

# DECISION POINT

Connecting conservation policy  
makers, researchers and practitioners

Issue #92 / September 2015

## The curlew has landed

Planning for complex  
migratory networks



**Chytrid and the corroboree  
frog**



**Aussie crayfish desperately  
in need of protection**



**Saving koalas from cars**

### Decision Point

*Decision Point* is the monthly magazine of the Environmental Decisions Group (EDG). It presents news and views on environmental decision making, biodiversity, conservation planning and monitoring. See the back cover for more info on the EDG. *Decision Point* is available free from <http://www.decision-point.com.au/>

### Plus

Detectability and environmental impact studies  
IPBES chooses Young Fellows from CEED  
A good 'fellow' for tropical forests  
Climate induced resource bottlenecks

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*Eastern curlews migrate each year from the Arctic to Australia, stopping to refuel at tidal flats across the East Asian-Australasian Flyway. Habitats across its migration are being lost to multiple threats. Managing these multiple interacting threats is a major challenge. See our story on page 10. (Photo © Dean Ingwersen)*

## On the point

### The species in question

*The work of the Environmental Decision Group is about better conservation outcomes. Sometimes, however, when the talk is all about evaluation, adaptive management, spatial optimisation and project prioritisation, it's possible to lose to sight of the purpose of the science – protecting, enhancing and restoring nature, ecosystems and species. It's kind of the reverse of seeing the forest for the trees. Sometimes all the talk is about policy and management for the forest when everyone is more interested in the beauty and wonder of individual trees. In this issue of Decision Point we bring the focus back squarely on to the value of our research to species – threatened species, declining species and species that hold a special place in our hearts.*

*Georgia Garrard kicks the ball off with a discussion on how much effort needs to go into detecting threatened species during an environmental impact study (see page 4). She illustrates her point with how much effort is needed to find the tiny spiny-rice flower in a field of kangaroo grass.*

*Ben Scheele discusses the curse of chytrid fungus, threatening over 200 frog species with possible extinction (see page 6). He focusses on the case of the iconic southern corroboree frog.*

*Lucie Bland speaks up for the freshwater crayfish of Australia (see page 8). Few people appreciate that Australia is home to around a quarter of the world's species and many of them are in trouble.*

*Migratory shorebirds are another group in big trouble. Claire Runge explains why on page 10 and outlines the many challenges surrounding their conservation (with a little story about the eastern curlew in the process).*

*Tal Polak, Jonathan Rhodes and Hugh Possingham then talk about cars and koalas (page 12), never a good pairing. And yet, with a bit of maths and clear objectives, there's a lot we could do to minimise the impact of roads on koalas.*

*Of course, each story presents insights that extend way beyond the species in question in terms of conservation outcomes. However, now and then it's nice to see the relevance of a piece of conservation science simply in terms of a species we'd like to see stick around. 🐦*

*David Salt  
Editor  
Decision Point*

## DECISION POINT

**Decision Point** is the monthly magazine of the Environmental Decision Group (EDG). The EDG 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, RMIT and CSIRO.

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## Climate-induced resource bottlenecks and species vulnerability

Resource bottlenecks – periods of severe restriction in resource availability – can be triggered by increased climate variability. This is believed to represent an important mechanism through which climate change will affect biodiversity and yet little is understood about its potential impact. Martine Maron and colleagues recently reviewed the topic. They synthesized the key global change processes that might exacerbate the severity of bottlenecks in resource availability on animal populations, and outlined how adaptation responses can help buffer the impacts.

They collated examples from the literature of population-level impacts of resource bottlenecks induced by extreme weather and climate events to explore the types of population impacts that have most frequently been recorded, and the type of extreme events associated with them. They then developed a conceptual framework that captures the factors contributing to species' vulnerability to climate-induced resource bottlenecks (in time and space) in increasingly variable environments.

They found forty-nine instances of population-level impacts from climate-induced resource bottlenecks in the published literature, including four extinctions and ten population crashes. Anthropogenic land-use change interacts with increasing climatic variability to exacerbate these resource 'crunches'. In some instances, however, they can sometimes also act as a buffer for species.

Resource bottlenecks are likely to be a large class of climate-sensitive stressors whose impacts may play out at the population scale, even well within a species' apparent climatic envelope. More effective conservation responses to climate-related threats include managing protected area networks for spatial and temporal resource complementarities and other targeted actions to buffer vulnerable species against bottlenecks. 🍌

### Reference

Maron M, CA McAlpine, JEM Watson, S Maxwell & P Barnard (2015). Climate-induced resource bottlenecks exacerbate species vulnerability: a review. *Diversity and Distributions* 21: 731–743. <http://onlinelibrary.wiley.com/doi/10.1111/ddi.12339/full>

## Can growling grass frogs cope with chytrid?

New research from Geoff Heard and colleagues demonstrates that the impact of chytridiomycosis (a disease caused by amphibian chytrid fungus) on populations of growling grass frogs (*Litoria raniformis*, an endangered species) is mediated by wetland microclimate and water chemistry. Prevalence of the disease is considerably lower in warm and saline wetlands.

It's known from previous work (on this system and others) that the prevalence and intensity of chytrid infections declines with increasing temperature and salinity (because chytrid is sensitive to both), but this new study is the first to demonstrate that these relationships have important implications for the persistence of frogs threatened by chytrid, a disease that is driving declines in over 200 species of frog around the world.

Using 11 years of monitoring data, the researchers have shown that populations of growers in warmer, saltier wetlands have a higher chance of persistence through time because the prevalence of infections is low. Moreover, they have shown that some metapopulations of growers are unlikely to survive without these warmer, saltier wetlands; that is, without their refuges from disease.

Metapopulation persistence in fragmented landscapes depends on habitat patches that can support resilient local populations and sufficient connectivity between patches. Yet epidemiological theory for metapopulations has largely overlooked the capacity of particular patches to act as refuges from disease, and has suggested that connectivity can undermine persistence. This study shows that relatively warm and saline wetlands are environmental refuges from chytridiomycosis for an endangered Australian frog, and act jointly with connectivity to sustain frog metapopulations. 🍌

### Reference

Heard GW, CD Thomas, JA Hodgson, MP Scroggie, DSL Ramsey & N Clemann (2015). Refugia and connectivity sustain amphibian metapopulations afflicted by disease. *Ecology Letters* 18: 853–863.

Note: for more information on the threat of chytrid see Ben Scheele's story on page 6. For more information on Geoff Heard's research, check out his [blog](#).

## What happens to wildlife when farmland becomes a plantation?

What happens to the wildlife in patches of native vegetation when the surrounding agricultural landscape is converted from open grazed land to closed pine plantation forest? This is far from being an academic question as this situation is increasingly common as plantations are often established on cultivated or grazed land.

Alessio Mortelliti and colleagues conducted a large-scale (30 km<sup>2</sup>), long-term (14 years) fully controlled and replicated (111 sites) 'natural experiment' in south-eastern Australia to answer this question. The study focused on the effects of changes occurring in the agricultural matrix on mammals which inhabit patches of native eucalypt woodland.

They found that none of the five target species in their study responded negatively to pine plantation establishment. For three species (the sugar glider *Petaurus breviceps*, the red necked wallaby *Macropus rufogriseus* and the swamp wallaby *Wallabia bicolor*) the response to plantation establishment was positive (ie, increase in colonisation/patch use in sites surrounded by pines) whereas the two possums (the common ringtail possum *Pseudocheirus peregrinus* and the common brushtail possum *Trichosurus vulpecula*) were positively affected by the amount of native tree cover surrounding sites, rather than pine plantation establishment.

The researchers believe there are two strong implications arising from these results. 1) The conservation of agricultural land to pine plantations will not affect the mammalian species they looked at negatively; rather, it may facilitate colonisation of remnant patches of native vegetation by some species. 2) These findings underscore the critical importance of preserving remnant native vegetation within plantations, as it may decrease the risk of local extinction for some species or facilitate the colonisation of new sites for others. Thus, retention of patches of remnant native vegetation should be part of the design of future plantations. 🍌

### Reference

Mortelliti A, M Crane, S Okada & DB Lindenmayer (2015). Marsupial response to matrix conversion: Results of a large-scale long-term 'natural experiment' in Australia. *Biological Conservation* 191: 60-66. <http://www.sciencedirect.com/science/article/pii/S0006320715002384>

Note: The site where this data was collected, Nanangroe, was also used for a study on the impact of pine plantations on birdlife. This was discussed in [Decision Point #91](#).



# Detectability, threatened species & environmental impact assessments

## Why detectability matters and what we should do about it

By Georgia Garrard (RMIT University)

It is now widely accepted that many species are not perfectly detectable during an ecological survey. This means that, sometimes, a species that is present at a site will not be detected by an observer (or observers) during a survey of that site. The probability that the species will be detected if it is present (its 'detectability') is influenced by many factors. One of the most important factors is the level of effort put into the survey. In general, the more effort that is expended, the higher the chance of detecting the species (Figure 1).

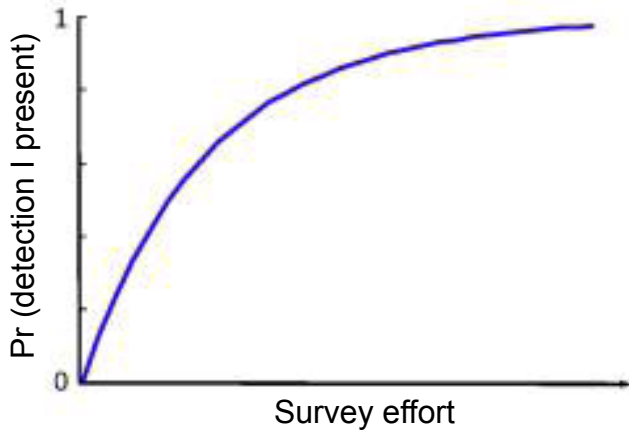


Figure 1: Detectability curve showing how the probability of detecting a species when it is present increases with survey effort

Why do we care about this? Well, there are many reasons. Imperfect detectability affects our ability to determine a range of important ecological metrics, such as the size of a population and the spatial extent or distribution of a species. It also makes it difficult to detect changes in these metrics, which is particularly important when we invest valuable funds in programs designed to address things such as declining population size and shrinking ranges.

But the implications of imperfect detectability can be particularly severe when we are considering the potential impacts of development on a threatened species. Falsely assuming the species is absent may mean that decisions about the future use of the site will cause unknown impacts on the species. In many cases, the species will be lost from the site and, at worst, the chance of the species going extinct will be increased.

Despite this, most environmental impact assessment regulations do not specify requirements for survey effort to ensure that the probability of detecting threatened species is high.



The spiny rice-flower (*Pimelea spinescens* subsp. *spinescens*) is a shrub endemic to the grasslands of the Victorian Volcanic Plains west of Melbourne. It is listed as critically endangered under the EPBC Act.

“The minimum survey effort requirements identified in our study are well above the effort traditionally expended in environmental impact assessments for this species.”

In the past I have undertaken a range of studies on various aspects of detectability (see the box 'Have we looked hard enough?'). In this most recent study we sought to demonstrate how to use detectability estimates to set minimum survey effort requirements for environmental impact assessments (Garrard et al, 2015).

### Regulator vs developer

In our analysis we considered two methods for determining minimum survey effort requirements for threatened species during environmental impact assessments. One method allows the regulator to specify the survey effort required to ensure that the species will be detected (with some probability) if it is present. This method uses a simple relationship between detectability and survey effort to estimate the probability of detection given the species is present.

The second method allows the regulator to place the burden on the developer to demonstrate that the species is absent from the site. This requires information on the belief – prior to conducting surveys – that the species is present. The basic premise of this method is that, when surveying a site that you have good reason to believe is occupied by the species (for example, because the species has previously been recorded there, or because the habitat is thought to be suitable), a greater investment in survey effort is required to convince you (or anyone else!) that the species is truly absent if it is not detected than if you were surveying a site that was deemed unlikely to contain the species (See the box 'Have we looked hard enough?'). We applied each of these methods to estimate survey effort requirements for *Pimelea spinescens*, a critically endangered native grassland plant species

We found that *Pimelea spinescens* has a detection probability of less than 0.53. This means that, during a survey of a site that contains the species, about 1/2 of the observers won't find it. We also found that detectability of the species is substantially higher when experienced observers are used, and when the cover of the dominant grass species (kangaroo grass, *Themeda triandra*) is low.



Working against its chances of effective protection is the fact that it can be very difficult to detect during environmental impact assessment surveys, especially at sites where the biomass of kangaroo grass is high.

The survey effort required to achieve a 0.95 (95%) probability of detecting the species when it is present is around 200 minutes per hectare for an observer experienced in grassland surveys, surveying at a site where the cover of *Themeda triandra* is 35%. This increases dramatically when a less experienced observer is used (Figure 2).

### Shifting the burden of proof

When undertaken by an experienced observer at sites with 35% *Themeda* cover, less than 2 hours (104 mins) per hectare is required to demonstrate that the species is absent with probability of 0.95, when the prior belief in presence is low (prior probability of presence = 0.2). This increases to more than 3 hours per hectare when the species is thought equally likely to be present as absent before survey (prior probability of presence = 0.5), and to almost 5 hours per hectare when there is strong evidence to believe the species is present (prior probability of presence = 0.8) (Figure 3).

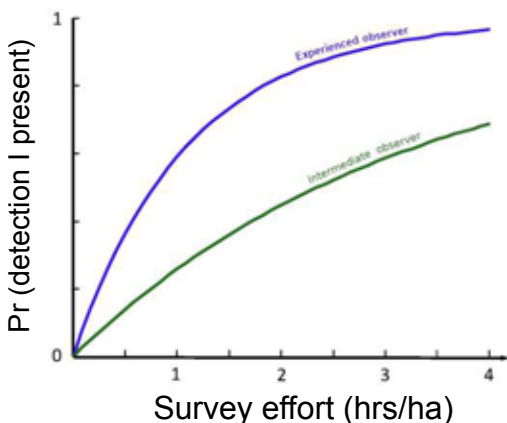


Figure 2: Detectability curves for experienced and intermediate observers at sites where the cover of *Themeda triandra* is 35%.

What does this add up to? Most importantly it underscores that determining minimum survey effort requirements is not something to take for granted (or make up as you go). It involves making decisions about the level of risk to the species we (as a society) are prepared to accept and acknowledge the trade-offs between the site-level value of the species and the value of alternative uses of the site.

Determining minimum survey effort requirements also depends on where the burden of proof lies. For example, should it be the responsibility of the developer (or person undertaking activity at the site) to demonstrate that the species is absent from the site? Or should the regulator make an assessment based on whether the reported survey effort was sufficient to detect the species if it was present. These questions cannot be answered by science alone.

### What does this mean for the spiny rice-flower?

The qualitative findings of our study – that experienced observers and low cover of dominant grasses improve detectability of *Pimelea spinescens* – are already reflected in the guidelines for determining significant impact for the species under the EPBC Act. Our study has demonstrated – for the first time – how much survey effort is required to detect the species. The minimum survey effort requirements identified in our study are well above the effort traditionally expended in environmental impact assessments for this species.

We also showed how much MORE survey effort is required if the observer does not have the appropriate experience, or the grass biomass at the site is high. The latter finding is particularly important in urban and urban fringe environments, where biomass reduction management through burning or mowing is limited or non-existent. We have shown that taking action to reduce the cover of *Themeda*

## Have we looked hard enough?

### How long do we have to look?

While many ecologists are aware of issues of imperfect detection during biological surveys, policy has yet to catch up with this issue. How long do we need to spend surveying in a single visit to a site to achieve a reasonable chance that we will detect a threatened plant species if it's present?

Garrard GE, SA Bekessy, MA McCarthy & BA Wintle (2008). When have we looked hard enough? A novel method for setting minimum survey effort protocols for flora surveys. *Austral Ecology* 33: 986-998. [Decision Point #34](#) (p3-5)

### Interpreting non-detection when observations are imperfect

If the species is especially cryptic such that you're unlikely to detect it in any one visit, but the habitat is ideal, you need to revisit the site many times. If the habitat is poor and the species is easy to detect, a lesser effort is required.

Wintle BA, TV Walshe, KM Parris, & MA McCarthy (2012). Designing occupancy surveys and interpreting non-detection when observations are imperfect. *Diversity and Distributions* 18: 417-424. [Decision Point #57](#)

### Detecting species without species-specific guides

Trait-based models should provide sensible bounded estimates of detectability on which to base survey design and effort requirements.

Garrard GE, MA McCarthy, NSG Williams, SA Bekessy & BA Wintle (2012). A general model of detectability using species traits. *Methods in Ecology and Evolution* 4: 45-52. [Decision Point #66](#) (p8,9)

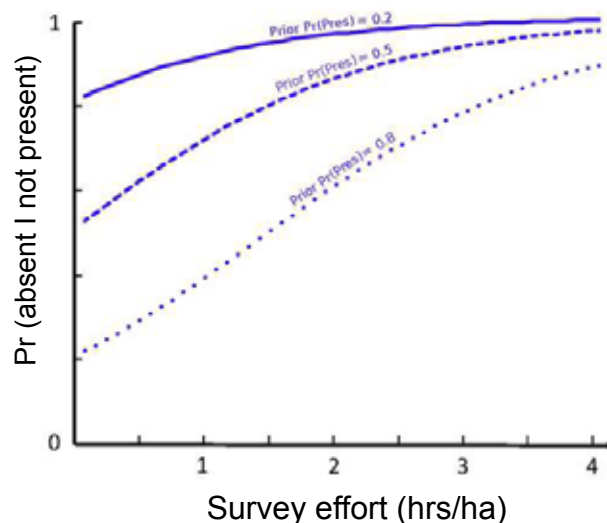


Figure 3: The survey effort required to demonstrate absence when no detections are made increases with the prior belief in species' presence. All curves are for an experienced observer searching at a site with 35% *Themeda triandra* cover.

prior to surveying for *Pimelea spinescens* may reduce survey effort requirements by as much as 50% or 75%.

We argue that minimum survey requirements be established for all species listed under threatened species legislation and hope that our findings will provide an impetus for collecting, compiling, and synthesizing quantitative detectability estimates for a broad range of plant and animal species. 🌱

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### Reference

Garrard GE, SA Bekessy, MA McCarthy & BA Wintle (2015). Incorporating detectability of threatened species into environmental impact assessment. *Conservation Biology* 29: 216-225. <http://onlinelibrary.wiley.com/doi/10.1111/cobi.12351/full>

# Dealing with the curse of chytrid

## Coming to terms with amphibian chytrid fungus in Australia's High Country

By Ben Scheele (Australian National University)

Frogs are in trouble. A third of all frog species are threatened with extinction. The usual culprits of habitat loss and climate change are at work, but another more insidious threat looms. A devastating disease called chytridiomycosis has been wiping out frogs, often from pristine habitats. The disease is caused by a fungus – amphibian chytrid fungus (pronounced kit-tyrid). The fungus disrupts the skin function of infected frogs leading to cardiac arrest (heart attack).

The numbers are sobering. Since the identification of chytrid by Australian researchers in 1998, the pathogen has been documented in over 500 amphibian species, and is now found on all continents (except Antarctica). Fortunately, the pathogen is not universally deadly with some species demonstrating high resistance (though this produces some problems of its own as I'll explain later).

However, many species are highly susceptible and the pathogen has been identified as the primary driver of decline for over 200 species of frog! Consider that for a moment. Enormous effort is put into saving vertebrate species from extinction and when, for example, a microbat, the Christmas Island pipistrelle, went extinct in 2009 there was an enormous outcry. Chytrid is threatening over 200 vertebrate species with extinction. It's believed that 113 of these species are likely already extinct.

### Chytrid in Australia

Although the origin of chytrid remains uncertain, recent evidence suggests the pathogen may have originated from Brazil and has since been distributed around the globe unwittingly by humans.

The earliest record of chytrid in Australia is from a frog specimen in a museum collected in 1978, in south-eastern Queensland. From a potential introduction point of Brisbane, chytrid appears to have spread rapidly both north and south, reaching far north Queensland in the mid-1990s and Tasmania by 2004. The cooler, wetter conditions of the Great Dividing Range have proved highly suitable for the pathogen and its impacts have been severe along the entire east coast of Australia. While chytrid is now present throughout eastern Australia, luckily, it doesn't tolerate the hot, dry conditions found in many inland regions.

Over the past three years we have focused on the long-term impacts of chytrid on frogs of the Australian High Country – a region that is home to several frog species found nowhere else in the world. In the mid-1980s mysterious frog declines were reported from the region and, with the benefit of hindsight and retrospective museum sampling, we can now be confident that these declines were caused by the initial emergence of chytrid. In conjunction with Threatened Species Manager David Hunter from the NSW Office of Environment and Heritage we have examined population trends of susceptible species and the ongoing threat posed by chytrid three decades after its emergence.

Broadly speaking, impacted frog species can be classified into three groups: declining, stable and recovering.

**“Without conservation interventions, the number of Australian species driven to extinction by chytridiomycosis will almost certainly rise. While preserving habitat is crucial, it is not enough on its own.”**

### Moving towards extinction

Let's get the bad news out of the way first. Worryingly, some species are in a continued state of decline, being pushed closer and closer to extinction every day. These declining species include some of our most iconic fauna, the corroboree frogs.

The northern corroboree frog was once highly abundant in Kosciuszko and Namadgi National Parks. In the 1980s, populations were decimated by chytrid, with dramatic declines and many local extinctions. Seemingly overnight, chytrid almost turned the lights off on the northern corroboree frog; this in highly protected habitat. However, as with many other chytrid-affected species, a handful of remnant populations survived.

Unfortunately for the northern corroboree frog, the common eastern froglet – a highly resistant species – also remains abundant at these sites. In ongoing research, we have shown that the common eastern froglet acts as a reservoir host – a species that carries infection, but is rarely killed by disease. The presence of a reservoir host amplifies the impact of the disease in corroboree frog populations and drives ongoing declines. Although the prognosis for the corroboree species is alarming, understanding the mechanism controlling chytrid dynamics is facilitating the development of innovative management strategies.

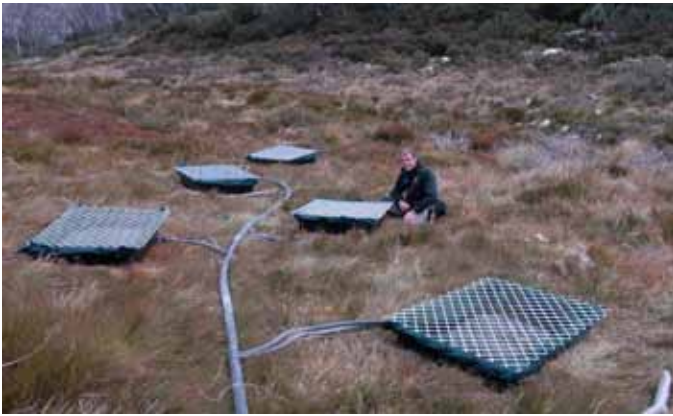
### On the edge

- The southern corroboree frog is a small, vividly-coloured species restricted to Kosciuszko National Park, in south-east NSW. It breeds throughout summer. Males call from moist terrestrial nest chambers, typically around the edge of pools in sphagnum bogs. The eggs wait for autumn rains or snow melt before the tadpoles hatch and enter the pools. Adapted to life in cooler climates, this species may take three to five years to mature and can live for at least nine years.
- Its striking yellow and black longitudinal markings make it one of Australia's most easily recognised frogs. They also warn potential predators of lethal alkaloids within its skin.
- But even with no known predators and a distribution almost entirely within a pristine wilderness area, thanks to chytrid the southern corroboree frog is one of Australia's most threatened vertebrates.



An adult southern corroboree frog. (Photo by David Hunter)





Artificial ponds in natural breeding habitat in Kosciuszko National Park, where captive and wild bred eggs from the Critically Endangered southern corroboree frog (*Pseudophryne corroboree*) have been placed to prevent contact with co-occurring reservoir hosts and eliminate mortality from premature pond drying. This is one strategy among many being explored to overcome the challenge of chytrid. (Photo by David Hunter)



A recently metamorphosed southern corroboree frog emerging from one of the artificial ponds pictured on the left. (Photo by David Hunter)

## Pick a strategy (and learn)

Assessing which management strategies are most suitable for a given frog species depends on a detailed understanding of chytrid dynamics and frog species ecology. Interventions against chytrid should target amphibian life history stages most affected by disease or at high risk of chytrid exposure. Ecological surveys are needed to identify outbreaks, ongoing declines, and prioritize high-risk populations. For most species, a variety of approaches implemented at different spatial scales will be necessary. Given the lack of proven effective strategies, all interventions should be implemented within an experimental framework. To optimize progress, research aimed at understanding the mechanisms underlying interventions should occur concurrently with their application.

### Hanging in there

While it is clear that some species are in an ongoing state of decline, for other species, such as the endangered alpine tree frog, the situation appears a little better. The alpine tree frog experienced a similar pattern of decline to the corroboree frogs. Remnant populations of alpine tree frogs, however, now appear relatively stable despite the continued presence of chytrid. Studying these populations, we have found that their persistence is facilitated by high juvenile frog recruitment (Scheele et al, 2015).

During the breeding season, the prevalence of chytrid can exceed 90% in adults, resulting in very low survival between years. Crucially though, the pathogen is rare in tadpoles and juvenile frogs. This allows the next generation to disperse into woodland habitat free of the disease. Because chytrid is an aquatic pathogen, individuals have low risk of becoming infected in terrestrial environments. However, when individuals reach sexual maturity they re-return to wetlands to breed and subsequently become infected. Luckily, adults are able to breed prior to succumbing to the disease.

### Bouncing back

Although the impact of chytrid has been horrendous, it's not all bad news. In the foothills of the Snowy Mountains, the whistling tree frog, a close relative of the alpine tree frog, is bouncing back (Scheele et al, 2014a).

Surveys in the 1970s found that whistling tree frogs were ubiquitous on the NSW southern tablelands; if there was a pond or farm dam, they were just there. Like so many other species, whistling tree frog populations crashed in the 1980s and the species was considered rare in the Canberra region by the early 1990s.

When we commenced our surveys in 2011, we found that the species was present in many areas where it was absent two decades earlier. Ongoing surveys in 2012 and 2013 demonstrated that, year by year, the species is re-expanding into habitat occupied decades ago. Whilst more work remains to be done on the mechanism facilitating recovery (chytrid prevalence remains high and appears to drive high adult mortality), we found that sites that retained frogs during the cycle of population decline and recovery had high quality habitat. This highlights the potential for habitat to buffer species from novel shocks.

### A framework for innovative intervention

In Australia, some frog species are in an ongoing state of decline due to chytridiomycosis. Without conservation interventions, the number of Australian species driven to extinction by

chytridiomycosis will almost certainly rise. While preserving habitat is crucial, it is not enough on its own to mitigate the effects chytrid fungus on many species. Appropriate and complementary direct action is also required.

Building on our field research and a review of the international literature, we developed a framework to help guide the management of chytrid-threatened species (Scheele et al, 2014b). Within our framework, we identified two broad management approaches: 1. reducing chytrid fungus in the environment or on amphibians and 2. increasing the capacity of populations to persist despite increased mortality from disease.

At a national level, a whole raft of measures ranging from investigating frog capacity for evolved resistance to assisted translocation into environments with low disease suitability are needed to combat chytrid fungus.

Responding to the chytrid threat has appeared extremely daunting over the last 15 years. However, our research indicates we are now at a turning point, with the potential to make real progress in the management of this terrible disease. 🍄

**More info:** Ben Scheele [benjamin.scheele@jcu.edu.au](mailto:benjamin.scheele@jcu.edu.au)

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# Conserving freshwater crayfish in Australia

## Aussie inverts desperately in need of a bit of protection

By Lucie Bland (University of Melbourne)

When Thomas Huxley – Darwin’s ‘bulldog’ and greatest advocate – searched for an animal on which to base his *Introduction to Zoology* (1880), he naturally settled on the humble crayfish. In his own words, he wanted to show how “the careful study of one of the commonest and insignificant of animals, leads us [...] to the widest generalisations and the most difficult problems of zoology”. Unfortunately, he completely ignored one of the richest countries in freshwater crayfish – Australia.

Home to 148 of the 600 species recognised globally, Australia is a heavy weight of crustacean diversity. This includes the world’s largest freshwater invertebrate – the Tasmanian giant *Astacopsis gouldi*, weighing in at a whopping 5 kg – and some of the smallest species, measuring barely 1 cm. Not only are Aussie crayfish species numerous and diverse, they are evolutionary relicts. They diversified around 150 million years ago – the same age as the global radiation of birds.

Australian crayfish drifted away from their South American and Malagasy cousins during the split of the Gondwanan supercontinent. Isolated on a continent with extremely variable water availability, they slowly evolved to fill a number of niches. Some crayfish live exclusively in fresh waters, some live in temporary desert springs, whilst others dig burrows to access the water table. These extensive galleries would often fall under the weight of cattle and horses in the 19th century, so parts of eastern Victoria were renamed ‘crabhole country’. Problems of land subsidence decreased as crayfish went locally extinct due to damaging farming practices.

The global IUCN assessment recently revealed the dire condition of Australian crayfish – 66 species are threatened with extinction (Richman et al. 2015). The proportion of threatened species in some genera is extremely high: more than 80% in the spiny crayfish species (*Euastacus* spp.), and three out of five burrowing species from Western Australia (*Engaewa* spp.). Yet local conservation measures are lagging behind the global recognition of the threatened status of crayfish. Only 11 species are included on the EPBC act, leaving dozens of species in urgent need of listing (consider Figure 1).

Australian species are affected by a wide range of interacting threats. They suffer from the loss of riparian vegetation, invasive species (cane toads and other crayfish), and the deposition of nutrients, mercury and sediments in waterways. Climate change is an emerging though poorly-understood threat (see the box ‘How will climate change affect Australian crayfish?’). This means that crayfish populations are likely to decline further if threats remain unabated.

So, what can be done? The good news is that crayfish are well-known invertebrates: there is considerable ecological data, a complete phylogeny (Owen et al. 2015), and all species are mapped within their IUCN assessment. Further work in Australia could leverage the international interest triggered by the global assessment as well as help build national capacity. Many university departments focus on fish and crayfish biology, and crayfish enthusiasts (‘astacologists’) are very knowledgeable and passionate. Crayfish are appreciated by the general public, both as pets and as delicious sandwich fillings – the economic value of crayfish farming is estimated at 20 million dollars. Crayfish therefore have the capacity to become flagship species for the conservation of freshwater invertebrates.

Key research and conservation questions will need to be answered to move crayfish conservation forwards. This includes transferring knowledge from well-known to poorly-known species; testing

“Crayfish may be the first on the line when it comes to climate change, and forty species have been identified as potentially sensitive to climate change by the IUCN.”



Australian freshwater crayfish come in all shapes and sizes. Consider the mighty Glenelg spiny crayfish (top, photo: Lucie Bland), the tiny swamp crayfish (middle, photo: aquariumlife.com.au), and the Critically Endangered hairy maroon (bottom, photo: Arkive).



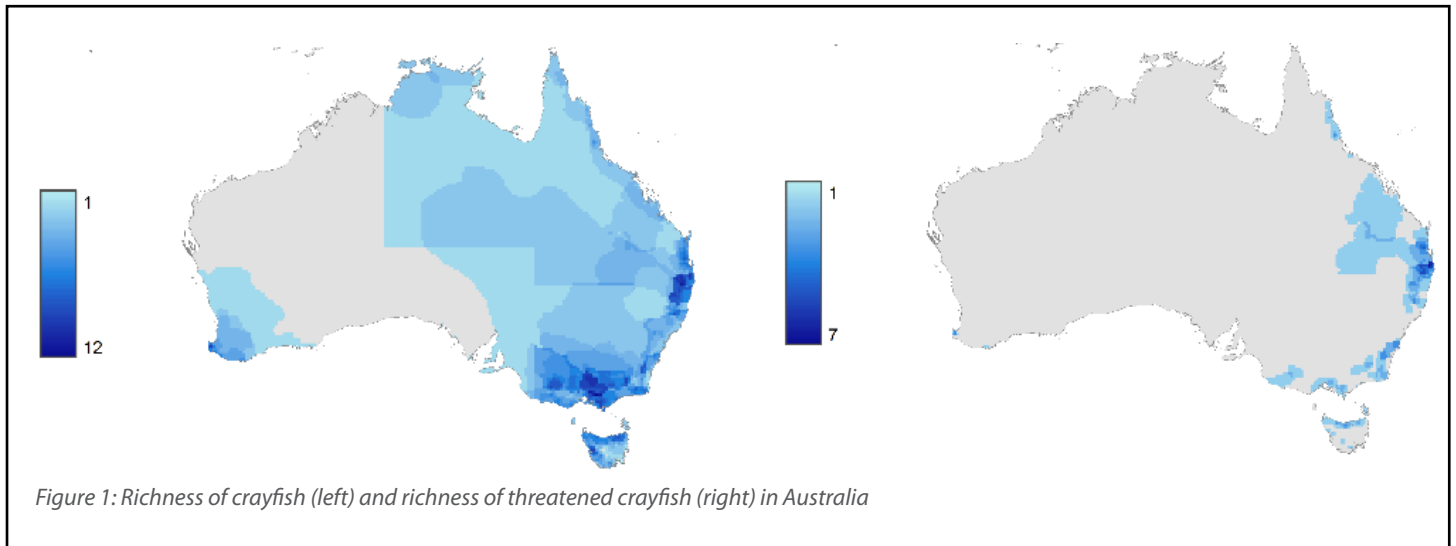


Figure 1: Richness of crayfish (left) and richness of threatened crayfish (right) in Australia

the efficacy of conservation measures (such as revegetation of riparian areas); and developing guidelines on captive breeding and translocation.

The process of listing crayfish under the EPBC Act also needs to be enhanced – especially for crayfish which live in flowing water, which remain largely underrepresented on the list (3 out of 11 species). Maintaining up-to-date recovery plans and conservation advice is also a challenge due to the lack of ongoing monitoring.

CEED researcher Lucie Bland is leading a global study on the factors predisposing crayfish to high extinction risk, and a global study on assessing crayfish vulnerability to climate change (following the framework proposed by Foden et al, 2013). She hopes that large-scale ecological information will help inform research priorities within Australia, and identify transferable conservation methods from other continents. 🍷

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Owen CL, et al. (2015). A synthetic phylogeny of freshwater crayfish: insights for conservation. *Philosophical Transactions of the Royal Society B: Biological Sciences* 370: 1662

Richman NI, M Böhm, SB Adams et al (2015). *Multiple drivers of decline in the global status of freshwater crayfish* (Decapoda: Astacidea). *Philosophical Transactions of the Royal Society B: Biological Sciences* 370:1662

“Local conservation measures are lagging behind the global recognition of the threatened status of crayfish. Only 11 species are included on the EPBC act, leaving dozens of species in urgent need of listing.”



*Gilgias (Cherax quinquecarinatus)* are freshwater crayfish endemic to southwest Western Australia. Around 10 to 12cm long, 'gilgie' is a Noongar word that has been adopted into English. (Photo: National Museum of Australia.)

- **How will climate change affect Australian crayfish?**
- Crayfish may be the first on the line when it comes to climate change, and forty species have been identified as potentially sensitive to climate change by the IUCN. The effects of climate change on crayfish are likely to vary among species, and may be enhanced by other threats. For example, crayfish experience mass mortality during droughts and floods, when they are stranded on river banks to be snatched by collectors and cane toads.
- Most spiny crayfish are mountain-top endemics, so their habitats may become unsuitable under climate change. In lowlands, the disappearance of riparian vegetation is likely to deprive crayfish from cool microhabitats. Burrowing crayfish may need to burrow further to track low water tables, and may not be able to disperse across agricultural landscapes.
- Finally, invasive crayfish adapted to warm waters may spread more widely, as has already been witnessed in Europe.
- The effects of climate change are very difficult to predict as there is little information on individual crayfish species.
- Thermal sensitivity experiments have only been conducted on two species, so more lab and field studies are desperately needed. Progress also needs to be made in modelling the effects of climate change as most tools are adapted to data-rich, terrestrial species.



## Conserving migratory species

### The multiple challenges of planning for complex migratory networks

By Claire Runge (University of Queensland)

Migratory species are pretty amazing. Some species travel vast distances in a single migration. An individual bar-tailed godwit, a migratory wading bird, was once tracked as travelling an incredible 11,000 km in a single flight! Arctic terns travel the equivalent of to the Moon and back three times over the course of their life. But it's not just the distances they cover that is awe inspiring. Some of them return year after year to the same location, navigating across landscapes that have been transformed by humans.

Given such Herculean feats, it seems tragic that many of the world's migratory species are now in serious decline (see 'Birds in the red', [Decision Point #59](#)). Unfortunately, addressing the causes of these declines presents a major conservation challenge. Migratory species rely on many different landscapes, often across multiple political boundaries. Even if we had the capacity to save habitat in distant parts of the world – far beyond our own borders – there's enormous uncertainty about which part of the network of sites used by migratory species we should focus on.

The good news is that in some cases conservation actions for migratory species can result in rapid benefits. For example, zebra migration in Botswana spontaneously resumed when fences were removed. These fences had blocked the traditional migration route for decades.

#### Connections between places

Migrant species rely on multiple sites including breeding grounds, non-breeding grounds and the places they travel through on the way between the two. This reliance on multiple sites makes migrants particularly vulnerable to habitat loss or degradation (consider Figure 1). In the extreme, if all individuals of a species regularly move between two areas, the area in worst condition will dictate the overall status of the species. Conservation measures taken in the less critical area may make little difference.

Places such as stopover sites or drought refuges can also be crucial to a large proportion of the population even though they might be occupied only for a short period of time. Conservation interventions for migrants need to take these connections between places into account and ensure that migratory species have the resources they need across their breeding grounds, non-breeding grounds and

*Eastern curlews (*Numenius madagascariensis*) migrate each year from the Arctic to Australia, stopping to refuel at tidal flats across the East Asian-Australasian Flyway. The species has recently been listed as nationally threatened, and habitats across its migration and non-breeding range are vulnerable to degradation and loss through declines in prey, reclamation, changes in sedimentation patterns and sea level rise. Managing these multiple interacting threats requires conservation actions that take account of migratory connectivity, and that operate in many countries across the Flyway. One important conservation initiative has been the formation of the East Asian-Australasian Flyway Partnership, an alliance of 30 governments and NGOs working across the region. The Partnership has already listed a network of more than 100 important sites across the Flyway in 16 countries.*

(Photo © Dean Ingwersen)

the stopover sites or corridors they use along the way. This can be difficult, particularly where migrants move across jurisdictions or habitats. But it can be crucial for their long-term survival.

For example, the number of migratory shorebirds using the East Asian-Australasian Flyway has declined dramatically in the past few decades, and evidence implicates habitat loss at important stopover sites in the Yellow Sea (see 'Between a rock and a hard place', [Decision Point #81](#)). If this hypothesis is correct, then action to manage shorebird habitat elsewhere in the Flyway might fail to halt the decline of these birds without corresponding management at stopover sites in eastern Asia. Similarly, the migratory leatherback sea turtle is declining as a result of a combination of egg-poaching at its nesting sites and mortality from both inshore fisheries and pelagic long-line fishing. International restrictions on pelagic long-line fishing will not halt the decline of this species without corresponding effort at inshore locations and nesting sites.

**“Places such as stopover sites or drought refuges can also be crucial to a large proportion of the population even though they might be occupied only for a short period of time.”**



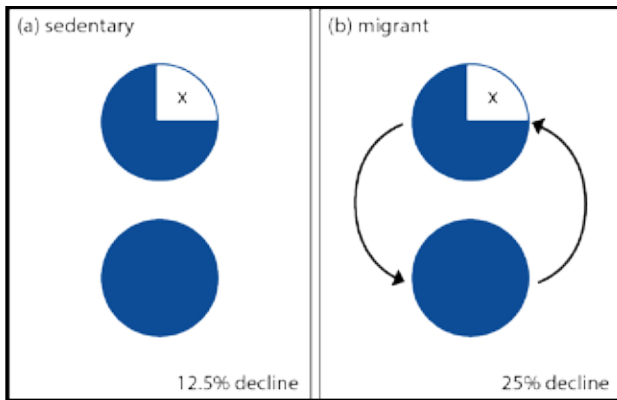


Figure 1: In this theoretical example, habitat loss has affected one-eighth of the total available habitat to a species that occurs in two patches. If habitat quality and population abundance are evenly distributed within and among patches, we might predict that a sedentary species (a) will decline in total population size by one-eighth as a result of the habitat loss. Where the two patches are linked by migration (b), we might predict a population decline of one-quarter because the entire population passes through the affected patch at some point during its life cycle. Taking it one step further, if one habitat patch is lost altogether, extinction of the migratory species may result.

## Planning across networks

One of the key challenges in the conservation of migratory species is developing ways to design conservation plans across a complex network of sites. Conservation planning has tended to assume that the targets of management, such as species or ecosystems, are static in space and time. Of course, we have to start somewhere so it's not really surprising that management targets are static because accounting for migratory movements can be pretty complicated.

However, the growing sophistication of conservation planning tools means it's now possible to incorporate the dynamic needs of migrants into our conservation plans. Spatial prioritisation software such as Marxan and Zonation have already been used to design conservation networks which manage migrants across the whole migratory cycle.

Some of the approaches we need for migratory species conservation have yet to be developed. We should be able to design solutions that maximize future evolutionary potential, or minimize the chance of random events, like cyclones or bushfires, wiping out populations. Such solutions, which will be needed to address the dual threats of climate change and habitat loss, might focus on the conservation of multiple sub-populations and dynamic migratory corridors.

## Learn or act?

Given financial and time constraints, an intensive research-driven approach to conservation will not be feasible for the vast majority of migrants, especially where little is known about the connections between parts of their range.

Where information is limited, planners have basically three choices:

1. Invest in activities that improve current knowledge (ie 'learning more')
2. Use existing information to estimate the optimal conservation plan, or
3. Undertake a combination of learning while taking action (ie adaptive management)

Although it is what we often fall back on, 'learning more' is not always the most effective way to achieve the best conservation outcomes. Delays in action, the risk of catastrophic population declines while new knowledge is acquired, and the fact that resources might be diverted from on-the-ground management all mean that postponing action may result in unacceptable losses

A lot of the time we know a lot more than we think. Tracking studies, stable isotopes measurements, or genetic studies can be used to get information on the connections between parts of migratory species' ranges, though these approaches can be costly, time-consuming and require specialist knowledge. Luckily, we can often use expert elicitation (a formal way of obtaining expert opinion, see 'So you think you're an expert', [Decision Point #58](#)) to get a good approximation of migratory connectivity between parts of a species range, and use this to guide our conservation decisions when we have limited resources.

Similarly, the use of decision-theoretic approaches and artificial intelligence can aid decision making where data are scarce. These techniques can also demonstrate how to optimally allocate time and resources between learning and taking action across space and time.

The application of decision science to solve migratory species conservation problems follows the same basic principles as any well-designed prioritization process: (1) define a clear objective (eg, what to minimize or maximize); (2) specify a set of conservation actions from which a subset will be chosen as priorities; (3) make hypotheses on how specific conservation actions will help meet the conservation objective; (4) consider resource constraints (ie, time and money); and (5) implement decisions in a way that promotes learning.

## A future with migratory species

Large-scale conservation schemes are yet to incorporate the needs of migratory species. That's not surprising given the complex, multi-jurisdictional challenge of migratory conservation. However, the need is great and, as I hope I have convinced you here, the tools are now available. With a little care and some well-designed investment, it's a challenge we can meet. And in doing so, future generations will hopefully be able to experience the amazing and inspiring phenomenon that is wildlife migration. 🌟

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## Reference

Runge CA, TG Martin, HP Possingham, SG Willis & RA Fuller (2014). Conserving mobile species. *Frontiers in Ecology and the Environment* 12: 395–402. <http://dx.doi.org/10.1890/130237>



A flock of bar-tailed godwits. Migratory shorebirds such as these have been experiencing worrying declines in recent years. Will people in the future be able to witness their amazing feats of migration? (Photo by Rob Clemens)

# Using maths to plan roads for wildlife

## Saving koalas from cars

By Tal Polak, Jonathan Rhodes and Hugh Possingham (University of Queensland)

We all have to negotiate roads in our daily lives; we cross roads to get to the shops, our kids cross roads as they walk or ride to school, and most of us have a road outside where we live. Although they are part of everyday life they pose significant risks to our safety. Vast amounts of money are invested every year making roads as safe as possible through the considered placement of busy roads and the installation of safety infrastructure, such as barriers and pedestrian crossings. The issue is exactly the same for our wildlife moving around the landscape. Yet we currently lack comprehensive plans to make our road networks as safe as possible for wildlife. EDG researchers are addressing this gap using the power of maths to develop new planning tools for environmentally-sensitive road planning.

Roads are pervasive and can invade some of the most remote places on Earth. Some consider them one of the greatest emerging threats to biodiversity. As such, roads are having significant impacts on wildlife worldwide. The most obvious threat is when individual animals are hit and killed by motor vehicles. A more subtle effect is interference that roads cause to animal migration or dispersal. But what can we do?

There are essentially two ways in which these impacts can be reduced (apart from not building roads in the first place). The first is by changing where we put roads. The second is by constructing fences and overpasses. Because conservation funds are limited, choosing what to do is hard because there are so many options. Luckily we can turn to decision science to help. In two recent studies we have developed insights into principles for road placement and tools for prioritising mitigation structures and their locations. In both cases we used koalas for the case study.

### New roads or improved roads?

In the first study we were interested in the problem of designing whole road networks to accommodate increases in road traffic that would minimise the impact on wildlife. In doing so we considered two potential road design principles: (1) increases in vehicle numbers are accommodated through the construction of new roads, and (2) increases in vehicle numbers are accommodated through upgrades to existing roads (Rhodes et al, 2014).

We applied a mathematical model that is explicit about traffic volumes and road densities to a koala population around Port Stephens on the NSW north coast. We found that in almost all cases

“These studies make important contributions to understanding how best to plan future road infrastructure if mitigating the impacts on wildlife is part of the planner’s remit.”

the effect of building new roads was more detrimental to wildlife populations than upgrading existing roads. This occurred because the additional impact on animals having to cross more roads was generally much higher than the additional impact of increases in traffic volume. Our modelling also suggests that building of new roads was only preferable when the existing road network (the starting point) was of very low density, but with very high traffic volumes. This might apply, for example, for a busy highway passing through a rural area with few other roads.

Although our modelling looked at the impact of roads on koalas, the conclusions appeared generally robust enough that they are likely to apply to many other species as well. If so, then it has important implications for how we design road networks in general. Indeed, it’s possible to conceptualise road planning in way that is analogous to the land sharing / sparing debate in agricultural landscapes. At one end of the spectrum are planning strategies that aim for many roads spread across the landscape, but with each road having low traffic volumes; a road sharing approach with few road-free areas. At the other end of the spectrum are planning strategies that aim for few roads spread across the landscape, but with each road having high traffic volumes; a road sparing approach with many road-free areas. In designing road networks there are clearly a range of trade-offs that need to be considered such as cost, traffic flow, and accessibility and a range of options between the road sharing/sparing extremes. However, our work suggests that, at least from a wildlife point of view, a road sharing-like approach is likely to be a poor option.

### Impact mitigation

In the second study, we developed a new framework for prioritising among different road mitigation options (fences and crossings) that can be applied to road networks to minimise the impact on wildlife. More specifically, our framework identifies the positioning of mitigation measures, such as fences and animal passages, in such a way that the abundance of a species is maximized while taking costs into account (Polak et al, 2014). This research represents the first attempt to use decision science to identify road mitigation actions for biodiversity conservation.

To test our framework we used information about a koala population located on the Koala Coast (in south east Queensland, see the box ‘The ‘Coast’ is clear’). These koalas are greatly affected by roads, with vehicle impacts representing the second highest cause of mortality for this population. We developed a population model for four patches of habitat separated by four roads with different lengths,

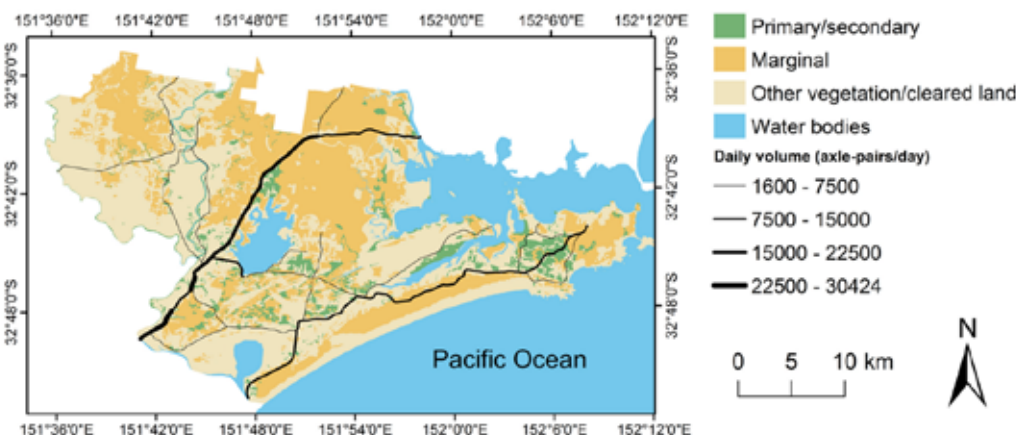


Figure 1. Map of study area near Port Stephens used in the analysis of whether new roads or upgraded roads had more impact on koalas. The map shows the the estimated distribution of koala habitat, and the estimated average daily traffic volume (axle-pairs/day) on major roads. The biggest roads in the area carry over 20,000 vehicles per day. (From Rhodes et al, 2014)



traffic volumes and mitigation measures. We considered three possible mitigation actions for each of the four road segments: do nothing; erect fences without wildlife crossings; and erect fences with wildlife crossings. For each mitigation action combination we used the population model to predict population sizes in 100 years.

We discovered that there is a strong need for mitigation as the already declining koala population will be reduced to near extinction without it. Sadly, for this case study, there was no 'easy win' solution where we could achieve an adequate level of conservation for a low monetary cost. We found an almost linear relationship between the benefit to koalas and cost that indicates there are no cheap solutions for this system. Further, if we want to maintain the local koala population we need to invest a substantial amount of resources; we estimate that an investment of 1.7 million dollars in road mitigation is essential, and this applies for an area with only 8 km of roads!

Our approach appears to be very flexible and can be adapted to other species, systems and even the employment of other mitigation actions. The population model can be adjusted to match the needs of different species, indeed multiple species. This new framework will allow decision-makers to clearly measure the trade-off between potential biodiversity benefits and economic cost in road mitigation measures. It's our hope that this approach will be adopted by decision-makers and applied to locations in need of mitigation in order to protect species threatened by roads all over the world, rather than the ad-hoc approaches commonly used now.

### The road ahead

The impact of roads on wildlife populations arises from a range of complex spatial processes involving interactions between movement behaviours and the spatial pattern of habitat and roads. These studies make important contributions to understanding how best to plan future road infrastructure if mitigating the impacts on wildlife is part of the planner's remit. One of the key challenges now is developing ways to effectively integrate the results of studies such as these into strategic planning processes for infrastructure and wildlife management. 🍓

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## The wandering male

The Port Stephens study (Rhodes et al, 2014) showed that male koalas were more susceptible to road traffic mortality than females and the range of conditions under which building new roads was the better strategy was even more limited for males than females. The reason for this is that males generally have larger home ranges and move greater distances than females, particularly during the breeding season, with the result that males tend to cross roads more frequently than females. This is consistent with empirical evidence on differences between the sexes in vehicle collision mortality rates in koalas. The higher movement rates of male koalas also makes them more susceptible to the effect of increased road densities versus increased traffic volumes on existing roads. The general implications of this are that, for very mobile species, upgrading existing roads is even more likely to be the better strategy than it is for less mobile species.



## The 'Coast' is clear

The Koala Coast is located 20 km south-east of Brisbane, and covers an area of around 375 km<sup>2</sup>. It contains one of the most significant koala populations in Australia, but this is a population at risk. The region is experiencing rapid human population growth with associated urbanisation and the loss of habitat. This has also resulted in elevated rates of mortality due to vehicle collisions and domestic dog attacks. There has also been an increased prevalence of disease, which might be due to increased stress levels associated with habitat loss. What it adds up to is a 64% decline in this koala population over the past 10 years, and the very real possibility that Australia's Koala Coast might one day soon be a place where koalas are no more.

More info: [Decision Point #50](#), p6-8 (Images by Liana Joseph)

## IPBES chooses Young Fellows from CEED

ECRs to contribute to an international effort to save the planet's biodiversity

Vanessa Adams and Sugeng Budiharta are two early-career conservation scientists based at the University of Queensland working with CEED. Their science will soon be informing international efforts to save biodiversity as they have just been selected as Young Fellows of IPBES.

IPBES stands for the Intergovernmental Platform on Biodiversity and Ecosystem Services (<http://ipbes.net/>). It's an independent intergovernmental body established by the United Nations in 2012 to provide policy advice to governments at all levels to protect the world's precious biodiversity. It now has around 120 member countries signed up. IPBES has many parallels with the IPCC (Intergovernmental Panel on Climate Change), which provides regular assessments that bring together the best data and models on climate change. Over time the IPCC has had an enormous impact in influencing policy. The hope is that IPBES will do the same.

IPBES will provide an interface between the scientific community and policymakers, and aims at strengthening the use of science in policymaking. Its role will be to assess global and regional trends in biodiversity and associated ecosystem services, analyse their causes, and explore possible future changes.

To ensure IPBES fulfils its potential it is enlisting the world's best conservation scientists into its assessment processes. Part of this effort includes enlisting some of the most talented early career researchers (ECRs) by establishing a Young Fellows Programme. Not only does this harness the finest emerging talent in the international effort to save biodiversity, it is hopefully engaging a cadre of top scientists that will be informing the effort over many years to come.

Vanessa Adams is a Postdoctoral Research Fellow whose research applies economic concepts and social consultation to make on-ground conservation more effective and equitable between groups of stakeholders. Sugeng Budiharta is a Doctoral student studying how best to use available resources, from money to indigenous knowledge, to restore degraded forests in the tropics for the delivery of biodiversity conservation and ecosystem services (see the story on page 16). Both are skilled in spatial modelling and environmental decision science. When IPBES put out a call for early career researchers to join its assessment process, they saw it as a fantastic opportunity.

"Participating in the assessment as a Young Fellow allows me to connect my research directly with policy as well as providing me with a unique opportunity to work with leading global experts," says Vanessa. "I try to partner with relevant government agencies and NGOs when conducting my research to ensure that it is relevant to policy makers and is positioned to influence on-ground conservation. Being involved in IPBES was an obvious extension of

**“Scenario modelling and the incorporation of risk into decision-making are two areas that are central to the assessment work of IPBES and are key to its future success. CEED’s strengths lie in these fields.”**

this approach of partnership.”

Sugeng, an Indonesian, believes that globally important biodiversity areas like Indonesia, Peru and Madagascar are usually less represented in global forums. "These countries face huge challenges in conserving and restoring biodiversity and ecosystem services while boosting their economies," he says. "Yet, our capacities to meet these challenges are limited. The IPBES Young Fellows Programme is a great opportunity to learn and contribute!"

However, putting your hand up and being selected are two different things. Around the world there were some 700 applications to the Young Fellows Programme. Of these around 450 were nominated. But the area in which Vanessa and Sugeng nominated, Land Degradation and Restoration, it was even more competitive. From a pool of more than 130 applicants, only seven candidates were selected to participate in the assessment as co-authors. Vanessa and Sugeng were two of these seven.

Getting through such a tough selection process is testament to Vanessa and Sugeng's skills. It's also reflective of CEED's international standing in the field of environmental decision science. Indeed, CEED has played an important support role throughout IPBES's short history, providing valuable input into many of IPBES's assessment processes (see [Decision Point #61](#)).

Scenario modelling and the incorporation of risk into decision-making are two areas that are central to the assessment work of IPBES and are key to its future success. CEED's strengths lie in these fields. The hope is that with contributions from Young Fellows like Vanessa Adams and Sugeng Budiharta that CEED will be making valuable contributions to IPBES now and long into the future.

The next step for these two Young Fellows is a meeting with other 'Land Degradation and Restoration' IPBES assessment authors in Germany in September. 📍

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### Other points of CEED contact

Other CEED researchers involved in IPBES include Associate Professor Brendan Wintle (Coordinating Lead Author on the use of scenarios and models to inform decision making), Dr Marta Pascual (Reviewer of the first draft of the scenarios and models chapter), Associate Professor James Watson (member of the Data and Knowledge taskforce), Dr Ram Pandit (Expert Group Member of Values and Valuation group, Lead Author on Asia Pacific regional assessment and Coordinating Lead Author on Land Degradation and Restoration) and Dr Maria Martinez-Harms (reviewer on the pollination assessment). Associate Professor Kerrie Wilson also played an important role by arranging for CEED to be an observing organisation of IPBES and coordinating two CEED reviews of the IPBES conceptual framework.



# Causal inference in conservation

## A CEED Workshop, University of Queensland, July 2015

By Elizabeth Law & Kerrie Wilson

How can we be confident that a conservation intervention had a positive impact? This was the central question at a recent workshop at the University of Queensland on causal inference.

We've all heard the adage that 'correlation does not imply causation' – so we wanted to find out what does! We brought in Paul Ferraro, an international expert on the topic to train 30 CEED staff and students on the art (and science) of causal inference. (Paul is the Bloomberg Distinguished Professor at Johns Hopkins University; he's also an advisor to the Global Environmental Facility). Paul has over a decade of experience in environmental policy evaluation, including vibrant contributions to both the peer-reviewed literature and conservation practice.

Participants in the workshop included representatives from three CEED nodes (Brisbane, Melbourne, Perth), CSIRO, as well as CEED visitors from the University of British Columbia, the University of Cambridge, the Basque Centre for Climate Change, and James Cook University.

And what did we discover? It turns out that the key to identifying causal effects is to eliminate rival explanations that may mimic or mask a relationship between a cause and an effect. Logical, yes, but this consideration requires a greater attention to analysis design than is often given. It can have significant implications for interpreting the effectiveness of conservation actions. For example, naively comparing deforestation rates inside and outside parks (and not considering that parks are usually biased towards areas of low conflict with other uses) may lead to an overestimation of the effectiveness of protected areas in delivering avoided deforestation – by over 65%! Lucky we now know about causal inference!

While this classic approach to causal inference is great for post hoc analyses, much of the work we do is planning for the future. The second half of the week narrowed the workshop to thirteen participants, nutting out the question of how we can incorporate these methods into our planning work. Keep an eye out for our upcoming paper on this! 🍷

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Workshoppers discuss the finer points of causal inference at the CEED workshop at the University of Queensland in July. (Photo by Jane Campbell)

## Dbytes

*Dbytes* is EDG's internal eNewsletter. It gets sent to members and associates of EDG each week, and consists of small snippets of information relating to environmental decision making. They might be government documents, research articles, blogs or reports from other research groups. Here are six bytes from recent issues. If you would like to receive the *Dbytes* eNewsletter, email [David.Salt@anu.edu.au](mailto:David.Salt@anu.edu.au)

### 1. Outcomes-based Policy under the EPBC Act

The Australian Government has developed policy and guidance on outcomes-based conditions under the EPBC Act. Comments are invited. Outcomes-based conditions specify the environmental outcome that must be achieved by an approval holder without prescribing how that outcome should be achieved. Outcomes-based conditions allow approval holders to be innovative and achieve the best environmental outcome at the lowest cost, while increasing the public transparency of the required environmental outcomes. Submissions close on 5 October 2015.

<http://www.environment.gov.au/epbc/consultation/policy-guidance-outcomes-based-conditions>

### 2. Eleven iconic Australian world heritage sites under threat from climate change

From the Climate Council

<http://www.climatecouncil.org.au/11-iconic-australian-world-heritage-sites-under-threat-from-climate-change>

### 3. Management Strategy Evaluation, GBR inshore

A NERP Tropical Ecosystems Hub report discussing the comparison of two techniques for the management of Great Barrier Reef inshore areas has revealed that external social and political factors play a huge part in determining the effectiveness of consultation techniques.

<http://www.nerptropical.edu.au/publication/project-92-final-report-design-and-implementation-management-strategy-evaluation-great>

### 4. What's the point of saving endangered species

BBC web story

"Whether it's tigers, pandas, California condors or coral reefs, much of the world's wildlife is under threat. It's initially upsetting, and eventually just numbing."

<http://www.bbc.com/earth/story/20150715-why-save-an-endangered-species>

### 5. Biodiversity offsets and double dipping

Conservation conundrum: Compensation paid by developers who damage biodiversity may do more harm than good if it is misused by governments, say researchers.

<http://www.abc.net.au/science/articles/2015/07/23/4278534.htm>

### 6. Feral pigs a priority in Lake Eyre Basin

A team of Brisbane-based decision scientists (including many CEED/NERP personnel) have recently published research on priority threat management in the Lake Eyre Basin. Managing feral pigs is one of the most effective ways to ensure the basin remains healthy in the future.

<https://theconversation.com/protecting-australias-lake-eyre-basin-means-getting-our-priorities-right-44836>

## A good 'fellow' for tropical rainforests

Sugeng Budiharta is passionate about conserving biodiversity and restoring tropical forest, and in particular the forests of Indonesia, his country of origin. That's why he chose to undertake a PhD at the University of Queensland and work with CEED in trying to understand the trade-offs between different types of forest restoration.

It's often said that the restoration of degraded tropical forests is a win-win situation in which biodiversity can be enhanced and greater amounts of carbon can be stored in the vegetation and soils. But such a characterisation overlooks the fact the places you might undertake restoration (revegetation) to maximise carbon storage aren't necessarily the same as the places you would restore to improve wildlife habitat.

Sugeng led an analysis that systematically prioritised investments in restoration in the tropical landscape of East Kalimantan, Indonesia (Budiharta et al, 2014). He found that when the objective is solely to enhance carbon stocks, then restoration of highly degraded lowland forest is the most cost-effective activity. However, if the objective is to improve the habitat of threatened species, multiple forest types should be restored and this reduces the accumulated carbon by up to 24%. Their analysis framework provides a transparent method for prioritizing where and how restoration should occur in heterogeneous landscapes in order to maximize the benefits for carbon and biodiversity.

Sounds like Sugeng would be good 'fellow' to have around in any effort assessing biodiversity, land degradation and restoration. Therefore it comes as no surprise that he's just been selected by the IPBES Young Fellows Programme. See p14. 🍓



Sugeng Budiharta (on the left) counting epiphytic orchids in Indonesian forests.

### Reference

Budiharta S, E Meijaard, PD Erskine, C Rondinini, M Pacifici & KA Wilson (2014). Restoring degraded tropical forests for carbon and biodiversity. *Environmental Research Letter* 9 <http://iopscience.iop.org/1748-9326/9/11/114020/>

## What's the point?

### Ten year science plan for 'blue' economy

The *National Marine Science Plan* is a consensus document from over 23 marine research organisations, universities and government departments and more than 500 scientists. It provides a set of recommendations for science that will be at the heart of dealing with the challenges of our marine nation.

According to the 'Plan', Australia's marine industries will contribute around \$100 billion each year to our economy, with our oceans and coasts providing a further \$25 billion worth of ecosystem services, such as carbon-dioxide absorption, nutrient cycling and coastal protection.

The Plan focuses on seven key challenges associated with our oceans and provides a template for how business, science and government can now work towards growing Australian's oceans economic potential while safeguarding its longer term health. 🍓



The Environmental Decision Group (EDG) 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, RMIT University and CSIRO. *Decision Point* is the magazine of the EDG.

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