124. doi:10.1038/nclimate2918 http://www.nature.com/nclimate/journal/v6/n2/full/nclimate2918.html

Building smarter collaborations for conservation

When attempting to build collaborations to meet an environmental challenge, is it better to allow them to develop by themselves (bottom-up efforts at self-organisation) or should they be designed 'top-down' by the powers that be (ie, government departments and so forth) in order to be 'fit for purpose' and efficient? New research from CEED researcher Angela Guerrero and colleagues suggests that bottom-up forms of collaboration have a lot going for them. However, a little bit of 'top-down' guidance might make them even more effective.

"A challenging aspect of many environmental problems is that they often extend over large geographic areas, often over multiple jurisdictions, and require management over extended periods of time," explains Angela Guerrero. "Part of the solution is to foster collaboration between the different stakeholders but establishing and maintaining collaborative arrangements takes time, effort and resources, all of which are very limited."

The research led by Guerrero found some support for the effectiveness of bottom-up self-organisation but it also found that the collaborative governance might be stronger if it was guided to better match the ecological systems in which it was situated.

"Our results suggest that in some cases the establishment of bottom-up collaborative arrangements would likely benefit from specific guidance to facilitate the establishment of collaborations that better align with the ways ecological resources are interconnected across the landscape," says Guerrero.

Reference

Guerrero AM, Ö Bodin, RRJ McAllister & KA Wilson (2015). Achieving social-ecological fit through bottom-up collaborative governance: an empirical investigation. *Ecology and Society* 20: 41. http://www.ecologyandsociety.org/vol20/iss4/art41/

Building protective sea walls using coral reef that has been blasted is now a common practice in some of the islands off northern Papua New Guinea. Investing in the integrity of the coral reefs and surrounding mangroves is likely a much more cost-effective defence against the coming impacts of climate change. (Photo by James Watson)

Restoring marine coastal ecosystems

Counting the costs and assessing the feasibility

By Megan Saunders and Elisa Bayraktarov (University of Queensland)

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

There is now considerable interest in reversing trends in the decline of coastal ecosystems. This means restoration – the process of removing the factors which are causing ecosystems to disappear, and/or establishing plants or animals to replace those which have been lost. Restoration is also an important element of biodiversity-offsetting projects – where losses of biodiversity from a development at one site are 'offset' (replaced) by restoration at another (degraded) site (see *Decision Point #63*).

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

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

Key messages

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

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

The median (middle) price for coastal restoration was typically around $80,000 per hectare. The average price, however, was up at $1,600,000 per hectare. The big difference between the median and average cost is due to some marine restoration projects being incredibly expensive, costing many millions of

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

An oyster restoration project. The review revealed that the published literature didn't have much data on oyster restoration projects such as this. (Photo by Erika Nortemann, The Nature Conservancy)

dollars per hectare. Examples of these types of projects involve the use of artificial structures to rebuild the ecosystems in 'expensive' countries like the USA and Australia.

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

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

We were surprised to find that project success was unrelated to the amount of money spent. And restoration cost-per-unit effort did not decrease with increasing project areas (so there was no economies of scale). This suggests that marine restoration techniques still need a bit of work. Further studies will be required to achieve a transition from small-scale to large-scale restoration of marine coastal ecosystems. (It should be noted that this inability to scale up restoration is also an issue on land, see *Decision Point #68*).

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

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Reference

Bayraktarov E, M Saunders, S Abdullah, M Mills, J Beher, HP Possingham, PJ Mumby & CE Lovelock (2016). The cost and feasibility of marine coastal restoration. *Ecological Applications* http://onlinelibrary.wiley.com/doi/10.1890/15-1077/abstract

Mapping the Flickr of night lights

"Take nothing but pictures, leave nothing but footprints" goes the old saying. Scientists looking to better conserve the natural values of our planet are now using the information on where these pictures were taken to prioritise our conservation efforts.

As human populations grow, our impact on natural areas beyond urban centers is rapidly increasing. There's a need to estimate not only where people live and work but also where humans are found in the more remote and natural areas, which are often the targets of protection efforts.

"Apart from a few well-monitored national parks, spatial patterns of human recreational activity remain largely unknown," explains Associate Professor Noam Levin from CEED and the University of Queensland. "And we need accurate data about human presence in remote areas to help guide our conservation efforts."

Levin and colleagues developed an innovative analysis that combines information from social media with remote sensing (Levin et al 2015).

"We combined an analysis of 'big data' coming out of Flickr, a social media site where people load up their geo-tagged photos, with remote sensing data that records artificial night lights," says Levin. "We used data from the Flickr photo-sharing website as a surrogate for identifying spatial variation in global visitation, and complemented this estimate with spatially explicit information on stable night lights between 2004 and 2012. The night lights help us identify urban centers."

Natural regions attracting visitors were defined as areas both highly photographed and non-lit. The researchers confirmed that the number of Flickr photographers within protected areas was a reliable surrogate for estimating visitor numbers by comparing the information with local authority censuses.

While most photos are taken by people outside protected areas, the millions of Flickr photos uploaded to the internet combined with night-light imagery allowed the researchers to map and quantify, for the first time, worldwide visitation of both protected and unprotected areas. This enables the identification of visitation hotspots (and coldspots) for multiple countries and ecoregions across the world.

"The technique we have developed has many applications," says Levin. "It can be useful for assessing the gaps of future protected area, help in devising strategies, and enhance the effectiveness of protected area management in relation to visitor pressure."

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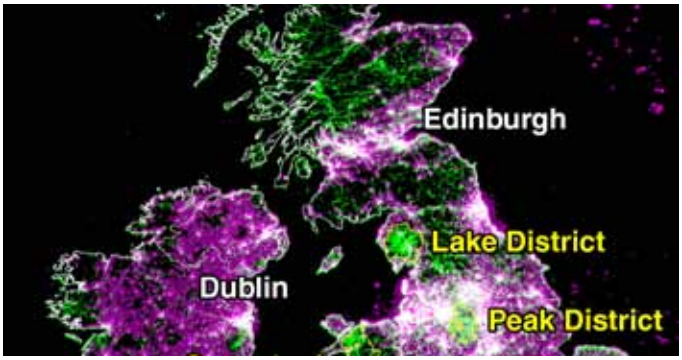
Reference

Levin N, S Kark & D Crandall (2015). Where have all the people gone? Enhancing global conservation using night lights and social media. *Ecological Applications* 25: 2153–2167. http://onlinelibrary.wiley.com/doi/10.1890/15-0113.1/abstract



Scanning the horizon for threats and opportunities

Pre-empting the future of global conservation

By Bonnie Wintle (University of Cambridge)*

For the past eight years or so, a group of people from around the world have been convening in Madingley Hall at Cambridge University to consider what the future might look like for global conservation. The 20 or so participants include professional horizon scanners, a journalist, and experts from a wide range of disciplines relevant to conservation science (such as ecology, biosecurity, public health, social science and technology studies).

The annual workshop is the culmination of three months of collating new and emerging issues that participants and their networks believe will become important for the environment in the foreseeable future. Participants locate these issues by regularly scanning the media, various websites, published and grey literature, conferences and by simply talking to friends, family and colleagues. Importantly, they are monitoring information from a host of different domains, from economics to geopolitics to medicine, looking for any flashes in the pan that could conceivably affect global conservation.

The 'issues' that are identified and discussed tend to come in two forms: sometimes they are novel or emerging threats, such as the environmental consequences of increasing milk consumption in Asia, or increasing pharmaceutical discharges with aging populations. But they also come in the form of new opportunities for conservation, for example, a new probiotic therapy for treating the deadly chytrid fungus in amphibians, or high frequency monitoring of land cover change with advances in remote sensing.

In 2014, while working on a postdoc for NERP, I was invited by Professor Bill Sutherland to contribute to one of their annual horizon scans. It led to some fascinating discussion and a fast-tracked publication in *Trends in Ecology & Evolution* (Sutherland et al 2015). I was very excited to be invited back in 2015.

Basically, the process is this. Each of the participants submits short summaries of up to five issues that they think are 'on the horizon' for global conservation. Altogether, 89 issues were submitted. Each participant reads the issue summaries and privately scores each of the 89 issues from 1-1000, according to novelty and potential impact.

A shortlist of the top scoring 34 issues is then circulated, and participants have the opportunity to 'save' any issues that didn't make the cut. Every member of the group is assigned 3-4 issues from the shortlist for which they act as 'cynics'—so called because their job is to find holes in the topic. In researching the topic, they might ask themselves questions like: is this issue genuinely new, or is it just a repackaging of something we've seen before? Is it based on credible research? Is it really plausible that the issue will unfold in the not-too-distant future, and have genuine implications for the environment?

By the time the workshop comes around, everyone is armed with their knowledge and insights, and every issue on the shortlist is systematically dismantled by the full group. In light of this workshop discussion, everyone rescores the shortlist, and a final list of the top 15 issues rises from the ashes!

These 15 issues are published in the annual *TREE* paper.

So, what are the issues that made the final list for 2015? Here's a short summary. (Note that a new list of issues has been published at the beginning of 2016, see the box on scanning the horizon in 2016.)

1. Compounds that disrupt the capacity of insects to sense airborne compounds

A new insect repellent (VUAA1) activates all of an insect's olfactory receptors simultaneously, making it highly challenging for insects to detect food sources. This new class of compounds is highly effective but indiscriminate, potentially affecting non-target species.

2. Bioplastics from waste

Bioplastics produced by bacteria that feed on carbon dioxide and methane have recently been developed. This offers an alternative to petrochemical-based plastics, and also to bioplastics derived from plant-based feedstocks.

3. Algae as a replacement for palm oil

Increased pressure to move away from unsustainably produced palm oil has led to the exploration of genetically modified substitute oils. There has been recent interest in oils produced by algae. The algae are grown in a bioreactor and pressed to produce oil that can be used in cosmetics, foods, and detergents.

4. Adoption of electric vehicles

The market for electric vehicles has been historically constrained by high purchase prices, limited range, long recharging time, and limited recharging infrastructure. These constraints are fast being overcome.

5. Legalisation of recreational drugs

Increased legalisation of recreational drugs could have flow-on effects for the environment. For example, legalisation of cocaine could reduce drug cartel influence and increase access to tropical forests, with implications for citizens, governments and logging.

6. Underground gasification of coal

This new approach for harvesting coal through underground gasification enables access to previously inaccessible coal deposits, potentially extending the lifetime of global coal reserves by several hundred years. Techniques for capture and storage of carbon dioxide produced by the process are being developed.

7. Pharmaceutical-induced loss of aquatic biofilms

The algal, bacterial, and fungal films that cover rocks in streams provide food for invertebrates and fish, and contribute to water quality. But they are highly sensitive to toxicants. The composition and function of biofilms is at risk with the increase of pharmaceuticals in waterway.

8. Sustainable intensification of high-yielding agriculture

This refers to the goal of intensifying food production in existing agricultural areas while reducing overall environmental impact. Rather than focusing on particular methods of agricultural production, sustainable intensification policies focus on profitable business models that account for environmental and social side effects.

9. Increases in coral disease in the Indo-Pacific

Recent research suggests an increase in the extent, frequency, and effects of coral disease outbreaks in the Indo-Pacific region. Outbreaks are exacerbated by changes in water quality, disturbance and climate, potentially leading to serious changes in coral reef structure.

10. Effects on krill of marked decline in Antarctic sea ice

Since krill are dependent on epontic algae that grow in sea ice, reduced extent of winter sea ice will likely reduce krill densities the following summer. The largest krill populations occur in areas where sea ice extent has declined most markedly.

11. Novel coastal ecosystems associated with ice retreat

Glacial and sea ice retreat is revealing new areas of permanently ice-free intertidal seabeds and open water. These areas could be colonised by species that have been virtually absent from Antarctica since about 400,000 years before present.

12. Increasing the legal status of non-human species

Increased awareness of animal consciousness and welfare has led to greater protections for them, with flow-on effects being two-fold. First, it could lead to more objections to culling of invasive species for ecological purposes, and second, it may increase engagement in conservation.

13. Impact investing

A new class of financial instruments aims to benefit both the environment and the financial sector by adding conservation projects to the investment portfolio. Financial returns may come from carbon credits, ecosystem service valuations, agriculture, tourism and other revenue generating activities.

14. Reproducibility in environmental science

Many disciplines, including psychology, biomedicine, economics, political science, and chemistry, have come under increasing media scrutiny due to their difficulty replicating experimental results. This has reduced the perceived credibility of those disciplines. If a similar criticism is levelled at environmental science, it could undermine efforts to apply the science to environmental policy and practice.

15. Investor-state dispute settlements in free trade

The two largest trade agreements in history are the *Transatlantic Trade and Investment Partnership* (under ongoing negotiations between the US and the EU) and the *Trans-Pacific Partnership* (signed in February 2016 after 7 years of negotiations between US, Canada, Australia and several other Asia Pacific nations). Both agreements include provisions for investor-state dispute settlement. Under certain conditions, these provisions allow foreign investors to initiate claims against a government for profits lost due to legal or regulatory changes, including those concerning the environment or public health.

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**Bonnie Wintle is a former Research Fellow at the Centre of Excellence for Biosecurity Risk Analysis (CEBRA), University of Melbourne, and has recently moved to the University of Cambridge to take up a postdoc with the Centre for the Study of Existential Risk (CSER). Her participation in the 2014 horizon scanning workshop (for 2015) was made possible with the help of a CEED Early Career Travel Fellowship.*

Sutherland WJ, M Clout, M Depledge, LV Dicks, J Dinsdale, AC Entwistle, E Fleishman, DW Gibbons, B Keim, FA Lickorish, KA Monk, N Ockendon, LS Peck, J Pretty, J Rockström, MD Spalding, FH Tonneijck & BC Wintle (2015). A horizon scan of global conservation issues for 2015. *Trends in Ecology and Evolution* 30: 17–24.

Scanning the horizon in 2016

Trends in Ecology and Evolution recently published the 2016 list (Sutherland et al 2016) and here's what's on it. This story is open access so anyone can download this issue (for free) if you want to find out why these issues are considered significant.

Artificial Superintelligence

Changing Costs of Energy Storage and Consumption Models

Ecological Civilization Policies in China

Electric Pulse Trawling

Osmotic Power

Managed Bees as Vectors

Unregulated Fisheries in the Central Arctic Ocean Threaten Expanding Fish Stocks

Increasing Extent of Construction of Artificial Oceanic Islands

Increasing Aquatic Concentrations of Testosterone

Effects of Engineered Nanoparticles on Terrestrial Ecosystems

Satellite Access to Shipborne Automatic Identification Systems

Passive Acoustic Monitoring to Prevent Illegal Activity

Synthetic Body Parts of Endangered Animals

Artificial Glaciers to Regulate Irrigation

Invasive Species as Reservoirs of Genetic Diversity

Reference

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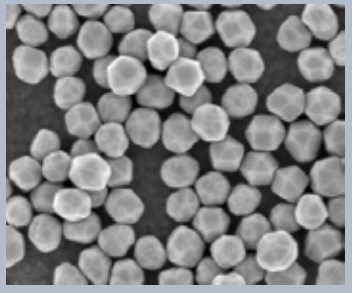


‘Robots’ vs environmental managers

Automated model-based algorithms compete against humans in conservation games

By Matthew Holden (University of Queensland)

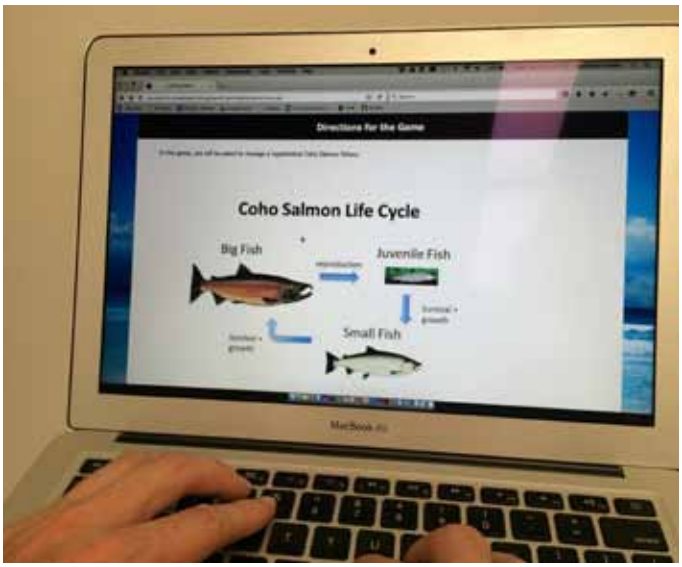
Given all the real world complexities involved when managing ecosystems, do quantitative methods (which ignore most of these complications) really help decision makers achieve better environmental outcomes? How do these quantitative methods compare to the alternative: humans making decisions based on intuition, experience and their best judgement?

Unfortunately, it is difficult to answer this question in real life because experiments in management are usually not repeatable. That is, once a manager ‘acts’ based on their experience, it’s usually impossible to compare the results to how well an alternative decision, aided by a mathematical model, would have performed.

But what is difficult or impossible in real life can sometimes be achieved in the virtual world. Computer games allow us to pit human-based decisions against automated, model-based decisions (a.k.a. ‘robots’ following simple mathematical rules). For every game a human plays (using intuition), a robot plays using predetermined instructions which are optimal given some quantitative model. The model, being a simplification, is an approximation meaning it is always, to some degree, wrong.

We explored this approach using environmental science university students (Holden and Ellner, 2016) as our test humans. We had them play an online computer game where the players tried to harvest a hypothetical salmon population in order to maximise long-run, sustainable profit.

If the player harvests too few fish, then they don’t make much money. But, if they harvest too many fish early in the game, there are no fish in the ocean to harvest during the later turns. The player decides how many fish to take out of the ocean on each turn balancing the future benefits of leaving fish in the ocean against the present profits from fishing. To allow the students to gain some experience managing the fishery, all players played a practice game before playing the game for a score.



In this game you will be asked to manage a hypothetical Coho salmon fishery.

Key messages

- **Computer games allow us to compare** human-based decisions against model-based decisions
- On average **the ‘robots’ made better decisions** than humans using intuition
- There is **real value in the greater use of quantitative methods** in environmental management

Can lessons from games with robots inform environmental management in the real world? (Photo by Megan Saunders)

Unbeknown to the students, robots were competing against them behind the scenes, making decisions based on simple mathematical rules. Even when these rules were based on completely incorrect descriptions about how the salmon population changed through time, the automated player still on average made better decisions than humans using intuition and their past experience (from playing a practice game).

This shows there is real value in the greater use of quantitative methods in environmental management. We’re not saying that humans should be removed from the decision making process. Humans will be absolutely necessary for defining conservation goals (and revising them), engaging stakeholders, choosing appropriate models and analysing data, and deploying on the ground actions. While we would argue for increased transparency and objectivity (which modelling can help to provide), we are still a long way away from robots taking over the field of environmental management.

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Mapping an argument

Dispelling the curse of knowledge

By Tim van Gelder (University of Melbourne)

Presenting written arguments to others – whether in a risk assessment, legal opinion, policy proposal, scientific paper, incident report, or any other form – is one of the inescapable chores of professional life.

Unfortunately, clearly explaining our reasoning in writing is something most of us find difficult, and we don't always achieve the effect we were after. Sometimes our audience doesn't 'get' our argument. Sometimes they do get it, but spot logical holes (oops!). Sometimes they just give up, not even reading what we've taken so long to put together.

Fortunately, there is a technique which can help. It's called argument mapping. This usually involves creating simple 'maps' or diagrams of your reasoning. However the essence of argument mapping is really just applying simple, timeless principles to organising arguments and evidence.

The roots of argument mapping are in philosophy, reaching back as far as Ancient Greek syllogisms (eg, Socrates is human; All humans are mortal; so…). For some decades, philosophy instructors have used the technique to help students develop reasoning and critical thinking skills – for which it is has been shown to be remarkably effective.

More recently, argument mapping has broken out of 'the academy' and made itself useful as a tool for managing complex reasoning about real-world problems.

For example, in 2015 argument mapping was introduced to biosecurity risk analysts and managers at the Australian Government Department of Agriculture and Water Resources (in Canberra) and the New Zealand Ministry of Primary Industries (in Wellington, NZ). One of their challenges is to make judgements about the level of risk involved in potential imports, such as table grapes from India. They must defend these judgements with scientific arguments and evidence, knowing that there will be intense scrutiny and probably lots of 'flak' from stakeholders on one side or the other (or both).

They found that argument mapping can help them take a mass of scientific detail and fit it into a framework where the key points can be succinctly stated and understood by anyone, with details slotted in underneath for anyone who wants to delve into them further.

The technique is based on applying a pattern or template called CASE (Contention, Argument, Evidence, Source). It starts with: what is your **Contention**? That is, what is the position you are taking or conclusion you have come to? Second, what are the general **Arguments** (reasons) supporting that contention? Third, each argument needs to be supported by **Evidence** (ie, specific information to back up the argument). And, finally, the **Source** shows where your evidence has come from.

Key messages

- Clearly **explaining our reasoning in writing is a challenging task**
- Argument mapping **can help in organising arguments and evidence**
- Argument mapping **helps draw out hidden assumptions**

For example, you might be arguing that:

(C) There is a high risk that the bacterial disease *Xanthomonas campestris pv. viticola* will be introduced if table grapes are imported from India, because

(A) table grapes can be infected while showing no symptoms, since

(E) the bacterium was detected on asymptomatic 'Red Globe' grape berries, as reported in

(S) Tostes et al 2014.

Of course, this is just a simple example. The plot thickens when we start to consider multiple distinct lines of argument and evidence; counter-considerations; and ladders of reasoning with more than four rungs. All these patterns are commonly present in real-life arguments, and if you don't apply strong ordering principles, you can quickly end up with logical spaghetti.

One way to try to make a content-dump look like orderly reasoning is to use lots of dot points. Sometimes you'll see a report where almost every paragraph is bulleted. This is 'cargo cult' logic: it has some outwards signs of organised thinking, but lacks genuine logical order.

One of the strengths of argument mapping is its ability to bring out hidden assumptions. Experts in any field tend to suffer the 'curse of knowledge': they're not aware of how much others don't know. An argument which makes perfect sense to an expert can seem, to a general audience, to be making huge leaps – if indeed it is comprehensible at all. Applying some of the simple rules of argument mapping can have an almost magical effect in exposing ideas which bridge the gaps between evidence and conclusions.

Within an organisation, one of the benefits of argument mapping is consistency. In biosecurity risk assessments, for example, the same general types of arguments tend to recur from one pest to another, with just the technical details varying from case to case. Argument mapping helps teams develop domain-specific templates which can expedite the drafting of assessments and help ensure that analysts will come up with the same kinds of arguments and draw similar conclusions from similar evidence.

One reason for the uptake of argument mapping methods is the emergence of software to support the process. For example, participants in the DAWR and MPI workshops used a new, free add-in for Microsoft Word. In most organisations Word is still the default tool for developing positions and supporting arguments, so it makes sense to create maps right there on the page. A little bit of reformatting then transforms maps into standard prose format, while retaining strong logical structure.

One of the guiding principles of argument mapping is "Don't make me [the reader] think!" That is, present your arguments so clearly that it is nearly effortless for readers to understand what you are saying and why. When this happens, they tend to engage with the issues much more constructively.

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Note: Tim is a collaborator with CEED's long-time friend Mark Burgman at the University of Melbourne. He welcomes all enquiries from anyone in CEED wishing to explore the potential of argument mapping in their research.

Learning about past restoration effort

The case of the grey-crowned babbler

By Peter Vesk (University of Melbourne)

Many resources are spent on restoring habitat to counter the impacts of land clearing and habitat degradation on wildlife populations. But individual projects involving restoration usually have severe time and resourcing constraints. These constraints mean that the effectiveness of these projects in achieving their long-term goals (of improving the population viability of particular species) is rarely assessed. As a result, many restoration programs cannot demonstrate their effectiveness.

So what can be done about this? Well, one approach is to call for all new programs to include monitoring. This may help with future work. But what of all the hard work that has been done in the past. Can we learn anything about past efforts?

This is a story of trying to learn from past investment. Since the early 1990s, Doug Robinson from Trust for Nature in Victoria has been leading efforts to restore woodland habitat in northern Victoria for the grey-crowned babbler, a long-lived, colonial-nesting, woodland bird, in decline in south-east Australia. The question was simple, has this restoration effort been effective in improving the population viability of grey-crowned babblers?

But the route to answering that question was not so straightforward. It involved:

- **a revisitation survey** (resurveying sites first surveyed some 13 years previously);
- **a stratification of the surveys** so as to include restored and unrestored sites;
- **an investigation of the demographic parameter** of babbler family-group size (which has direct impacts on local population growth since an extra bird in the group translates into about half an extra fledgling per breeding season per group);
- **an accounting for habitat variation** between sites and effects of distances from occupied sites; and finally
- **a determination of whether differences** between the two surveys weren't due to imperfect detection or to simple year-to-year variation.

The key result from all this was that restoration was effective in stemming the decline in group size; whereas at unrestored sites, decline continued. The restoration meant roughly an extra bird per group which has an important effect on the reproductive success of the social group.

A native planting next to remnant native vegetation. Restoration work such as this has improved the outlook for declining woodland birds such as the grey-crowned babbler. (Photo by Doug Robinson)

Key messages

- Understanding the value of **restoration requires measuring change through time**
- **Measure response variables that are meaningful**
- **Counterfactuals are necessary**: Compared to what?

The grey-crowned babbler, a long-lived, colonial-nesting, woodland bird, in decline in southeast Australia. (Photo by Doug Robinson)

But the bottom-line assessment is only part of the story. The lessons that have emerged from this study are the importance of measuring change over time and the need to include counterfactuals – you need a reference or control to compare with. Measuring 'meaningful' performance variables (such as group size) by themselves without the comparison of what happened on unrestored sites yielded little information.

Studies such as this help us demonstrate that we can learn from past conservation interventions. It may not always be possible, but it's worthwhile if the information is available over time. We showed that good use can be made of existing data, coupled with good design for collecting new data. This is important because we need to know the effectiveness of past investments.

In this case, the work was only possible because of Doug Robinson's championing the cause. He led volunteers from Friends of the grey-crowned babbler group to conduct surveys. Funding from The Norman Wettenhall Foundation and Goulburn Broken Catchment Authority assisted and ultimately, many landholders and managers contributed to habitat restoration.

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Reconciling 'irreplaceability' and 'importance'

Quantifying the relative irreplaceability of important bird and biodiversity areas

By Moreno Di Marco (University of Queensland)

The expansion of the world's protected area network is often held up as a measure of global progress towards effective biodiversity conservation. However, having more protected areas does not necessarily mean better biodiversity outcomes. In the past, two main approaches have been used to identify priority sites for biodiversity conservation: one based on thresholds, the other on complementarity. We recently combined both approaches to guide conservation planning.

Threshold-based approaches build largely on the Important Bird and biodiversity Areas (IBAs) program of Birdlife International. IBAs are a set of more than 12,000 sites around the world identified using four criteria that relate to the occurrence of:
-globally threatened species,
-restricted-range species,
-species assemblages confined to a single biome, and
-congregations of one or more species.

In order for a site to meet one or more of these criteria and qualify as an IBA, it needs to have more than a minimum threshold number of bird species and/or individuals (for example, a congregation of over 20,000 water birds).

Complementarity-based approaches identify sites for protection that complement, rather than replicate, each other. These approaches are typically associated with the measure of 'irreplaceability', defined as the contribution of a site in achieving biodiversity conservation targets or the extent to which the options for achieving the targets are compromised if the site is lost.

After decades of parallel development between threshold- and complementarity-based approaches, and in light of a pressing need to find shared strategies for an efficient expansion of protected areas, we brought together these approaches by performing a complementarity-based analysis of irreplaceability in IBAs (Di Marco et al, 2016). Our objectives were to determine: 1) whether irreplaceability values are higher inside than outside IBAs, and 2) whether any observed difference in irreplaceability depended on known characteristics of the IBAs.

We focused on three regions with comprehensive IBA inventories and bird distribution atlases: Australia, southern Africa, and Europe. These regions represent a broad spectrum of conditions. For example, Australia and southern Africa have more endemic birds than Europe, whereas Europe has smaller and more numerous IBAs. In each of the study regions we used the software Marxan to measure irreplaceability inside and outside of IBAs.

We found that irreplaceability values were significantly higher inside IBAs than outside of them. The differences were much larger in Australia and much smaller in Europe. This is likely because Australia has more restricted-range birds and fewer IBAs than Europe. In fact, in all regions we found that higher irreplaceability values in IBAs were associated with the presence and number of restricted-range species. The relationship between higher irreplaceability and presence of restricted-range species is not surprising: representation targets for widespread species can typically be met under many different spatial solutions; whereas, there are relatively few options for meeting targets for small-range species.

The orange-bellied parrot is endemic to Australia and critically endangered. Eighteen IBAs have been identified in Australia for the presence of this species. (Photo: © Jeremy Ringma.)

Key messages

- **Priority sites** for biodiversity have **in the past** been **based on thresholds or complementarity**
- **A complementarity-based analysis of irreplaceability** in Important Bird Areas seeks to **combine these two approaches**
- **It is important to complement** the **threshold-based identification** of important biodiversity sites with the **systematic identification of irreplaceable sites**

The irreplaceability of a site depends on its characteristics and its regional context, while the IBA status is an absolute, rather than relative, attribute (it only depends on the characteristics of the site). In some cases, the two approaches are expected to produce convergent results: a site that includes the only occurrence of one or more endemic bird species is totally irreplaceable and is also an IBA. The relationship between the two approaches in other situations is context dependent and requires testing.

The correspondence between threshold-based and complementarity-based approaches can be complex. Sites with species below IBA-threshold levels could still be important to efficiently achieve species' representation targets, especially when they have high levels of complementarity with other sites. On the other hand, a site may be of particular importance for a given species (eg, if the species congregates there) and be identified as an IBA even if it has low irreplaceability. We stress the importance of complementing the threshold-based identification of important biodiversity sites with the systematic identification of irreplaceable sites. Failing to do this may create significant gaps in any reserve system built on these sites.

Recently the IUCN has undertaken a process to consolidate global standards for the identification of Key Biodiversity Areas (KBAs). This builds on existing approaches such as IBAs. Our results informed this process and in particular a proposed criterion for irreplaceability that will allow the new KBA standard to draw on the strengths of both threshold-based and complementarity-based approaches.

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Addressing unconscious bias in science

And what CEED is doing about it

By Alienor Chauvenet, Katrina Davis, Roberto Salguero-Gómez, Martina Di Fonzo, Duan Biggs, Megan Barnes, and Kerrie Wilson (University of Queensland)*

The Centre of Excellence for Environmental Decisions (CEED) is currently composed of over 75 associates and 116 members, of which about 55% are women. Although as scientists we are trained to be impartial, we are no exception to some pervasive prejudices. Only by becoming aware of our prejudices can we work to overcome their effects. But what if our biases are unconscious?

'Unconscious bias' is a well-known phenomenon that impacts our behaviour and decisions. It refers to the sub-conscious assumptions and mental filters that affect our decisions and actions without us even being aware of them (see Morley 2011 for an excellent overall discussion on unconscious bias). Gender bias is one of the key biases – together with ethnicity, cultural background, and religion. Our 'gender schema', or gender expectation, is set from very early on in our life. Men tend to be associated with 'agentic' traits (eg, task-oriented, focused and driven) while women tend to be associated with 'communal' traits (eg, empathetic, gentle and kind).

Key messages

- **Unconscious gender bias is alive and well** in the discipline of science
- **Becoming aware of it is an important step** in overcoming its effects
- Ridding ourselves of our unconscious biases is **a difficult, long-term task that takes continuous evaluation**

We are all subject to societal biases and prejudices. Thus, only by becoming aware of these issues can we work to overcome their effects. Unconscious gender bias can disadvantage women in numerous ways: it can influence hiring decisions, our expectations of how different people should behave, and even how we treat colleagues in meetings.

In science, both men and women have been shown to display unconscious bias against women. For example, a recent study of biology, chemistry and physics professors found that both genders ranked identical job applications lower if they were given a woman's name rather than a man's (Moss-Racusin et al, 2012). This implies that for job opportunities in academia, assuming two candidates have the exact same skills and competencies, a woman is less likely to be hired. Unconscious bias can have far-reaching consequences for both genders throughout their careers; it can also negatively impact employers because single gender (ie, gender-biased) teams are less productive and have lower collective emotional intelligence than gender-balanced teams (Woolley et al 2010).

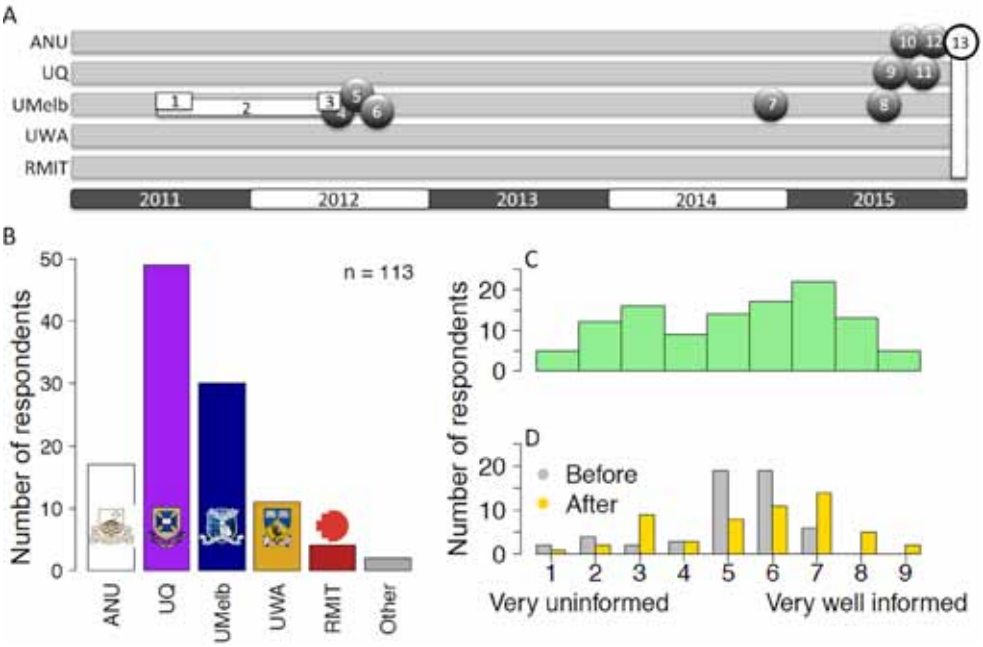

Figure 1. The landscape of unconscious-bias awareness at CEED.

A. Time line of events (workshops, seminars, discussion) of working groups per CEED node (1. Facilitated consultation with staff and students over gender equity concerns and prospects. 2. Monthly social lunch meetings among female members. 3. Gender equity reading group. 4. Consultation with human resources regarding new staff equity and diversity framework. 5. Consultation with Walter & Eliza Hall Institute staff on equity policies. 6. Seminar on gender stereotyping and neurosexim. 7. Discussion on implicit bias, backcasting and brainstorming over retreat. 8. Discussion with Prof Cathering Pickering on gender equity and opportunity. 9. 'Careers in science' research seminar for first year undergraduates on gender equity and unconscious bias. 10. Bias incognito on gender equity in science talk. 11. Seminar for the Centre for Biodiversity and Conservation Science on gender equity. 12. Equity plenary at ESA by Prof Emma Johnston and Prof Mark Burgman. 13. Same talk at the CEED conference based at ANU, with all participating nodes.) B. Participation of CEED nodes in the survey on unconscious bias, numbers of responses were generally proportional to the number of people in each node. C. Self-assessment of awareness about unconscious bias among the 113 participating CEED members. D. effect of attending an unconscious bias session on self-assessment of unconscious bias (only includes respondents that attended a session).

At CEED, we ran a number of sessions on unconscious bias in science where we discussed what could be done to address it. Seminars, workshops and group discussions took place at various CEED nodes across Australia. Figure 1A includes the timing and type of events at each node. These were tailored to the needs of each node and their goals and format varied.

At the Australian National University (ANU), the sessions were led by a private consultant (Deborah May) and organised by participants of the CEED leadership program. At The University of Queensland (UQ) the focus was on awareness raising and self-reflection and was organised by UQ early career researchers. At the University of Melbourne (UMelb), activities have included structured reading groups, seminars and data collection, and informal and social meet-ups.

To measure the impact of these sessions we conducted a survey of CEED workers (here's the questionnaire). The specific goal was to understand whether we felt more informed about unconscious bias after attending a session. A total of 113 members participated in the survey, with the breakdown by node provenance shown in Figure 1B. When asked about how informed respondents felt about unconscious bias, we received a wide range of responses from very uninformed to very informed (Figure 1C).

Of the total pool, 49% participated in at least one of the events about unconscious bias. Of these (that is the 49% who attended some form of activity relating to unconscious bias), we found an overall improvement in the degree of self-assessment on awareness about the issues of unconscious bias at CEED (Figure 1D). Overall, women came out of these sessions feeling as informed about unconscious bias as did men, and every single one of them reported improvement in the awareness of this topic.

Although ridding ourselves of our unconscious biases is a difficult, long-term task that takes continuous evaluation, there are many things we can all do now that will help limit the adverse effects of this phenomena. Those actions are listed in the box (Taking on unconscious bias).

Unconscious gender bias is all around us and contributes to many unfair and undesirable outcomes. If you are aware of it then maybe it's not so 'unconscious' to you. If that's the case, what will you be doing differently from now on to neutralise its unwanted influence?

**We would like to thank the wider CEED network, who have been actively engaged in discussing and acting on unconscious bias, and especially Megan Evans, Claire Foster, Stephanie Pulsford, Heini Kujala, Yung En Chee, Cindy Hauser, Jane Elith and Bonnie Wintle for their help with this article.*

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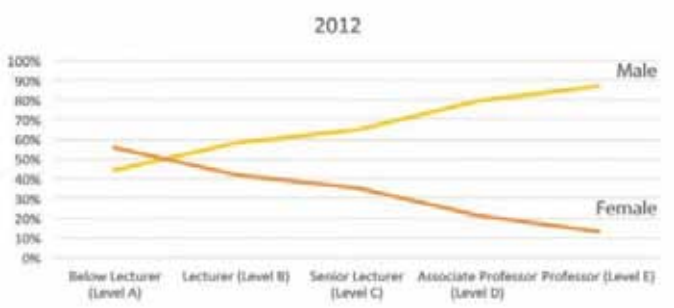

Figure 2: Gender disparity in the natural and physical sciences at the higher academic levels (B to E). Source: Higher Education Research Data Collection 2012, Department of Education; Office of the Chief Scientist, Australia. Source: https://www.science.org.au/sage/gender-equity

Unconscious bias was a major theme at the 2015 CEED Biennual Conference. Pictured is a group forum on the topic.

Taking on unconscious bias

Here is a list of actions you incorporate into your day-to-day life to reduce the impacts of unconscious gender biases:

1. Work the ratio: aim to have equal numbers of women and men present at workshops and working groups, as well as presenting plenaries or other seminars. In some disciplines, a higher ratio representative of the proportion of women in the field is appropriate.

2. Pass the opportunity along: if you are invited to participate in an event you can't attend – recommend a woman to take your place (men are often the default).

3. Employ best practice strategies for gender-equitable recruitment, including:

a. Have well-defined selection criteria
b. Make the first round of the selection process blind: keep names off applications
c. Use structured interviews and evaluate every individual based on their actual merits relative to opportunity, rather than perceived correlates of merit.
d. Avoid group think – individual interviews before panel discussions prevent dominant personalities and bias influencing all panel members' perception.

4. Encourage women to lean in – at all levels (and conversely, men to lean out when appropriate): this includes for promotions and awards.

5. Build the culture: create a workplace culture where people are encouraged to speak out against bias, and it is safe to do so.

6. Allow for flexibility: workplaces which allow for flexibility in working environments, e.g. working hours, travel commitments, options for maternity and paternity leave, will benefit both women and men.

7. Manage your questions: seminar chairs can manage question time to encourage equal numbers of questions, and engagement, by both men and women.

On target to save more species

Trading off target-persistence levels and numbers of species conserved

By Martina Di Fonzo (University of Queensland)

Targets such as a species' minimum viable population size or the optimum proportion of land that should be protected (*Decision point #83*) are important for translating the complexities of biodiversity conservation into clear, generalizable rules. However, setting the same high-aspirational target across different species and landscapes may not be very efficient. To begin with, it is unlikely that different species will respond in exactly the same way to the same conservation target. This could result in unequal levels of protection, and eventually lead to an overestimation in the amount of conservation actually achieved.

On top of this, setting high-level targets (ie, aiming for high probabilities for a species to persist into the future) will mean that fewer species can benefit from conservation funding when the budget available for these activities is limited. That is because it costs a lot more to achieve those high probabilities.

We recently investigated this by evaluating the trade-off between carrying out intensive levels of conservation effort to provide a high level of persistence for a few species against applying lower amounts of effort across more species (resulting in greater numbers of species surviving at lower persistence levels; Di Fonzo et al, 2016).

Our analysis involved modifying the species persistence target of a well-known framework for prioritising management of threatened species, the Project Prioritisation Protocol (PPP, see *Decision Point #29*). PPP ranks species according to their cost-efficiency, and selects the set of species for conservation in order, until the budget is expended (see the box Dial triple P).

As a case-study for our analysis, we used a dataset of 700 threatened species from New Zealand with relevant information on the cost, likelihood of success, and the potential benefit of working on each species project. Specifically, we compared the conservation outcomes for our 700 species under different budgets when we reduced the PPP's target from 95% down to 5% probability of persistence.

Conservation outcomes were evaluated on the basis of the 'expected number of species saved' in each scenario, which is a metric that takes into account the number of species prioritized for conservation management, their respective probabilities of persistence, as well as the total probability of persistence of all unmanaged species.

Is it better to put all your eggs into one (or a few) basket(s) (invest all your resources on a few species with high persistence targets) or spread them out over many baskets (invest in more species at lower persistence targets)? (Image from www.forbes.com)

Key messages

- Setting **high-level persistence targets means few species can benefit** from a limited budget
- No matter how low your budget is, **it is always better to set a high persistence target** (above at least 75% probability of persistence)
- The persistence level that delivers the highest **conservation outcome is influenced by the available budget**

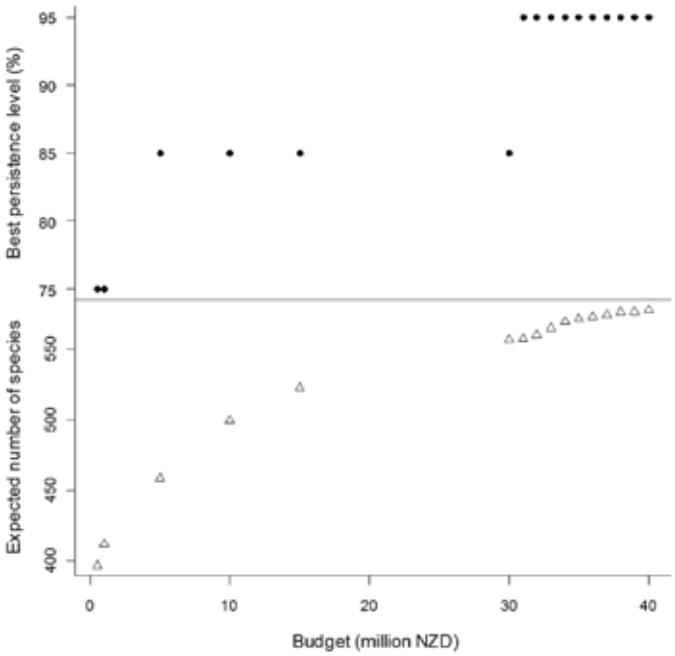

Figure 1: The upper points indicate the target persistence level (in terms of % probability of persistence) that results in the highest overall expected number of species persisting under a range of budgets. The lower triangles display the highest expected number of species under each budget (and corresponding best persistence target).

Our two main findings (summarised in Figure 1) are:

-it is always better to set a high persistence target (above at least 75% probability of persistence) in order to maximise the expected number of species saved, no matter how low your budget is; and

-the persistence level that delivers the highest conservation outcome is influenced by the available budget, such that lower budgets have slightly lower optimal targets.

It is important to note that we identify a threshold target of 75% probability of persistence, below which it is never optimal to aim for.

These findings demonstrate how the practice of undertaking low levels of management on more species (to give the impression of working on a wider range of species) can become inefficient when resources are spread too thinly.

The key message of our study is that it is important to carefully consider what target to aim for in order to achieve the greatest gains in conservation. We hope that our findings can be used to encourage conservation planners to maintain high targets (above 75% probability of persistence), but also to get them to question the value of setting even higher goals of 95% probability of persistence, which we believe might be 'over precautionary'. Indeed, working with a severely constrained budget makes the aspiration of a 95% probability of persistence sub optimal, because many other species will miss out.

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Dial triple P for better conservation outcomes

In 2009, Liana Joseph worked with conservation managers from New Zealand to develop a framework to guide the allocation of limited resources to save the greatest number of threatened species (Joseph et al, 2009). The framework was called the Project Prioritization Protocol and it comprises nine steps:

1. Define objectives (eg, maximise the number of species with 95% probability of persistence in 50 years),

2. List biodiversity assets (eg, threatened species),

3. Weight assets (eg, according to cultural significance, economic importance, evolutionary significance and so forth),

4**. List management actions** required for each asset to meet the objective,

5. Estimate the cost of each action,

6. Estimate the benefit to the species generated by carrying out the complete set of actions required to meet the objective,

7. Estimate the likelihood of success of each action,

8. State the constraints (eg, the budget limitation), and

9. Combine information on costs, values, benefits and likelihood of success to rank projects according to their benefits per unit dollar (E), using the following equation:

$E=(W \times B \times S)/C$

Where W is the weight, B is the difference between the probabilities that a species will persist in 50 years with and without this project; S is the product of the probabilities of 'input' (ie, implementation) and 'output' (ie, technical) success of all actions, based on expert opinion; and C is the cost of all the actions required to ensure a specific level of persistence. The process of prioritization starts by funding all species projects, then successively excluding projects with the lowest cost-efficiencies until the target budget is met. The weightings of the remaining species are iteratively updated as species are excluded.

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(And see the story on PPP in *Decision Point #29*).

Do you invest in saving the pigeon, the shag or the fern? How do you prioritise your choices with a limited budget? One way that is both robust and transparent is to compare the cost effectiveness of the different actions available to secure the persistence of each species. (Photos by Martina Di Fonzo)

How often, how far, how risky and how biased?

Movement behaviour mediates the impacts of habitat fragmentation at multiple scales

By Lorenzo Cattarino, Clive McAlpine and Jonathan Rhodes (University of Queensland)

Imagine you are an adult koala sitting on the top of a tall blue gum in a patch of forest located in an urban area of the Australian east coast. You mainly move among nearby trees and rarely venture away from your patch of trees. Your young offspring, however, is growing fast and will soon need to find a new tree away from yours.

There are two are major obstacles you and your offspring are facing if you want to move away. First, a few residential lots have recently sprung up in the area, with artificial ponds and child playgrounds, which have made it more difficult to reach the other trees within your forest patch. Second, the wheat crops at the foot of the hill have recently been expanded and now the forest patch on the hill looks much further away. To make matters worse, a few unfriendly dogs roam those fields, making it a quite inhospitable place for a koala. You are quite concerned: Will I be able to breed again the next reproductive season? Will my offspring be able to find a new home and reproduce? Will we still be around at all in a few years' time?

Fragmentation at different scales

Fragmentation of a species habitat – ie, the subdivision of intact habitat into small and isolated habitat fragments – is a major threat to the long-term persistence of species. Fragmentation can also occur at different spatial scales (eg, within a forest patch and between different forest patches), driven by different land uses (eg, urban development and agricultural expansion; See *Decision Point #82*).

We know that when habitat is fragmented simultaneously at multiple spatial scales, species need to move a lot more than when habitat is fragmented at one scale at the time (Cattarino at al. 2003). However, moving more requires effort (=energy that could be used for other purposes such as reproduction) and increases exposure to predators.

What we still do not know is how fragmentation at multiple scales affects the chances of an individual to reproduce and survive. Is fine-scale fragmentation more important? Or, is it coarse-scale fragmentation? Do different scales of fragmentation interact? Also, will the impacts of fragmentation within the forest patch, and between forest patches, be the same for our adult koala (that does not move much) and its travelling offspring? These questions are of fundamental importance to develop conservation strategies to mitigate habitat fragmentation and aid persistence of species in human-modified landscapes.

Example of fine-scale vegetation fragmentation (individual trees fragmented by urban development, NSW). (Image http://www.wagga.nsw.gov.au/city-of-wagga-wagga/recreation/lake-albert)

Key messages

- **Different scales of fragmentation have lethal consequences** for animals with certain movement traits
- For at-risk species, the **impact of fine-scale fragmentation** was **accentuated when fragmentation also occurred at the coarse scale**
- The land use to target with conservation actions to reduce fragmentation **depends on the scale at which fragmentation** occurs **and the movement behaviour traits of the species** of conservation concern

Building model landscapes

To shed some light on these questions, we first constructed a computer model of the life cycle of an individual animal that adopts different types of movements:

- short and tortuous movements within foraging areas; and
- long and straight movements between foraging areas.

We made sure that the chances that an individual survived and reproduced during the cycle depended on how far the individual moved to find habitat.

Next, we constructed artificial landscapes where habitat could be simultaneously fragmented within foraging areas (fine scale) and between foraging areas (coarse scale).

We then simulated the fragmentation of the habitat occurring at fine scale and coarse scales at the same time. To detect how this manipulation affected individual reproduction and survival, we recorded the total number of offspring produced by an individual during its lifetime. We repeated the analysis for individuals that adopted different types of movement with different frequencies, covered different inherent distances when moving between foraging areas, and incurred different risks of mortality when moving between foraging areas. We also

Example of coarse-scale vegetation fragmentation (forest patch surrounded by crops, South Brigalow Belt). (Image by Clive McAlpine)

considered individuals who were unable to distinguish suitable from unsuitable habitat when moving ('low habitat selection') and individuals who could move in the direction of suitable habitat ('high habitat selection').

Traits of movement behaviour are the key

According to our analysis, different scales of fragmentation could turn out to be potentially lethal for animals with a suite of movement traits. These include: (1) high frequency of movements between foraging areas, (2) large inherent movement distances between foraging areas, (3) high risk of mortality when moving between foraging areas, and (4) high habitat section. For such animals, the impact of fine-scale fragmentation was accentuated when fragmentation occurred at the coarse scale as well (Figure 1).

How might these findings help protecting species in fragmented landscapes? By guiding our efforts to manage habitat fragmentation. For example, if we want to improve the long-term survival of sedentary individuals, then we should aim to minimize fragmentation at finer scales.

In addition, thanks to our recent work on the causes of fragmentation at different scales, we can also improve land-use management. For instance, the future of sedentary individuals might look brighter if we direct conservation actions, such financial schemes that promote revegetation or retention of native vegetation, towards the land use that is responsible for fine-scale fragmentation. On the other hand, if our priority is to conserve highly mobile individuals, then we should target with management actions the land uses causing fragmentation at both fine and coarse scales.

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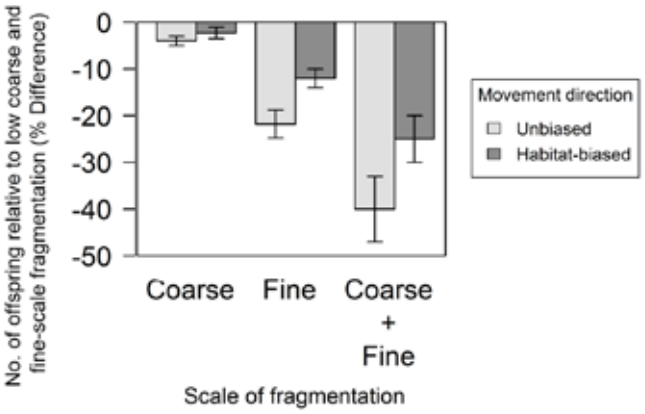

Figure 1. Bar chart showing the decrease in the number of offspring (average ± 1 Standard Error) produced when fragmentation occurred at different scales, relative to the case when no fragmentation occurred. The bar shows the case of animals that frequently move between foraging areas, covered large inherent distances between foraging areas, and have high risk of mortality when moving between foraging areas. Results for animals with different degrees of habitat selection are also shown.

Conservation planning in a very complex region

The 3rd International Workshop in Advancing Conservation Planning in the Mediterranean Sea

Back in 2012, a group of conservation researchers led by CEED scientists established a series of workshops that aimed to bring together scientists and managers working on conservation planning in the Mediterranean Sea (one of most human-impacted and jurisdictionally complex seas in the world). The aim of the workshops was to discuss gaps and challenges in the region and advance collaborative efforts, and enhance novel work leading to better science-based support for managers and policy makers based in and around the Mediterranean Sea.

The first workshop took place in Santorini, Greece in 2013. The second workshop took place in Nachsholim, Israel. The third workshop took place in Lecce, Italy, last year.

The Lecce workshop saw 21 people meet from eight Mediterranean and extra-Mediterranean countries (Australia and USA). Over two days, participants discussed the challenges faced by this complex region in devising comprehensive spatial planning both in coastal and in deep-sea environments. The researchers also sought to provide a framework for the implementation of marine conservation plans that accounted for invasive species.

Within the Mediterranean Sea, marine/maritime spatial planning (MSP) within the EEZ of countries is now mandated by the EU Maritime Spatial Planning Directive and as part of the Marine Strategy Framework Directive. This represents an unprecedented opportunity to include conservation planning in the broader planning of marine uses with the aim of reconciling environmental protection and economic goals.

"While general lessons and models for implementing marine spatial planning can be derived from previous experiences in northern Europe and around the world, comprehensive spatial planning in the Mediterranean faces additional challenges associated with the political and governance complexities of a semi-enclosed sea shared by 22 countries and rapid demographic, policy and environmental change," says CEED's Associate Professor Salit Kark, who has been a driving force and co-chair of the Mediterranean workshops.

"The Lecce Workshop discussed the challenges faced by this complex region. Insights from our analysis will provide guidance for how to incorporate future change in spatial planning in other marine ecoregions."

The workshops have resulted in over ten peer reviewed papers to date dealing with Mediterranean Sea conservation.

"We hope this tradition of collaborative research on Mediterranean conservation planning that we have begun, and CEED has supported, will continue long into the future," says Kark.

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And see *Decision Point #73* for background on the work being done in this region.

About CEED

One of legacies of CEED is the network of people it brings together. Here are a few of the faces of that nework, the people behind the stories in this issue of *Decision Point*.

Elisa Bayraktarov & Megan Saunders

Elisa's research interests are in the effects of global and local threats on endangered ecosystems and species in a changing future. Her current research at the University of Queensland (and involving several CEED scientists) focuses on the feasibility of different forms of coastal marine restoration (see the story on page 4) and the establishment of tracking indices for threatened species. The paper on restoration was co-authored with Megan Saunders, also based at UQ.

Elisa Bayraktarov

Megan Saunders

Megan's research examines how environmental variability affects marine organisms and ecosystems. Her current research aims to understand how coastal habitat restoration affects marine species. (And see Megan's story on sea level rise and sea grass in *Decision point #72*)

Peter Vesk

Peter is something of a jack-of-all-trades. Based at the University of Melbourne, he has a particular interest in comparative ecology, quantitative methods, and inference and modelling (especially for applied ecological problems). His quest is to improve our ecological management through better knowledge and better use of that knowledge. A good point in case is his work on the lessons we can draw on habitat restoration for the grey-crowned babbler (see page 10).

Moreno Di Marco

Moreno is a post-doctoral fellow at the University of Queensland. He's interested in the identification of global- and local-scale conservation priorities, using systematic conservation planning techniques and with a focus on international biodiversity targets. He's also interested in global conservation policy and the reciprocal feedback between conservation policy and conservation science. On page 11 he explores the notion of 'irreplaceability' and 'importance' in identifying priority areas for conservation.

Martina Di Fonzo

Martina's interest is in the analysis of population-level extinction risk. She has applied this analysis to develop methods for multi-species conservation prioritisation and to re-evaluate the concept of 'minimum viable population size' using decision theory. Recently she has been involved in a working group examining resource allocation problems for threatened species using the Project Prioritisation Protocol (see page 14).

Bonnie Wintle

Bonnie is an environmental decision scientist. She's interested in improving judgements and decision making in environmental science (namely risk analysis) ecology and natural resource management. Bonnie has just joined the Centre for the Study of Existential Risk at the University of Cambridge where she will be 'horizon scanning' for extreme risks associated with new technologies, such as Artificial Intelligence and synthetic biology. On page 6 she discusses horizon scanning and what it has turned up in recent years.

Matthew Holden

Matthew's research is at the interface of ecology, natural resource management and mathematics. Current and past projects include: improving pest management in sustainable agriculture, optimal detection and control of invasive species, the effects of habitat fragmentation on the conservation of endangered species, and quantifying the difference between the management of harvested populations using human intuition vs. using the output of mathematical models (as discussed on page 8).

Tim van Gelder

Tim is a philosopher by training who now provides facilitation, consulting and training services in analytical thinking for organisations. He's also a Principal Fellow at the University of Melbourne. Tim's career has traversed cognitive science, information design and software development, and these days he describes himself as an 'applied epistemologist'. One area he is helping people with is argument mapping (and you can read all about what this is on page 9).

Noam Levin

Noam has been interested in maps since he was a child, and in his professional life has pioneered many new methods of analyzing spatial information (including the use of historical maps, GIS layers, aerial photographs and satellite images). In this manner he studies geographical and environmental patterns and processes of land cover changes in the face of human and climate induced changes. His latest investigation involved mapping where people go using Flickr data and night lights (see

Workshopping the network

How can research on social networks be best applied to natural resource management? This was the focus of a recent CEED workshop in Brisbane that brought together researchers from around Australia and across the world.

Social networks consist of people – such as land holders, managers, government officials and organisations– and the relationships and exchanges that tie these 'actors' together. How the network is organized and functions has been identified as a key determinant of participation and performance in environmental programs.

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

Participants at the CEED workshop came from the University of Queensland, University of Melbourne, JCU, UWA, RMIT, University of Tasmania, CSIRO and the Stockholm Resilience Centre. Jointly organized by researchers from UWA and UQ, the workshop explored the theory, methodology and strengths and weaknesses associated with the application of social network analysis in NRM.

"Our discussions revealed the importance in considering the value of information obtained from social-network analysis relative to the costs associated with data collection and the risks associated with poor response rates," says UQ's Courtney Morgans, one of the workshop conveners. "Reasonable justification also needs to be given as to how the network of interest will be bound. For example, is it more appropriate to bound the network at an institutional level or a geographic region? Will it be feasible to obtain a comprehensive dataset at this level?"

In addition to these practical considerations, the workshop explored theoretical assumptions relating to the position of the social network on the causal pathway: does the social network shape management effectiveness or is it that social processes shape the social network.

Social networks can be used in multiple ways, from simply describing a system, to understanding the processes that drive the formation of a system, through to informing analysis for improved decision-making. How social network analysis can be best used to inform practical recommendations for NRM will form the focus of several upcoming papers.

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Workshopping social network analysis

A Macaroni penguin with attached tracking device. (Image by A Sheffer)

Tracking seabirds for conservation

Seabirds are arguably the most threatened group of birds on the planet and conservation scientists all around the planet are working to understand how we can better protect this group of animals. Many studies involve tracking the movements of these highly mobile birds using a suite of tracking technology (telemetry). CEED recently joined forces with BirdLife International to run a workshop on the use of tracking data to define marine protected areas (MPAs). The workshop formed part of the 2nd World Seabird Conference in Cape Town, South Africa held in October 2015. Around 150 people attended the workshop. Participants ranged from senior scientists to students and NGO representatives.

Seabird declines are being driven by a range of threats both on land and at sea. On land, nests are raided by invasive species such as rats and cats, and at sea climate shifts and fishing reduce fish stocks and the availability of food. Seabirds are also often snared in the fishing gear being deployed by boats (it's estimated around a million seabirds die this way every year).

"Marine Protected Areas are one of the tools needed to reverse declines in seabird species," says CEED's Jennifer McGowan, one of the organisers of the workshop. "MPAs can be an effective in a number of ways such as by protecting seabird prey and reducing bycatch mortality (when individuals die in fishing gear)."

As nations race to meet the goal of establishing 10% of their territorial waters as marine protected areas by 2020 (Aichi target 11), the 'game is on' to ensure those protected areas are actually conserving threatened seabird species.

"There is an opportunity and need for researchers and conservationists working on seabird conservation to communicate what the priorities are," says McGowan. "There's a need to make data available to the global effort to design networks of MPAs.

"Much data is now stored in the Tracking Ocean Wanderers database, an online repository of tracking data hosted by BirdLife International. The database holds information for over 100 seabird species. It is a key tool for seabird conservation."

Seabirds, like migratory waders, often require multiple distribution maps that reflect their feeding preferences in different seasons and age classes. Indeed much of the hard won data collected by seabird ecologists can inform these maps and the vast majority of the talks at the conference presented new insights on species distributions.

"One of the key challenges for the future is how to ensure the wealth of ecological knowledge derived from telemetry-studies is used to establish a global networks of MPAs that can maximise benefits to seabirds," says McGowan. "This will require new collaborations, communications and science to enable this research to lead to practical conservation actions."

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CEED leads international effort to make more of scenarios

CEED recently joined forces with CSIRO and the Belmont Forum project 'ScenNet' to explore ways that scenarios and models could be better used in setting and implementing conservation policy at national to global scales. (ScenNet is a global collaboration of researchers working on scenarios and models to support conservation assessment and decisions.)

Developing environmental policy at national-global scales is a complex task. Examples include the setting of Aichi Targets under the Convention on Biological Diversity (CBD) or the negotiation of a trade agreement such as the 'Trans-Pacific Partnership' (and agreement that has significant implications for biodiversity and ecosystem services). There are many variables at play; literally millions of stakeholders, countless possible outcomes, and considerable uncertainty. One way of making the process more tractable, thorough and transparent is by using models to explore potential outcomes of decisions under a range of future scenarios. (An excellent recent example of the use of scenarios to explore future economic and environmental outcomes under different policy settings is CSIRO's Australian National Outlook).

The potential role of biodiversity and ecosystem service models and scenarios in policy and decision-making was highlighted in a report recently ratified by the International Platform for Biodiversity and Ecosystem Services (IPBES). How to convert this potential into improved environmental decision-making was the topic of the workshop run by CEED, CSIRO and the Belmont Forum at Lorne on Victoria's south coast. (The workshop was convened by CEED's Brendan Wintle and CSIRO's Simon Ferrier)

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

"The workshop was prompted by our observation in the recent IPBES assessment that models and scenarios are commonly used to inform and support decisions at local scales, but almost never used in any kind of structured way in big decisions at national scales and above," says Brendan Wintle. "There is a lot of scientific literature on using modelling and scenarios in decision-making processes, but this work does not seem to have made its way into real world applications at national to global scales."

The Lorne Workshop bought together 23 researchers and policy makers working in a variety of areas. There were conservation biologists, economists, social scientists, human geographers, policy scientists and mathematicians from both here in Australia and overseas, with speciality in marine and terrestrial environments. IUCN, CBD, IPBES and WCS representatives took part in the meeting, providing a strong global policy perspective.

"Having researchers from diverse backgrounds – geographically, institutionally as well as from different fields of research – generated many interesting perspectives," says Natasha Cadenhead, one of the workshop coordinators. "I think we came up with some excellent ways of encouraging the uptake of models and scenarios."

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

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

"The meeting was particularly refreshing in going beyond speculative scenario-building, which is academically fascinating but has rather little impact on actual decision-making," says Thomas Brooks, IUCN's Head of Science & Knowledge. "The workshop explored new techniques like target-seeking scenarios, which start with goals agreed to by society (like the new Sustainable Development Goals), and then run models backwards to shed light on the combinations of decisions necessary to achieve these targets."

The planned outputs of the working groups will be further refined at a CBD meeting in Montreal at the end of April with anticipated publication of these outputs throughout this year.

As to engagement with Australian biodiversity, one yellow-bellied glider, several koalas, a feather-tailed glider and platypus were observed by participants at the Lorne Workshop. (One or two birds may have been noticed too.)

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