DECISION POINT

Connecting conservation policy makers, researchers and practitioners

Issue #94 / February 2016

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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

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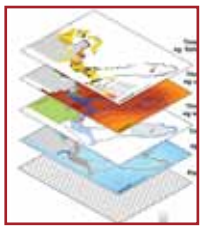

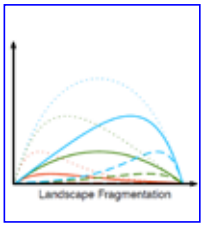

Pictured here are black-faced woodswallows. Some bird researchers consider these woodswallows are woodland-dependent birds but many don't (they are classified as a woodland bird in 37.5% of lists). Hannah Fraser explores the consequences of this inconsistency for conservation science. (Photo by Eric Vanderuys)

On the point

On threat and service

Two themes dominate many of the stories in this issue of *Decision Point*: managing conservation threats and accounting for ecosystem services. While these are quite different topics, underlying both of them in this set of articles is a plea to look at the bigger picture. What is the context of the threat or the ecosystem service being studied and managed?

The Tulloch twins (Viv and Ayesha) get the ball rolling in a discussion about threat maps and the danger of considering a threat in isolation of other threats (page 4). Focussing on a single threat is usually inadequate and wasteful. Focus on the fox, for example, and you risk a bigger problem with rabbit numbers exploding.

Nancy Auerbach continues on this topic (page 8) looking at interactions between management actions for different threats. Accounting for these interactions helps with the setting of effective conservation priorities. And she discusses how this might play out in the Burnett-Mary NRM Region.

Ecosystem services is another lens we use to set conservation priorities. It's an idea that's been floating around for a while now being advocated by many institutions including the MA, CBD, TEEB and IPBES (while I'm sure you know what these letters mean, we spell them out on page 13). However, Maria Martinez-Harms and Kerrie Wilson looked at the literature on ecosystem services (page 12) and found most of the assessments done so far were poor at involving stakeholders and developing user-related measures of the delivery of ecosystem services.

And Matthew Mitchell looks at the connection between landscape fragmentation and ecosystem services (page 10). He proposes a framework based on the supply, flow and provision of ecosystem services, and suggests this might be a good way to engage with the process of fragmentation.

And who are all these people I've just mentioned? They are part of CEED's intellectual muscle and in a new section (About CEED, page 14) we introduce you to them. How's that for service?

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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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Major shortfalls in marine conservation

A new study says that more than 17,000 marine species worldwide remain largely unprotected. The authors (including several CEED researchers) looked at the ranges of some 17,348 species of marine life, including whales, sharks rays and fish, and found that 97.4% have less than 10% of their range represented in marine protected areas.


Photo Catlin Seaview Survey

http://ceed.edu.au/ceed-news/ceed-media-releases/322-major-shortfalls-identified-in-marine-conservation.html

Migratory birds lack protection

CEED scientists have called for a greater international collaborative effort to save the world's migratory birds, many of which are at risk of extinction due to loss of habitat along their flight paths. More than 90% of the world's migratory birds are inadequately protected due to poorly coordinated conservation around the world. The research found huge gaps in the conservation of migratory birds, particularly across China, India, and parts of Africa and South America. This results in the majority of migratory birds having ranges that are well covered by protected areas in one country, but poorly protected in another.


Photo Aleks Terauds

http://ceed.edu.au/ceed-news/ceed-media-releases/320-world-failing-to-protect-its-migratory-birds.html

A new polar protection plan

A new pathway for saving Arctic and Antarctic biodiversity from climate change has been proposed by CEED scientists: the world should tackle immediate threats like pollution, over-fishing and invasive species in both the northern and southern polar regions to boost their ability to withstand climate change. Climate change remains the greatest threat to the Arctic and Antarctic – but there is much we can do right now to alleviate its impact on the polar regions.

http://ceed.edu.au/ceed-news/ceed-media-releases/298-ceed-release-polar.html

Australian cities critical for threatened wildlife

Australian cities can help conserve the country's endangered animals and plants say CEED scientists. New research reveals that Australian cities still retain a remarkable number of threatened species. All Australian cities and towns contain species that are officially listed as threatened. Sydney has the most, at 126 species, Kalgoorlie-Boulder in Western Australia has the most distinct collection of animals found in an urban area, and Kempsey in NSW has the most unique plants.

http://ceed.edu.au/ceed-news/ceed-media-releases/325-australian-cities-critical-for-threatened-wildlife.html

Tree of life reveals insights on plant variation

CEED member Roberto Salguero-Gómez manages a plant database called COMPADRE that brings together the life histories of over a thousand plant species. In a sense, it's a window on the 'tree of life' (see the story on page 16). Now Salguero-Gómez and colleagues have demonstrated the value of this window by using COMPADRE to explain the worldwide variation in plant-life histories. Amazingly, most of this variation can be explained by just two variables: how fast the plant grows and its reproductive strategy.

"The database includes demographic records of survival, growth and reproduction standardised into population matrix models," says Salguero-Gómez. "It's a rich data resource for anyone studying plants, and will allow researchers to address important questions in the fields of conservation biology, ecology and evolution."

The identification of patterns and underlying mechanisms governing the wide array of life history strategies across the tree of life is one example of this. Understanding these patterns is of vital importance to our prediction of population persistence, extinction and diversification.

"Plants exhibit a wide range of patterns of longevity, growth, and reproduction, but the general determinants of this enormous variation in life history are poorly understood," explains Salguero-Gómez. "We have used demographic data from COMPADRE for 418 plant species from all four corners of the globe to examine how growth form, habitat and phylogenetic relationships structure plant life histories."

The plant species being considered covers most of the spectrum of plant life on the planet, from tiny annual herbs to giant trees that live for many centuries, even millenia.

"We found that life history strategies of these 418 plant species – very different species from all over the world – can be explained by an axis representing the 'pace of life' and another representing their wide range of reproductive strategies," says Salguero-Gómez. "Our framework predicts responses to perturbations and long-term population performance, thus showing great promise as a predictive tool for understanding plant population responses to environmental change."

Understanding how life history strategies are structured is fundamental to our understanding of the evolution, abundance and distribution of species. These findings suggest that fast-slow growth strategies and reproduction strategies are a general organising principle in the plant kingdom. The findings have similarities with how life history strategies are structured in mammals, birds and reptiles suggesting they are central for how life is organised on planet Earth in general.

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COMPADRE: http://www.compadre-db.org/Compadre/Home

Reference

Salguero-Gómez R , OR Jones, E Jongejans, SP Blomberg, D Hodgson, C Mbeau-Ache, PA Zuidema, H de Kroon & YM Buckley (2015). Fast-slow continuum and reproductive strategies structure plant life history variation worldwide. *PNAS* http://www.pnas.org/content/113/1/230.abstract

Beyond threat maps

Targeting threats alone won't save our wildlife

By Vivitskaia Tulloch (University of Queensland) and Ayesha Tulloch (ANU)

Too often, governments and conservation organisations have only one goal for restoring populations of declining species: to reduce what they perceive as the main 'threat'. However, the big focus on 'threat hotspots' by nations and international conservation bodies can be wasteful and inadequate. It may even push threatened species closer to the brink.

To manage threats, organisations develop and use 'threat maps'. Often these are maps of human pressures affecting species (eg, loss of forest cover due to land clearing for agriculture and urbanisation, or the location of fishing pressure in marine areas). A huge number of organisations including The Nature Conservancy, The World Wildlife Fund, and Wildlife Conservation Society have a long history of developing and using threat maps to direct limited conservation funding. These organisations typically use threat maps to do one of two things:

Key messages

- **'Threat hotspots'** focussing on single threats are usually inadequate and wasteful
- An effective conservation decision-making framework needs to **consider all the threats**
- It **also needs to incorporate** what else lives in the area, whether the threat is stoppable, the costs of alternative conservation actions and how likely they are to succeed

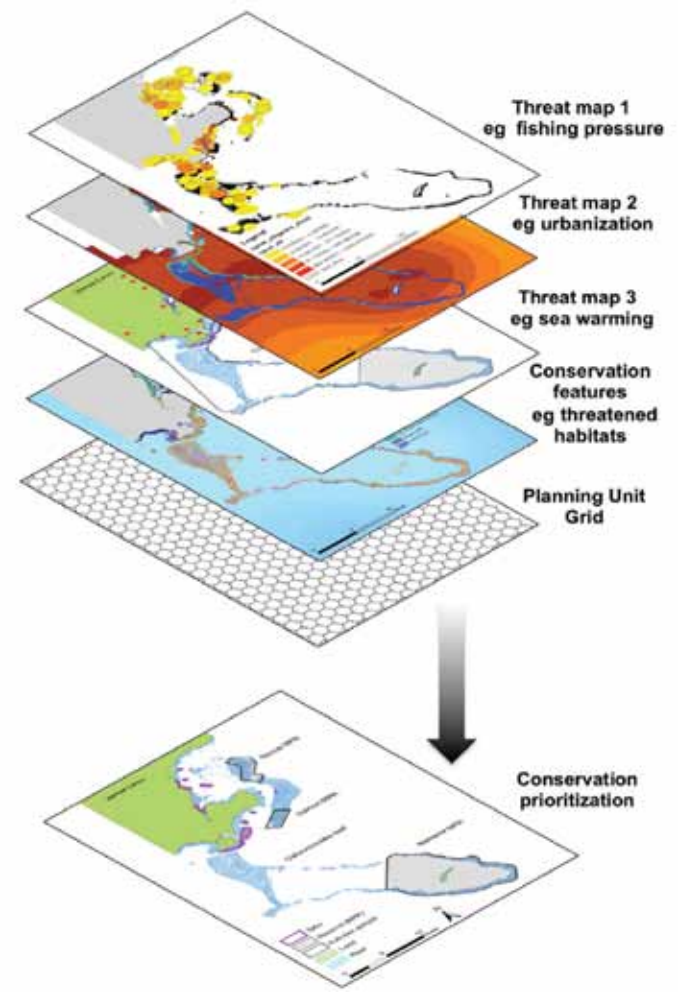

Figure 1: An example of the different maps often used in conservation planning. This example comes from a planning exercise for Marine Protected Areas in Fiji (see Decision Point #79). Traditionally, one or more of these are overlaid with conservation features and used to prioritize areas for conservation. For threat hotspot mapping, the three threat maps might be added together to develop a cumulative threat map that shows highest or lowest values in areas where all three threats are present or absent, respectively. (From Tulloch et al, 2015)

either target the areas that are the furthest removed from the threats for protecting wildlife (pristine 'wilderness' areas), or target the areas that have the highest perceived threats to wildlife and work on that threat.

Unfortunately, these kinds of traditional threat-focused approaches have a number of drawbacks. They limit conservationists to solving only one part of the problem, can be expensive compared with alternative management choices, and may have undesired outcomes if the threat being targeted is only one of a suite of problems affecting the wildlife in an area.

For example, consider Australia's numerous government-funded programs to eradicate introduced foxes in order to protect small native marsupials. If we only target the foxes with poison baiting, the numbers of feral cats and rabbits, which are suppressed by foxes, tend to boom once the foxes are gone. So in many places the small marsupials will still be hunted – only by cats instead – and the rabbits will wreak havoc in the landscape, depriving native animals of food and shelter. Continued investment in fox baiting will do little to restore these populations without new thinking about alternative actions. And this could have serious consequences for conservation.

We recently led an effort to develop a new framework for making efficient and effective conservation decisions that solve these problems. Our main issue is that reducing threats isn't a biodiversity outcome on its own. Prioritising threats rather than solutions leads us to cling to a single goal – and miss the big picture. To avoid putting all our resources into 'threat hotspots', we propose a new conservation decision-making framework that considers all the threats, what else lives in the area, whether the threat is stoppable, the costs of alternative conservation actions and how likely they are to succeed (Tulloch et al, 2015).

Through this structured decision-making process we can weigh up the pros and cons of each action, and pick the best one – the action that is not only cost-effective, but also results in positive outcomes for threatened wildlife.

Returning to our fox example, the new framework helps determine the best ways to achieve 'real' conservation outcomes, that is boost long-term survival of small marsupials, rather than simply decreasing the number of foxes. This gives us many more options besides killing foxes. For instance, it may

be cheaper to restore habitat to provide shelter that protects marsupials directly from multiple predators. Or it might be more effective to set up enclosures or guard dogs to protect the breeding locations of threatened animals – and not waste money on baiting foxes at all.

Using this structured framework helps us to pick our battles and know what we can and cannot stop. In doing so, we might find it's better to give up on one action when a threat is too difficult or costly to eliminate, and spend the money on something or somewhere else that will have a better outcome for threatened wildlife. We need new approaches such as these to help save wildlife by ensuring that actions are prioritized in locations where the best outcomes for biodiversity can be achieved – not just in the places that we can map the threat.

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Tulloch VJD, AIT Tulloch, P Visconti, BS Halpern, JEM Watson, MC Evans, NA Auerbach, M Barnes, M Beger, I Chadès, S Giakoumi, E McDonald-Madden, NJ Murray, J Ringma & HP Possingham (2015). Why do we map threats? Linking threat mapping with actions to make better conservation decisions. *Frontiers in Ecology and the Environment* 13: 91-99. http://www.esajournals.org/doi/abs/10.1890/140022

Rhinos and threat maps

With only 26,000 left alive, African rhinos are one of the most threatened animals worldwide, with numerous action groups and conservation organisations trying to save them. Despite this, poachers still kill thousands every year. To save the rhino, conservation bodies use 'threat maps' that show where poaching is worst and then put a lot of effort into trying to catch the poachers. However, poaching in turn is driven by poverty, lack of education and a booming illegal market for rhino horn. If we only target poachers, it restricts the supply of rhino horn at the same time as market demand increases. This drives up the prices – and leads to animals being killed at ever increasing rates. To overcome poaching we need to address the things which drive it in the first place – not just catch a few poachers, who will soon be replaced by others.

Threat maps only focussing on poachers are unlikely to save the African rhino. (Photo by Duan Biggs)

Small patches need greater protection

Small patches of native vegetation are critically important to biodiversity conservation and need greater protection from clearing according to a new analysis undertaken by Ayesha Tulloch and colleagues. Just because a patch of native vegetation might be small, doesn't mean we can afford to lose it.

The researchers examined historical and current patch-size distributions to evaluate how important small patches are to different ecosystems. Using data on vegetation clearing in Australian, they calculated the historical change in the contribution of small patches to overall extent.

"We found that many vegetation communities in Australia now occur disproportionately in small patches," says Tulloch. "At least 22% of major vegetation communities have over half of their remaining extent in patches smaller than 1,000 hectares. For some communities the loss of patches as small as 1 hectare would be catastrophic – for others it would make very little difference to persistence at all."

The researchers point out that many vegetation communities (such as Brigalow and Mulga in Queensland) are exposed to the double jeopardy of high loss and high fragmentation. These communities are currently undergoing increased clearing as a result of changes to clearing laws that allow clearing of land deemed to be of 'high agricultural value'. (See *Decision Point #76*)

"The long-term consequence of not accounting for the role of all vegetation patches is the continuous erosion of small patches in highly fragmented vegetation communities and the slow, inevitable decline of vegetation communities and the species dependent on them," says Tulloch. "Our approach is the first to explore the consequences of small-scale vegetation clearing due to the failure of current policies to protect vegetation patches smaller than a given threshold."

More info: Ayesha Tulloch Ayesha.Tulloch@anu.edu.au

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Tulloch AIT, MD Barnes, J Ringma, RA Fuller & JEM Watson (2015). Understanding the importance of small patches of habitat for conservation. *Journal of Applied Ecology*. doi: 10.1111/1365-2664.12547. http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12547/abstract

Clearing of mulga in central Australia. Conservation activities in heavily cleared landscapes focus on keeping the remaining large patches intact, often disregarding the increasingly important role of smaller patches in conserving biodiversity. (Photo by Michelle Venter)

What's in a name?

The consequences of inconsistently classifying woodland birds (and other terms)

*By Hannah Fraser, Georgia Garrard, Libby Rumpff, Cindy Hauser and Michael McCarthy**

**Hannah, Libby, Cindy and Mick are based at the University of Melbourne; Georgia is based at RMIT University.*

Woodland birds are bird species which depend on native woodlands. They are sometimes called woodland-dependent birds. Unfortunately, woodlands have been widely cleared for agriculture and urban development leading to a widespread belief that woodland birds must be declining. Many have studied the decline of woodland birds, most commonly studying the effect of changing tree cover and fragmentation. The results of these studies vary. Some find evidence of decline; others dispute that a decline is taking place. Similarly, the nature of the relationship between woodland birds and tree cover and fragmentation varies substantially too. These differences might be due to regional or scale differences between studies. But could there also be underlying disagreement about what actually constitutes a 'woodland bird'?

A shared understanding of the meaning of words is central to communicating ideas in all disciplines. In ecology, there have been sporadic efforts to promote consistency in terminology but little progress. Inconsistent terminology can lead to a range of problems including difficulties in finding relevant studies, redundant investigations and an inability to synthesise across studies (eg, meta-analysis). It can also create problems when communicating findings to other scientists, policy makers and the public. On the other hand, some argue that consistent terminology is unnecessary because often the meaning is clear from its context. What's more, multiple definitions of a term are thought to open fields of enquiry that might not have been possible with a restrictive definition.

So, how important is consistent terminology when it comes to determining the conservation status and trends of a group of birds loosely referred to as 'woodland birds'?

To answer this question, we systematically reviewed the literature and compiled a set of 38 lists of woodland birds. This allowed us to work out how consistently each species was classified as a woodland bird (Fraser et al, 2015). We found that 8 species were always classified as woodland birds and 13 species were always classified as non-woodland birds. The remaining 144 species were sometimes classified as woodland birds and sometimes as non-woodland birds. This surprised us as we had expected that only a few, less-well-understood species would be classified inconsistently. However, this high inconsistency suggested that further investigation was in order.

Why do researchers use different terms?

We surveyed the authors of the papers we had reviewed and found that the main reasons that researchers classify different species as woodland birds were:

- **Different aims of research:** Researchers tailor their list of 'woodland birds' to include species that they expect to respond most strongly to the phenomenon they are interested in
- **Disagreement about what a woodland is:** Bird researchers variously consider woodlands to be i) any area with trees, ii) areas with a low density of trees, iii) areas with vegetation matching Specht's classification or iv) areas designated as woodlands by vegetation maps (eg, EVC maps)
- **Disagreement about how to determine which birds depend on woodlands:** Researchers variously determine which species are woodland birds based on i) whether they saw them in a woodland, ii) whether they occur more often in woodlands than in other habitats, iii) their nesting and foraging traits, iv) what types of habitat they require or avoid (eg, do they need large areas of habitat or do they avoid degraded areas), v) process of elimination where certain types of species like water birds are excluded, or vi) whether they have been classified as a woodland bird in another article/book.

Key messages

- woodland birds are **inconsistently classified**
- this inconsistency has **a significant impact on research** involving woodland birds
- **inconsistencies in other areas of conservation science** are likely having similar impact

What impact does this have?

Georgia Garrard and colleagues modelled the effect of habitat aggregation (which is roughly the inverse of habitat fragmentation) on the occurrence of woodland birds, using a subset of species that they considered to be woodland birds (Garrard et al, 2012). We re-ran their model first using the entire complement of species and then using different subsets to emulate the effect of being increasingly selective about which species you consider to be woodland birds.

The brush cuckoo is classified a woodland bird in 62.5% of lists. (Photo by Eric Vanderuys)

We found that as you are more selective about which species you include, the estimated effect of tree cover aggregation increases. Our analysis revealed a systematic bias in results where studies which are less selective about which species are woodland birds are likely to obtain different results (probably with lower effect sizes) than those that are very selective about their classification. In other words, how you define woodland bird species has an important bearing on the results you obtain.

What does this mean? When comparing results from studies using different classifications it is impossible to know whether differences are attributable to data collection, survey area or analyses or whether they are due to differences in classification. This essentially renders all studies with non-identical lists incomparable.

This is particularly problematic for trying to understand woodland bird ecology or predict how they will react to management. Only a small subset of research uses identical lists of woodland birds, so researchers must choose between including all available information (which risks differences in classification confounding results) or only including studies which use the same list of woodland birds (which risks excluding valuable insights from other studies).

So what should we do?

This analysis leads us to suggest that woodland bird researchers should unite behind a single definition and list of woodland birds. We also believe that this is an approach that would be beneficial to ecology as a whole.

It is unlikely that woodland bird research is the only realm of ecology where terms are being used inconsistently and clouding results. If our findings hold true for other terms, we believe that it is extremely important to develop a consistent definitions of these terms. Our research shows that this is likely to be an unpopular suggestion but we believe that standardisation will make it easier to find and compile relevant evidence in the literature, avoid redundant scientific investigations and ease communication of research.

If we could standardise our approach to woodland birds we believe that there may be scope to list a woodland-bird Threatened Ecological Community under the EPBC Act. The first step towards this is identifying which species comprise a woodland bird community; then we will need to determine whether the community qualifies as threatened.

Long story short, how we name woodland birds, indeed any bird group, is important. It's about time the conservation science fraternity acknowledged this and we move to some accepted standard within which we can reliably pool our common knowledge.

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References

Fraser H, GE Garrard, L Rumpff, CE Hauser & MA McCarthy (2015). Consequences of inconsistently classifying woodland birds. *Frontiers in Ecology and Evolution* 3: 1–8. http://journal.frontiersin.org/article/10.3389/fevo.2015.00083

Garrard GE, MA McCarthy, PA Vesk, JQ Radford & 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: 14–23.

Which of the above birds are 'woodland birds'? It depends on who you ask. From the top are black-faced woodswallows (classified as a woodland bird in 37.5% of lists), the red-capped robin (classified as a woodland bird in 100% of lists) and the white-throated treecreeper (classified as a woodland bird in 94.3%). (Woodswallows photo by Eric Vanderuys, other two images by Patrick_K59 used under Creative Commons license)

Threat management and conservation priorities

Accounting for the interactions between management actions

By Nancy Auerbach (University of Queensland)

Threatened plants and animals often face multiple threats, each of which require different management actions. Because we're dealing with a connected system, actions over here create reactions over there; in other words management actions interact and those interactions can either amplify other threatening processes or, conversely, ameliorate the impacts of other threats.

For instance, more than one pest may need controlling in some areas of the landscape, so we don't create a worse situation. If both foxes and rabbits have invaded a particular area in Australia, controlling rabbits alone may lead to foxes preying more on native animals, while controlling foxes alone may result in a flourishing rabbit population.

Alternatively, reducing the effects of several threats by managing only one may also be possible. For example, many Australian mammals are vulnerable in degraded habitat, including having no escape from invasive, predatory cats. If we restore habitat with suitable refuges, perhaps investing in difficult and expensive cat control will be less important.

Choosing where we manage

To reduce costs, we can also consider interactions in choosing where we manage. When neighbouring landowners choose to cooperatively prevent the spread of weeds, they are opting to reduce a threat in connected areas. This could result in an overall cost reduction in managing weeds across the landscape.

Key messages

- **threatened species face multiple threats** that need managing
- effective management requires a consideration of **how management actions for different threats might act together**
- **considering management interactions** when choosing conservation priorities **is not common**

In all three cases (foxes and rabbits; cats and degraded habitat; and weeds in multiple locations), the best strategy would account for the interactions between management actions.

Managing for species complementarity is a good example where interaction is taken into account in conservation planning. The value of protecting species in one area depends upon what other areas have already been protected. In effect, the whole strategy of our protective action is worth more than the sum of its parts, and this enhances efficiency.

Integrating management

Unfortunately, taking interactions like this into account is not common. Generally, effects of management interactions are not well understood. Therefore it could be worth thinking about how to create integrated management strategies that take other interactions between management actions into consideration.

Threat management for the eastern bristlebird involves decreasing grazing pressure, managing fire for biodiversity, and controlling foxes. Conservation priorities differ when threat management interactions are explicitly considered, and when they are not.

One way we can select which actions we take first is to look at what economists do. Given that we have a limited budget, we can use cost-effectiveness analysis to find where we could act to get the best return on our investment. The cost effectiveness of taking conservation action in a specific location is calculated by dividing the amount of expected good we can do by the cost of doing the action.

By using this cost-effectiveness ratio to compare between different locations and combinations of management actions, we can find where we are likely to achieve the greatest benefit for our money.

Evidence suggests that we can be more efficient with an integrated strategy, as compared to managing threats independently. What hasn't been made clear is how we can make our money go further by targeting management that includes interactions, and what

happens when we do this at a regional level, where most managers work. A better understanding about the effects of management interactions could lead to better conservation outcomes.

In sum, our research finds that threatened species management that disregards interactions between actions may lead to misplaced investments or misguided expectations of the effort required to reduce threats to species. Alternatively, explicitly accounting for interactions between threat management actions may lead to better guidance in choosing where we can more efficiently act to protect our threatened species.

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Reference

Auerbach NA, KA Wilson, AIT Tulloch, JR Rhodes, JO Hanson & HP Possingham (2015). Effects of threat management interactions on conservation priorities. *Conservation Biology* 29:1626-1635. DOI: 10.1111/cobi.12551.

Focussing on the fox alone might unleash the rabbit population creating an even bigger impact on the threatened species being managed for.

Modelling costs and benefits in the Burnett-Mary Region

Our case study of a biodiverse region of southeastern Queensland (the Burnett-Mary Natural Resource Management Region) quantified how locations chosen for action, investment needed, and benefits expected differed when management interactions were taken into account (Auerbach et al, 2015). Threatening processes (for threatened species) included habitat degradation by domestic stock, fires that are too frequent and intense, and predation by the red fox.

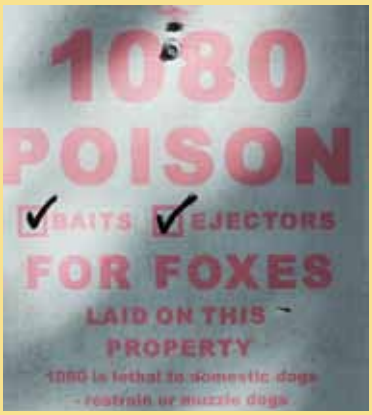
To quantify the cost of reducing threats across the landscape, we modeled the costs of decreasing grazing pressure, managing fire for biodiversity, and controlling foxes. We based our cost models on factors such as lost agricultural profit if stock are removed from an area, differing expenses of managing fire in peri-urban and rural areas, and wages for setting bait stations (fox control) at varied distances from roads.

We created species distribution models to determine where we thought habitat would exist for the threatened species in our study area, and overlaid these maps to determine where more and fewer species were likely to have suitable habitat. To quantify the benefit we expect to receive from our three management actions at each site, we made the assumption that if we take action in a site where we think one, or a set of, threatened species is likely to have suitable habitat, those species would receive benefit from our action. We next calculated the cost-effectiveness of taking each action, and each combination of actions, by dividing the expected benefit by its cost. Finally, we ranked each site-by-action combination from high to low cost-effectiveness value, so we could order where and which set of threats we would choose to work on, given a budget limit.

We mapped cost-effective management locations when each species benefitted 1) when we managed only one of their threats, 2) when we managed only all of their threats, or 3) when we disregarded interactions. In comparing these maps, we discovered that when we managed for interactions, our decisions about where to invest, and in which actions to invest, were different than when interactions were not considered. The expected management benefit for the same amount of money was also different in these three approaches.

Next, we mapped cost-effective management locations for one threat 4) when costs were reduced in sites close to management sites previously chosen, and compared this to 5) when we didn't account for locational interactions. We found that we could manage more compact areas for less money by accounting for interactions. However, we note that habitat fragmentation may limit the effectiveness of particular management actions, and restoration may also need consideration as an additional action.

Cattle grazing, changed fire regime and fox predation are three threats confronting threatened species in the Burnett-Mary NRM Region.



Modelling the potential benefits of mitigating these threats has shown that different choices will be made depending on whether the threats are managed separately or together.

Fragmentation and ecosystem services

Connecting a fragmented landscape with human wellbeing

By Matthew Mitchell (University of Queensland)

You've almost certainly seen the results of landscape fragmentation. Look out an airplane window almost anywhere in the world and you'll see small patches of forest or grassland surrounded by fields or houses. This is fragmentation – the breaking apart of natural lands, habitat, and ecosystems into smaller pieces, usually because of human activities. Agricultural expansion, urban growth, road construction and the damming of rivers have all resulted in ecosystem fragmentation, with serious consequences for biodiversity loss.

Human-dominated landscapes though, are not only managed for biodiversity; but also to provide benefits, or ecosystem services to people. Ecosystem services are the goods and processes from ecosystems that benefit human wellbeing. This includes material goods like food, timber, fibre and water; processes such as pollination, pest regulation, flood regulation and water purification; and more intangible benefits like aesthetic or spiritual fulfillment and opportunities for recreation or education.

While the ecosystem-services perspective doesn't please everyone (some suggest it 'commodifies' nature), there is no denying that humans rely on ecosystems for their wellbeing. In turn, the generation of ecosystem services often depends on biodiversity and when species are lost from ecosystems the production of ecosystem services can decline.

As human activities fragment landscapes, how might this affect ecosystem services? We tried to answer this question by thinking broadly about how landscape fragmentation might affect services. Our goal was to produce a new framework for thinking about the effects of landscape fragmentation in order to spur new research and understanding about these relationships in real landscapes. Knowledge in this area is critical if we want to manage landscapes to optimize ecosystem services and conserve biodiversity.

Ecosystem service supply, demand and flow

The core of our framework is the idea that ecosystem-service provision depends on supply, demand and flow. First, an ecosystem has to be able to generate a potential benefit for people. There has to be some good (eg, timber, food), process (eg, water filtration, flood water retention), or experience (eg, recreation, bird-watching) that could potentially improve human wellbeing. In turn, there has to be a demand by people for that good, process or experience. Without a human need for timber, clean water, or recreational opportunities in a landscape, an ecosystem service can't be realized. In other words, a person actually has to benefit before an ecosystem service is produced. Finally, people have to interact with ecosystems to gain a benefit. This interaction is what connects supply and demand and produces an ecosystem service flow. Flows occur when people harvest timber from a forest, drink clean water provided by an ecosystem, or pursue outdoor activities.

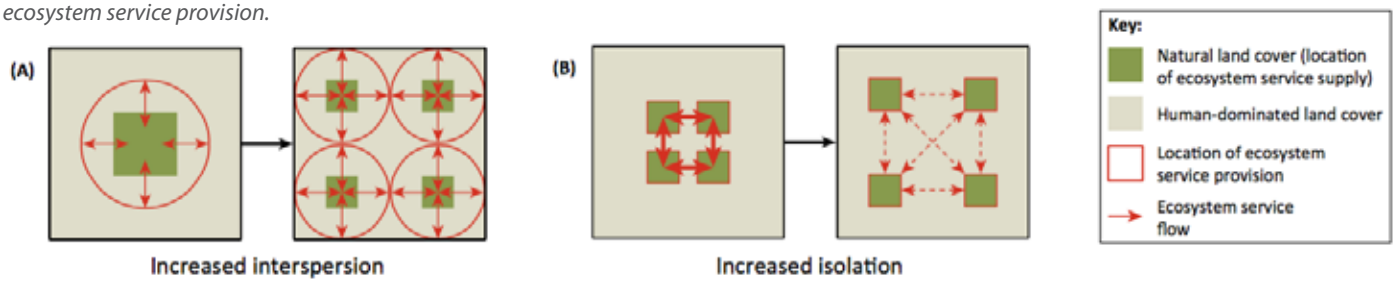
For most services, flow depends on the movement of organisms, matter or people. As an example, think about a local park where people might go to bird watch. This service depends equally on the park's capacity to support a diverse bird community (the supply) and the presence of people that like birds and don't mind getting up early (the demand), but also on the ability of people to access the park to watch birds (the flow). If the park is remote, or doesn't have easy access, then very little bird-watching will occur, despite the presence of different unique bird species and a local bird-watching community. Without a connection between the two, provision of this specific ecosystem service will be small or non-existent.

Other ecosystem services also depend on movement for a service flow to occur. For example, pollination of crops depends on pollinators being able to move from patches of forest or meadow into agricultural fields. Similarly, bio-control of crop pests depends on the movement of beneficial insects from

Key messages

- **natural landscapes are being fragmented** in Australia and around the world
- not only does this impact biodiversity**, it also disrupts the provision of ecosystem services**
- we propose a new framework that examines **the supply, demand and flow of ecosystem services as a means of assessing the impacts of fragmentation**

Figure 1: Two possible effects of landscape fragmentation on ecosystem service provision.



nearby ecosystems into fields; drinking water supply on the flow of surface water or groundwater to areas where people can collect and consume it; fisheries on the movement of people to fishing locations; and recreation, educational and spiritual services on the ability of people to travel to and access natural ecosystems.

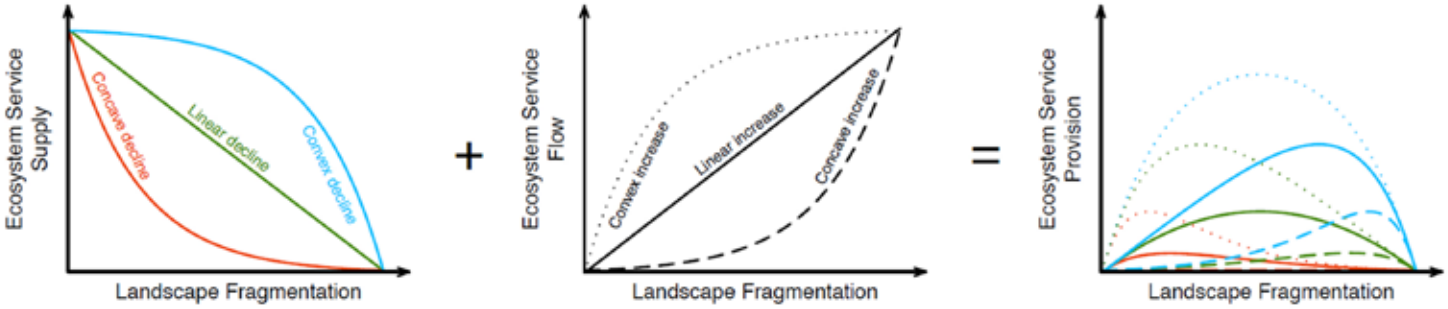
Contrasting effects of fragmentation

What we realized was that fragmentation can impact these flows both positively and negatively. An obvious effect of fragmentation is a reduction in the ability of organisms or matter to move across landscapes. In other words, the connectivity of the landscape for different species is reduced as a landscape is fragmented (Figure 1).

Roads, pipelines, clear-cuts, housing developments, fields and other human disturbances often negatively affect the ability of organisms to move across landscapes. If this movement is key for an ecosystem service like pollination or seed dispersal, then fragmentation will have a detrimental effect. Similarly, fragmentation can also affect human movements, reducing our ability to interact with ecosystems. For example, dams fragment rivers and can reduce their potential for recreation.

At the same time, fragmentation can also increase ecosystem service flow by increasing the interspersion of people and ecosystems. By putting areas of service supply and demand in closer proximity, service flows could increase. It is well known that small patches of forest or grassland interspersed within cropland can be effective at maximizing pollination or bio-control. Because pollinators and other insects only move specific distances across landscapes, small and regularly placed forest or meadow patches provide a more even distribution of these organisms than a single large patch. The same principles apply to human movement as well. More fragmented, but evenly distributed parks across cities can increase park access and visitation, with positive consequences for human health.

Figure 2: If landscape fragmentation negatively affects service supply (left panel) but positively affect service flow (middle panel), then complex patterns of ecosystem service provision with fragmentation can occur (right panel).



These conflicting effects of fragmentation on ecosystem service flow mean that predicting how fragmentation might affect service provision is much more complicated than we might first expect (Figure 2).

While extreme levels of fragmentation will likely cause levels of biodiversity loss that will result in significant loss of ecosystem services, intermediate levels of fragmentation could help maximize service flow and provision where interspersion is important. For other services where landscape connectivity is key, fragmentation could rapidly drive service loss via the simultaneous loss of biodiversity and landscape connectivity. Realizing that fragmentation has these conflicting effects on ecosystem services in human-dominated landscapes is a significant shift in our thinking.

What next?

The critical next challenge is to test this framework in real landscapes. We need information on the specific relationships between fragmentation and service provision, as well as the mechanisms that underlie these patterns across different services and types of landscapes.

At the same time, we need to work on integrating this knowledge into decision-making. Land-use decisions at a variety of scales affect levels of fragmentation across human-dominated landscapes. A concerted effort is needed to integrate scientific understanding of fragmentation and service provision with landscape planning policies and mechanisms to ensure that we create sustainable and multifunctional human-dominated landscapes.

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Making more of the concept of ecosystem services

How ecosystem services can better inform environmental decisions

By Maria Martinez-Harms and Kerrie Wilson (University of Queensland)

Ecosystem services are the benefits people obtain from ecosystems. In recent years they have become an important concept in science and policy arenas. This is reflected in a substantial growth in scientific research and widespread calls for integrating ecosystem services into management decisions. But how much of a contribution are assessments of ecosystem services actually making? We reviewed the scientific literature (Figure 1) and found that ecosystem service assessments are not covering all elements of the decision-making process. The assessments we reviewed were particularly poor at involving stakeholders in setting objectives and developing user-related measures of the delivery of ecosystem services.

Key messages

- **ecosystem services is a timely and relevant concept** in the science policy interface
- **most research on ecosystem services does not cover all elements** of the decision-making process
- **future assessments need to better articulate** objectives, identify performance measures and consider the alternative actions

The social-ecological context

Assessments of ecosystem service have incorporated a variety of ecological, social, abiotic, land use, and economic data, although it is unclear whether this reflects a desire to better understand the social-ecological context per se (Figure 2). We observed preferences towards particular types of data for estimating different categories of ecosystem service. For example, economic data have been mainly used for provisioning services such as food or water provision; ecological data for regulating services such as climate regulation and flood control; social data for cultural services such as recreation and tourism; and land-use and land-cover data for both provisioning and regulating services.

Overall, we observed a strong preference towards the incorporation of land-use and land-cover data in ecosystem service assessments. A more comprehensive evaluation of the social-ecological context would involve identifying what stakeholders wanted to know about different services and who are the potential beneficiaries. We also need to evaluate access to capital, technology and labour. These aspects ultimately determine the provision or perceived value of many services and would provide a more explict appraisal of the socio-ecological context.

Setting objectives

Objectives describe the outcomes that are being sought and the concerns that are being addressed for the management decision. The choice of objectives influences all aspects of the decision-making process, and it is essential that the outcomes of alternative actions be evaluated against the objectives. However, only a small number of the scientific publications have stated clear objectives (10%) and even a smaller number (8%) set objectives through stakeholder consultation.

Performance measures

Performance measures, the quantitative expressions of the objectives that are used to evaluate the performance of alternative management actions, describe how much of a service can be sustainably consumed in relation to the supply, or thresholds for its use. Only 8% of the studies we reviewed applied performance measures and predominately this was in the form of targets for the supply of an ecosystem service. The majority of studies have quantified ecosystem services as measures of the biophysical potential of ecosystems to supply services, irrespective of its use. By definition, ecosystem services provide benefits to people and therefore measuring only the potential supply of ecosystem services will deliver only partial information. Quantification of the final services delivered to and consumed by society will provide more realistic estimates of the value of ecosystem services.

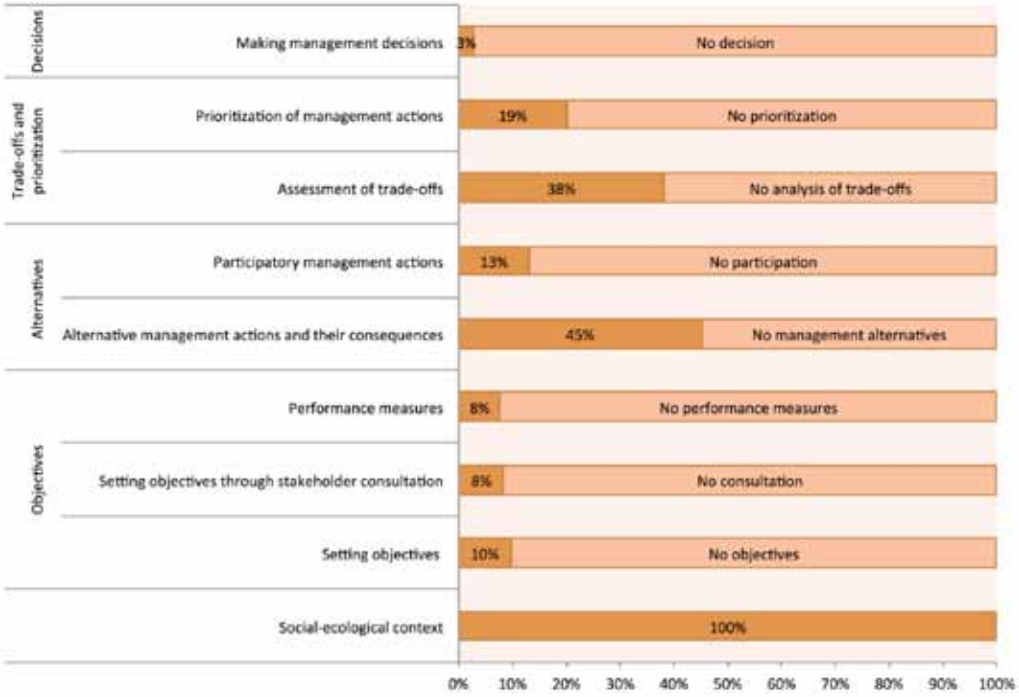

Figure 1: The proportion of scientific papers that address each of the core steps of a formal decision-making process.

Alternative management actions & their consequences

We found that almost half of the papers reviewed have defined and evaluated the consequences of

alternative management actions. Nevertheless only 13% of the studies we reviewed selected management actions through a process of consultation with decision-makers and other stakeholders. A consultative process of selecting and deliberating alternative actions would strengthen the dialogue with stakeholders, align the actions selected with the objective(s), and support an adaptive approach to decision-making.

Trade-offs and prioritization of management actions

The sustainable and efficient provision of multiple ecosystem services is challenging. Management decisions often involve a range of possible actions and multiple stakeholder perspectives and there is likely to be trade-offs between outcomes and potentially negative impacts. We identified that 38% of the studies we reviewed attempted to investigate synergies and trade-offs associated with ecosystem services. However, most of these studies focused on evaluating the spatial correlation and overlap between ecosystem services. Such assessments do not provide information about the trade-offs that arise as a consequence of implementing alternative management actions. We also found that only 19% of the studies reviewed have systematically assessed how resources should be allocated to alternative actions. Prioritization approaches offer new opportunities in this regard by providing information on desirable spatial locations and temporal timing for implementing alternative management actions given available resources.

Making management decisions

A decision occurs when an alternative action is selected and implemented through its internalization in policy, plans or an institutional arrangement. It is typically operationalized as some form of regulation or incentive. In the literature reviewed a diversity of potential decisions have been identified, including the use of financial incentives such as payments for ecosystem services, governance-based instruments, and the application of conservation strategies such as acquiring land. However, only 3% of the scientific papers reported the on-ground implementation of an action. This demonstrates a gap between academia and decision-making in the real world.

To bridge this gap, future efforts should capture the overall decision-making process. Such efforts should focus on articulating the objectives, identify the performance measures, and then deliberate on the alternative actions. Management decisions relating to ecosystem services should also be underpinned by the best available science and account for the values and preferences of stakeholders.

Deliberative and participatory methods could facilitate this and enable the opportunities and constraints for effective management to be identified. We see these as key ingredients for the ecosystem services paradigm to gain maximum traction in science and policy arenas.

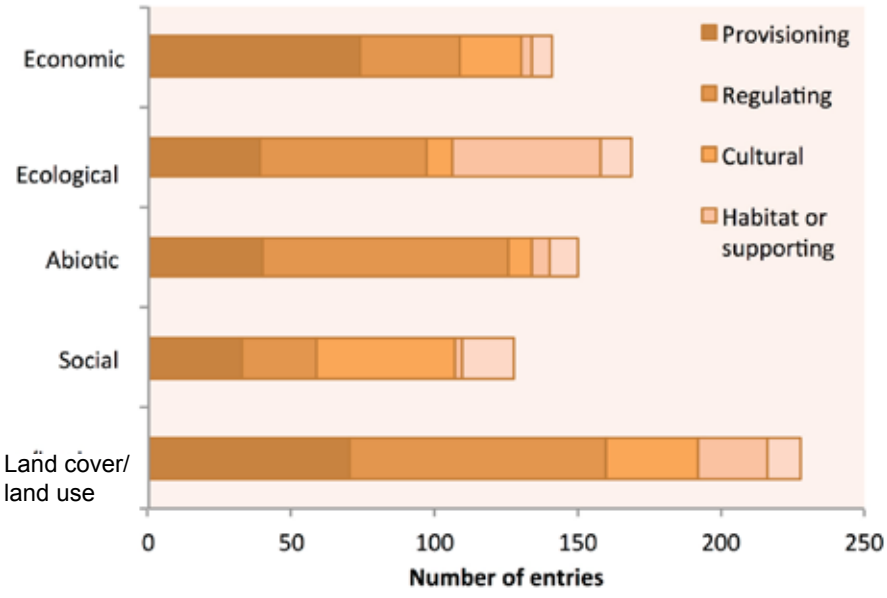

Figure 2: Social-ecological context of the studies reviewed represented by the type of data used to model different types of ecosystem services.

Who says ecosystem services are important?

Ecosystem services can be broadly defined as the processes and conditions derived from ecosystems that sustain and enhance human wellbeing. Concern over the degradation of ecosystem services has been increasingly reflected in international environmental policy. For example, several international initiatives have raised the ecosystem services paradigm to the attention of both scientists and policy makers. These included the Millennium Ecosystem Assessment (MEA), the Convention on Biological Diversity CBD), The Economics of Ecosystems and Biodiversity (TEEB) and The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Over the past two decades there has been a rapid growth in research related to ecosystem services and widespread calls for integrating the ecosystem services paradigm into real-world management decisions. However, our research suggests we still have some way to go in comprehensively addressing this issue.



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About CEED

What is CEED? Go to our website and you'll read it's a 'partnership' and a 'world-leading research centre' (for solving environmental management problems and for evaluating the outcomes of environmental actions). Of course, that's true but it says little about the people that make up CEED. At its heart, CEED is a network of people committed to undertaking excellent science that contributes to better conservation outcomes. This network is spread across Australia (and overseas) and while it's easy to figure out who are the network leaders and which institutions host the various bits of the group, it's harder to see the human faces, and what motivates them, behind the day-to-day research effort. In an effort to make these people more visible we're starting up a regular column in *Decision Point* providing brief intros to some of our people. Not only are they the doer's who create CEED's many 'outputs' and 'outcomes', in the longer run they are the real legacy of CEED's existence. Long after CEED is dead and buried these people will continue to generate quality science aimed at saving species, ecosystems and better environmental decision making.

The Tulloch twins

Ayesha and Vivitskaia Tulloch are (identical) twin sisters and conservation ecologists who both did PhDs at the CEED's University-of-Queensland node (with Viv currently in the process of finishing hers).

Ayesha is based at CEED's ANU node where she is conducting research into evaluating threats to Australian animal and plant communities, and finding the best way to track changes in these communities caused by global change and other threatening processes. Viv is focusing on managing indirect threats to different marine ecosystems, such as coastal habitats threatened by land development, and migratory species threatened by climate-induced changes to their food and environment.

The Tulloch Twins have been a force in CEED being keen participants in a range of conservation activities including running Marxan courses in Spain and playing a championing role in Eremaea eBird. You can read about some of their current research on pages 4 and 5.

Ayesha and Vivitskaia Tulloch. That's Ayesha on the right (or is that Viv; no it's definitely Ayesha).

Hannah Fraser

Hannah is just finishing off her PhD at the University of Melbourne. Unfortunately, rather than studying birds in pristine woodlands, Hannah's field work has involved studying woodland-bird researchers (see her story on page 6) over the internet and in workshops. However, in terms of adrenalin and exhilaration, this has proven even better than seeing a king brown snake after watching the dawn chorus. The lows sometimes experienced over 'differences of opinion' (sometimes verging on outright antagonism) are completely outweighed by the amazing perspectives and support these fantastic researchers have given her. Using the understanding gained from her work, Hannah is now working with a suit of these woodland-bird researchers to obtain national protection for the woodland bird ecological community under the Environment Protection and Biodiversity Conservation (EPBC) Act.

Matthew Mitchell

Matthew is a postdoctoral research fellow at the University of Queensland. He's interested in understanding how human activities alter landscape structure and biodiversity, and the benefits, or ecosystem services, that we obtain from the environment. His current research is focused on the urban and peri-urban areas of Brisbane, Queensland, but he has previously completed research in agricultural, alpine, forest, and grassland ecosystems. He completed his PhD in 2014 at McGill University where he studied the corn-soybean dominated agricultural landscapes of Quebec, Canada. You can read about his work on page 10.

Nancy Auerbach

Nancy is interested in facilitating biodiversity conservation in a changing world. She recently earned a PhD for her research into spatially explicit cost-effective threat management for threatened species (see the story on page 8), and has since been involved in field projects for northern quolls in the Pilbara, reptiles and mammals in the Simpson Desert, and the Bali starling in Indonesia. She enjoys birding and contributing to eBird. She is also very excited about a 2016 Antarctica expedition aimed at strengthening women's leadership in science and addressing climate change issues. (The project is called Homeward Bound and another CEED researcher, Justine Shaw, is helping to coordinate the science program during the expedition.)

Maria Martinez-Harms

Maria is a PhD candidate working under Kerrie Wilson's supervision. She studies the science-policy interface for ecosystem services and biodiversity to inform management decisions applying the theory and principles of structured decision making. Maria is interested in the development of methods to synthesize ecosystem services research to provide evidence that can be used in policy design and implementation (see page 13). Maria has also worked modeling and mapping ecosystem services under global change scenarios from local to regional scales in Latin America.

CEED's big bash

Every two years the ARC Centre of Excellence for Environmental Decisions brings its people together in one place to share new ideas, reflect on what's been happening and plan for the future. In December, CEED's 2015 conference was held in Canberra at the Australian National University. As always it generated a wealth of ideas, catalysed new collaborations and gave CEED's members a few insights on what their far-flung cousins (ie, members from different states and countries) are getting up to.

As with past conferences, a good deal of creativity was on display as the different nodes used a variety of techniques to convey the ideas behind their research. Researchers from the UWA set up a series of mock interviews between a 'current affairs' journalist and an archetypical regional politician, an economist and a farmer. The topics discussed were ecological restoration and ecosystem services, and the interviews explored the various values different parts of the community held about restoration.

RMIT put on a quiz show along the lines of the much loved TV program Spicks and Specks in which contestants had to guess the tune being sung using words from RMIT papers on urban biodiversity-sensitive design. Then there was the game based on Pictionary where the audience had to figure out the concept being drawn. (How do you draw the idea of 'perverse incentives'?)

The UQ node staged a play in which conservation planners drew up a reserve network for Middle Earth (which happened to be located in New Zealand) in order to best conserve giant spiders, elephants (which are now quite rare in New Zealand) and great eagles. The play explored the various tensions and trade-offs between different protected-area configurations with actors representing politicians, conservationists and researchers, all with their own points of view.

Much fun was had by all, as well as the innovative sharing of big ideas. There were also several original songs sung during the proceedings. All of which made for a memorable and possibly unique meeting for an ARC Centre of Excellence.

In addition to the inter-node presentations, the conference heard keynote addresses from Dr Fiona Cameron on the work of the Australian Research Council; Professor Peter Kareiva from TNC and UCLA on conservation in the Anthropocene; Professors Emma Johnson (UNSW) and Mark Burgman (UMelb) on gender equity and conservation science; and Professor Cath Lovelock on mangroves and sea level rise. There were also presentations from CEED's partner organisations in the United States, United Kingdom, Israel and Ireland. Throw in planning sessions, media training and nature walks and it's pretty sure everyone's interest was catered for.

UWA songbirds lament the many challenges of restoration (to the Beatles tune 'Yesterday').

Introducing COMADRE & COMPADRE

Two global demographic databases

By Rob Salguero-Gómez (University of Queensland)

Demography is simply the study of how the population of a species grows or shrinks over time. Obtaining high quality demographic information about a species is fundamental to conservation science. If a population declines too far it ultimately leads to its extinction (consider the Tasmanian tiger). If it expands too much, you may have an invasion (consider the cane toad). Not only will demographic information help us make better-informed decisions on which species need our attention before it's too late, it also guides us on what is the most appropriate action to take.

Unfortunately, obtaining demographic data can be a real challenge. It can be tedious to collect and often expensive; demographic fieldwork often involves following many individuals of several populations over multiple years to estimate their probabilities of survival, growth, reproduction and establishment. Despite this effort, the value of this information is enormous, and in recent decades population ecologists have been amassing a wealth of demographic info for both animals and plants. Until recently, however, these data were dispersed throughout the scientific literature, making it difficult to access and analyse with speed – and a rapid response is typically necessary for effective conservation.

So, when it comes to answering some of the big research questions in conservation science such as "how does climate change affect population dynamics of birds worldwide?", or "what life cycle stages should be the focus of conservation actions before the global decline of amphibian populations?" or "are sessile organisms like corals more prone to local extinction than mobile organisms like mammals?", there has been no central repository of demographic information to draw on.

It is our hope that COMADRE and COMPADRE will meet this need. COMADRE and COMPADRE are two demographic databases that I have been developing in collaboration with an international team (a project catalysed by the Max Planck Society and the ARC). COMPADRE is a Plant Matrix Database (Salguero-Gómez et al. 2015) (the name comes from the letters in 'Comparative Plant Matrix Database'), while COMADRE is an Animal Matrix Database (from 'Comparative Animal Matrix Database'). Each database is unprecedented in terms of data quality, taxonomic richness and global coverage.

What's more, access to these databases is free; COMADRE and COMPADRE are fully open-access, meaning anyone can use them. More information will be released periodically as it is digitised, error-checked and complemented with other information.

More info: Roberto Salguero-Gomez r.salguero@uq.edu.au & http://www.compadre-db.org

References

Salguero-Gómez et al. (2015) The COMPADRE Plant Matrix Database: an online repository for plant population dynamics. *Journal of Ecology* 103, 202-218.

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Big Data hits Conservation Biology

By Rob Salguero-Gómez (University of Queensland)

As a firm believer of the potential of big data for conservation biology, last year I co-organised a workshop at the UQ node of CEED together with Alienor Chauvenet (UQ), Jose Lahoz-Monfort (UMelb) and Michael Bode (UMelb) on "Big Data hits Conservation Biology". Over 30 researchers from the University of Queensland, the University of Melbourne and Southern Denmark University got together to assess how big databases such as COMPADRE and COMADRE, among others, can be used to address pressing conservation questions in Australia and around the globe.

Forthcoming manuscripts tackle these questions. We are currently working on two pieces that make a call for conservation scientists to avail themselves from all the large open-access ecological and evolutionary databases that have emerged in recent years. Another manuscript that I am leading as a result of this workshop examines the possibility to use anatomic and physiological traits as shortcuts of demographic information to predict species invasions and extinctions. Alienor Chauvenet is co-leading a manuscript on testing the ecological hypothesis that animal species' growth rates (extracted from COMADRE) are higher at the centre of their range, than on the edge.

Ultimately, I hope that the further development of COMPADRE and COMADRE will allow for a better integration of demographic data with other open-access databases (such as BIEN, GBIF, IUCN, GeneBank) to address global questions in conservation science.

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 ANU, the University of Melbourne, the University of Western Australia and RMIT. To contact us, please visit our website at http://ceed.edu.au/

Decision Point is available free at: http://www.decision-point.com.au/