

# DECISION POINT

Connecting conservation policy  
makers, researchers and practitioners

Issue #68 / April 2013

## Bridging the great divide

Road crossings  
and their  
value for wildlife



**Building bird-friendly  
cities - compact vs sprawl**



**Planning for biodiversity in  
the urban fringe**



**Is nature good for you?  
The benefits of biodiversity**

### 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/>

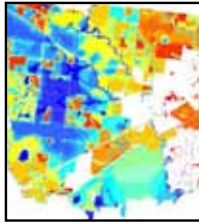
### Plus

How to meet global restoration targets  
Principles of population viability analysis  
Fat spiders in the city  
How much can a koala bear?

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*Our cover: What's that brush-tailed phascogale doing on that rope bridge? Crossing a wildlife-killing freeway, that's what. Find out all about rope bridges and other crossing strategies on page 8.*

## On the point

### Wild(life) in the suburbs

- *It's a funny thing but the concept of 'biodiversity' only seems relevant when you get out past the urban fringe. Cross that line back into the suburbs and things like 'wildlife' and 'protected areas' usually don't seem that important. The suburbs are for people. Beyond the suburbs is where all that other stuff happens.*
- *Why is it funny (and I don't mean in the humorous sense)? Because our urban footprint is now dominating the broader landscape, it's no longer a minor land use. Because over 50% of threatened species and ecosystems in Australia occur within the urban fringe and accelerating urbanisation is now a key threat. Because biodiversity brings a range of benefits for people living in our cities and suburbs. And because a growing body of emerging science is showing us that it is possible to develop our cities and still retain much of that biodiversity. The EDG is doing a lot of work on conservation in urban spaces and in this issue of Decision Point we hope to demonstrate that cities can have wildlife if we're willing to plan for it.*
- *Jess Sushinsky investigates Brisbane's future as a bird-friendly city by modelling what will happen if it follows a compact high-density trajectory (with good urban green spaces) as opposed to following a pathway of urban sprawl (see page 8).*
- *Sarah Bekessy demonstrates it's possible to apply conservation planning tools to development in the urban fringe (see page 13) whereby biodiversity can be explicitly factored in against other considerations.*
- *Kylie Soanes discusses the pros and cons of building crossing structures to help wildlife over major roads (see page 6) with some excellent night photography proving they work.*
- *And Richard Fuller explains why it's good to have nature around as it brings benefits for our mental and physical health (see page 14).*
- *So, before we pave paradise and put up a parking lot, let's reconsider the proposition that our urban spaces are not for biodiversity.*
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# 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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Short accounts of papers from EDG researchers. If you would like copies of any of these papers please visit:

<http://decision-point.com.au/research-briefs.html>

## Ecological Restoration for the 21st Century

Ten years ago the Society for Ecological Restoration published a 'Primer for Ecological Restoration'. It was regarded as a foundational document for the new field of ecological restoration. EDG researchers recently led a review of this Primer to examine how things have changed since then.

Through a series of organized discussions, the researchers assessed the Primer for its currency and relevance to ecological restoration as it is framed today. They focused their assessment on the 'Nine Attributes of a Restored Ecosystem' (a section in the original Primer; these attributes outline a "basis for determining when restoration has been accomplished" and thus should clearly encapsulate the goals of restoration) and grouped each of the attributes into one of four categories: species composition, ecosystem function, ecosystem stability, and landscape context. They found that in the decade since the document's inception, the concepts, methods, goals, and thinking of ecological restoration have shifted significantly.

They then suggested how the Primer might be updated to make it relevant. They proposed including a fifth category that they believe is increasingly acknowledged in ecological restoration: the human element. This element includes the incorporation of cultural or social values, acknowledging social influences in definitions of resilience/resistance and the necessity of buy-in by stakeholder.

The Primer is an important document guiding the practice of restoration. The hope is that this critical assessment will contribute to its ongoing development and relevance, and more generally to the development of restoration ecology, particularly in our current era of rapid environmental change. 🍌

### Reference

Shackelford N, RJ Hobbs, JM Burgar, TE Erickson, JB Fontaine, E Laliberté, CE Ramalho, MP Perring & RJ Standish (2013). Primed for Change: Developing Ecological Restoration for the 21st Century. *Restoration Ecology*. doi:10.1111/rec.12012  
<http://onlinelibrary.wiley.com/doi/10.1111/rec.12012/full>

## How much can a koala bear?

Habitat loss and natural catastrophes reduce the resources available to animals. Species can persist if they have access to additional resources and habitats. How much of this additional resource do koalas need to weather droughts and climatic extremes?

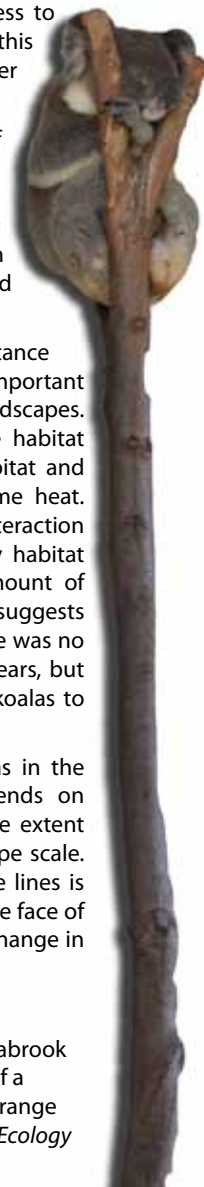
The researchers examined the pattern of occurrence of the koala at the periphery of its biogeographic range, in a semi-arid rangeland landscape. They used hierarchical mixed modelling to examine the effect of landscape change on koala populations and their habitat use during and after a prolonged drought.

They found that the tree species and the distance of a site from water courses were the most important determinants for koala presence in these landscapes. Koalas were predominantly detected in riverine habitat along the water courses, which are primary habitat and provide refugia in times of drought and extreme heat. There was a strong positive effect from the interaction between the amount of primary and secondary habitat in the landscape, although individually, the amount of each of these habitats was not important. This suggests koalas will persist in more intact landscapes. There was no difference in habitat use between dry and wet years, but they believe it can take several wet seasons for koalas to expand into habitats away from water courses.

These findings show that the presence of koalas in the semi-arid Mulgalands bioregion not only depends on river red gums along creek lines, but also on the extent of riverine and woodland habitats at the landscape scale. Protection of habitat on and away from drainage lines is therefore critical for the persistence of koalas in the face of predicted extreme weather events from climate change in modified agricultural landscapes. 🍌

### Reference

Smith AG, CA McAlpine, JR Rhodes, D Lunney, L Seabrook & G Baxter (2013). Out on a limb: habitat use of a specialist folivore, the koala, at the edge of its range in a modified semi-arid landscape. *Landscape Ecology* 28:415–426.



## Monitoring for the Stewardship Program

The Environmental Stewardship Program uses competitive auctions to contract individual land managers for up to 15 years to conserve critically endangered White Box/Yellow Box/Blakely's Red Gum Grassy Woodlands in south eastern Australia. These woodlands have been reduced to less than 3% of their original extent and persist mostly as small remnants of variable condition on private farmland. This paper reports on the design and implementation of ecological monitoring for the Stewardship Program.

The research team established monitoring sites on 153 farms located over 172,232 sq km. On each farm a monitoring site was established within the woodland patch funded for management and, wherever possible, a matched control site. The monitoring entailed gathering data on vegetation condition, reptiles and birds. Data was also gathered on the costs of experimental design, site establishment, field survey, and data analysis.

The costs of monitoring are approximately 8.5% of the Program's investment in the first four years and hence are in broad accord

with the general rule of thumb that 5–10% of a program's funding should be invested in monitoring. Once initial monitoring and site benchmarking are completed the researchers propose to implement a novel rotating sampling approach that will maintain scientific integrity while achieving an annual cost-efficiency of up to 23%. They discuss useful lessons relevant to other monitoring programs where there is a need to provide managers with reliable early evidence of program effectiveness and to demonstrate opportunities for cost-efficiencies. 🍌

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Lindenmayer DB, C Zammit, SJ Attwood, E Burns, CL Shepherd, G Kay & J Wood (2012). A Novel and Cost-Effective Monitoring Approach for Outcomes in an Australian Biodiversity Conservation Incentive Program. *PLoS ONE* 7(12) Read it here: <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0050872>

# How can global restoration targets be best met?

## Beyond the patch and across the landscape

By Richard Hobbs (EDG, UWA); Myles Menz and Kingsley Dixon (Kings Park and Botanic Garden and UWA)

Here's a lofty goal – the 2012 United Nations Rio+20 Conference on Sustainable Development endorsed a target to restore, by 2020, 150 million ha of disturbed and degraded land globally (see 'That's a big patch'). Although such initiatives can be transformative because of their scope and backing, they require technology and knowledge to deliver proven, scalable restoration. Can it be achieved? We recently examined some of the practicalities of attaining such a target (Menz et al. 2013).

### Scale and cost

The issue of scalability is a very important consideration here. Restoration is often practiced in relatively small areas such as individual properties or reserves. Indeed, intensive efforts at restoration have, to date, only been possible in such small areas. However, the extent of current environmental degradation and the increasing call for large-scale restoration necessitates approaches that can be applied over much larger areas. This involves restoring more individual patches but also considering broader landscape features such as water flows and connectivity (Figure 1).

As the area targeted for restoration grows so does the cost. In some cases economies of scale may be possible – for instance, it may be possible to restore a larger area of wetland by simply letting more water flow. However, in order to conduct restoration effectively at broad scales, the cost needs to be realistically factored in. In their review of the \$1.7 billion National Action Plan for Salinity and Water Quality (NAP), Pannell and Roberts (2010) found there was a strong tendency for environmental programs to attempt to achieve too much, allocating too few resources to too many projects. Overall, with a few exceptions, projects under the NAP generated few worthwhile salinity mitigation benefits and will have little enduring benefit. This was readily foreseeable given attention to the scientific and economic knowledge of salinity available at the time the program was developed.

Restoration practices must achieve the greatest value for money as far as socioeconomic and biodiversity conservation outcomes. Measuring these outcomes, as opposed to activity-based outputs like numbers of trees planted, is far from straightforward. Repeated national audit reports in Australia have condemned large-scale NRM investments (NAP and NHT for example) for failing to demonstrate any significant conservation outcomes.

### Beware simple solutions

Restoration solutions that are simple and cheap, such as the mass planting of fast growing monocultures, might be easy to roll out at the landscape scale but they are unlikely to achieve multiple outcomes and restore ecosystem services. Single species plantations may appear on the surface to be the most effective way to rapidly revegetate large areas, but diverse assemblages are likely to be able to achieve multiple outcomes more effectively – and have a greater capacity to withstand ongoing environmental change (consider the images on the next page).

**“Restoration solutions that are simple and cheap are unlikely to achieve multiple outcomes and restore ecosystem services.”**

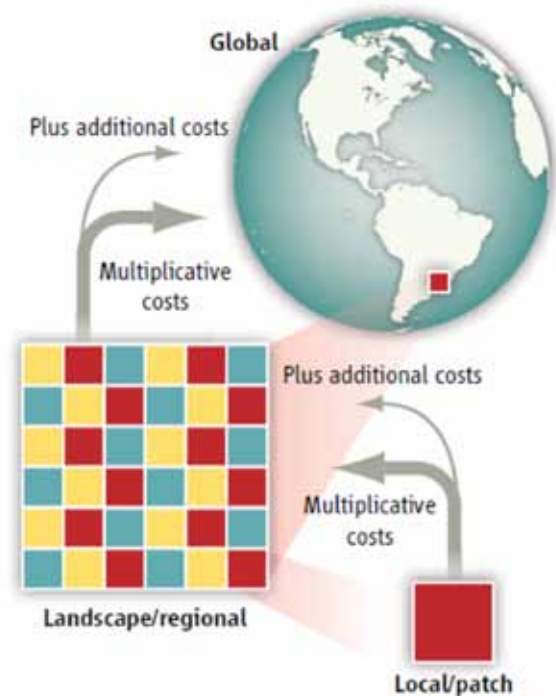


Figure 1: Scaling up restoration. Costs multiply as local patches are added, each requiring site treatment, seed or plant input, management, and so on. Additional costs and knowledge are necessitated by landscape and regional structures and processes (eg, hydrological management or transaction costs among different land uses). Economies of scale may be possible. Scaling up to the global level requires multiplicative and additional costs relating to social and political requirements. (From Menz et al. 2013).

Many initiatives start with good intentions but fail to achieve effective restoration goals. For instance, China's Great Green Wall of large-scale plantings of non-native trees may not be the most effective way to achieve multiple outcomes and restore ecosystem services. And then there's the need to be aware of the potential for perverse outcomes that might result from simplistic approaches (as has already been highlighted in our article on bio-perversities, see [Decision Point #62](#), p6,7).

### Still learning

In many regions, including many parts of Australia, our understanding on how to do restoration far outstrips scientific knowledge. A good example is the global biodiversity hot spot in

## Cracks in the Green Wall

The Great Green Wall of China will be a series of human-planted forests designed to hold back the expansion of the Gobi Desert. The project began in 1978 and is expected to be completed around 2050, at which point it is planned to be 4,500 km long! However, the focus on vast plantings of fast-growing tree monocultures has produced a range of unwanted impacts including dramatic drops in levels of groundwater and disease outbreaks. When doing things at a big scale, things going wrong can lead to big impacts. In the year 2000 one billion poplar trees were wiped out by disease.

Source: [http://en.wikipedia.org/wiki/Green\\_Wall\\_of\\_China](http://en.wikipedia.org/wiki/Green_Wall_of_China)



A restoration site in Sao Paulo state, Brazil. Originally this site was a hyper-diverse Atlantic Forest that was cleared for sugar cane. Now it supports a clonal eucalypt plantation. Monocultures of fast growing trees like this can return tree cover to an extensive area quickly. It can produce rapid biomass growth but it does not restore diversity, structure and function, and it lacks resilience to disturbance and environmental change over time. (Photo by Richard Hobbs)



A multi-species planting on former sugar cane fields, Sao Paulo state, Brazil. Restoration such as this returns diversity, structure and habitat in an area where the original Atlantic forest has been heavily fragmented. However, such efforts are very expensive and challenging to roll out at larger scales. (Photo by Richard Hobbs)

WA's south-west. Early efforts at restoring Jarrah Forests following mining in south-western Australia involved planting non-native and non-local species. This was based on best practice at the time but the results were less than impressive. However, over 30 years of research both within the mining company and in collaboration with other researchers has led to continued improvement in practices and outcomes. The same effort now needs to be put into finding effective (and cost-effective) restoration measures in the many other ecosystems in the region.

Scientific and practitioner communities are beginning to get to grips with what is likely to be required as we scale up from patch- to landscape-scale restoration. However, much remains to be done. To achieve success, we need to continue to identify gaps in knowledge, develop capacity and more effectively translate research into policy and practice.

If landscape-scale restoration is to be rolled out at a global scale, what else needs to happen? We propose a four-point plan to ensure restoration sustains and enhances restoration values (Menz et al 2013):

1. Identify focal regions with high restoration demands (such as drylands, which will suffer greatly from climate change)
2. Identify knowledge gaps and prioritise research needs
3. Create restoration knowledge hubs
4. Publicise the political viability of restoration by showing the economic and social benefits that restoration will provide.

## That's a big patch!

How big is 150 million hectares? One hectare is 10,000 square metres which is a square with sides of 100 metres. That's approximately the size of a football field.

A million hectares is therefore around million football fields, a size difficult to picture but it's bigger than Australia's Wet Tropics World Heritage Area and about a sixth of Tasmania. It's sobering to note, especially in this discussion on restoration, that Indonesia is losing around 1.1 million hectares of forest annually.

An area of 150 million hectares is therefore around 25 Tasmanias (or 75 Kakadu National Parks).

## Restoration shouldn't be the only option

As a society, we need to acknowledge the limitations in certain areas of restoration ecology. It is a relatively young discipline and consequently, restoration ecology is not yet at the stage of being able to provide instant, biodiverse ecosystems. In this context, we need to be mindful that in many cases, programs such as biodiversity offsets may simply result in the loss of high-quality habitats that we are currently unable to replace (a point explored by Martine Maron in [Decision Point #63](#), p6,7).

An example of this is banksia woodland in WA. We do possess the knowledge to achieve a level of success in restoring biodiversity values in these woodlands. But should this capacity for limited and delayed restoration be a green light for development to go ahead because land cleared today may lead to enhanced biodiversity somewhere else at a later time?

Each year approximately 800-1000 hectares of native bush is cleared, mostly for urban development in the Perth region. In addition to the immediate loss of biodiversity through clearing, this habitat also supports populations of the nationally threatened Carnaby's Black-Cockatoo, a mobile iconic species. Despite restoration projects and offsets being tabled to conserve this species, restored patches may not provide the necessary resources in time to halt species decline.

The restoration community needs to think broadly and engage with multiple stakeholders to build capacity in order to meet the many challenges associated with large-scale restoration. At the same time, we suggest that governments and society would do well to acknowledge that preventing environmental loss and damage remains a far better and cost-effective option than restoration after damage has happened. 🍷

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- Menz MHM, KW Dixon, & RJ Hobbs (2013). Hurdles and opportunities for landscape-scale restoration. *Science* 339: 526-527.
- Pannell DJ & AM Roberts (2010). Australia's National Action Plan for Salinity and Water Quality: a retrospective assessment. *The Australian Journal of Agricultural and Resource Economics* 54: 437-456.



## Bridging the great divide

### Road crossings and their value for wildlife

By Kylie Soanes (EDG, University of Melbourne)

People need roads – whether it's to travel across the country or nick down to the local shops. Unfortunately, roads – especially big ones – come with a high cost for many species of wildlife. For many animals, roads are big, noisy, sometimes lethal barriers. They cut through patches of habitat and restrict movement, dispersal and gene flow. They essentially have all the impacts of habitat fragmentation with the added risk of being flattened by a freight truck.

Road ecology is the study of the environmental impacts of roads and the ways we can try to mitigate these impacts. I see it as a bit like playing the 1980's arcade game 'Frogger'. There are a limited number of lives – our wildlife population – and we need to move animals safely across the road to access habitat, food and mates on the other side. If too many are killed by traffic, or don't cross the road at all, we lose too many lives and the population goes extinct. Game over.

One of the most common methods of mitigating these impacts is to build crossing structures. These might be bridges that go over roads, or tunnels that pass under them. The purpose of these structures is to help wildlife cross safely.

### Easy snacks for wise predators?

Gliders are prey for large nocturnal raptors like barking or powerful owls. One concern is that an owl could sit and wait near a crossing structure for their next easy meal to walk across – they're supposed to be wise after all. It's something we keep an eye out for, but so far we've had no evidence of owl predation near the structures. Unfortunately, these owls are usually also threatened species and in a lot of places there aren't many left to cause too much damage. If it were to become an issue we could install predator shields and refuge sites on the structures to give gliders and possums extra protection. It only becomes a problem, however, when the number of gliders eaten by owls while crossing the structure is more than the number of gliders that would be killed by traffic if the structure wasn't there.

*Another squirrel glider makes it alive over the great divide – the Hume Freeway.*

### Bridging the gap for arboreal mammals

Not all roads are impassable to all species; but the bigger the road, the harder it is to cross. The squirrel glider, for example, is a small threatened marsupial in south-east Australia that has no problem crossing small roads. It's great at crossing gaps in tree cover and can easily glide 30 – 40 m between trees. Unfortunately, major roads like the Hume Freeway (linking Melbourne to Sydney) are 50 – 100 m wide, and this presents a major problem for glider populations.

Road ecologists working on squirrel gliders have used radio-telemetry to track the nightly movements of almost 50 gliders and found that while squirrel gliders could easily cross the short gap over quiet, single lane roads (control sites), they didn't cross the 50 m gap across the freeway (van der Ree et al. 2010). However, at some freeway sites, squirrel gliders used tall trees present in the centre median as a 'stepping stone' and crossed in a few short glides. The freeway also reduced population survival rates, with mark-recapture revealing the survival rate of squirrel gliders living near the freeway was 60% lower than populations living at control sites further away (McCall et al 2010). The most likely cause is roadkill, as animals attempting longer glides across the freeway stray into the path of traffic.

As a result of this research, crossing structures were installed in 2007 at five sites where the Hume Freeway was a barrier to glider movement. These structures included glider poles and canopy bridges. The poles are tall wooden stakes, resembling oversized telegraph poles, in the centre median. They act as surrogate trees to reduce the gap across the

**“To justify the cost of these efforts we need to know that mitigation is producing results significantly better than no mitigation.”**



Squirrel gliders aren't the only animals who make use of the canopy bridges. A range of possums have also been recorded regularly crossing on them as well as brush-tailed phascogales (pictured above).



And once in a while something comes along that no-one would have predicted. Pictured above is a crafty goanna making use of the bridge. This shot, taken during the day, also shows just how wide the road barrier is.

freeway. Canopy bridges are long rope ladders strung between trees on either side of the freeway. They provide a structure for the gliders (and other wildlife) to climb across. These structures aimed to help squirrel gliders to cross safely, providing connectivity, reducing roadkill and ultimately enabling viable roadside populations.

### Connectivity restored?

What we needed to know next was how well these structures worked and the first thing we investigated was animal movement. We installed motion-triggered cameras on the canopy bridges and glider poles to see which species would go across and how often.

Things started slowly – we detected only five squirrel glider crossings during the first two years. However, thanks to those brave pioneers, gliders eventually adapted to the structures and over five years of monitoring we've detected more than 2000 crossings (Soanes et al 2013). Other regular visitors include common brushtail possums, common ringtail possums, brush-tailed phascogales and sugar gliders. Even a goanna has had a go.

We also repeated the previous radio-telemetry study, allowing us to

compare glider movements before and after mitigation at control sites and impact sites. Canopy bridges, glider poles and vegetated medians increased the probability that squirrel gliders would cross the freeway, while unmitigated sites remained a barrier to movement (Soanes et al 2013). However, no mitigation effort increased the probability that a glider would cross to the same level as control sites, those narrow, quiet roads. So, while movement was re-established, it was not restored.

### What's next?

We now know that squirrel gliders need vegetated medians, canopy bridges or glider poles to cross major roads. We also know that even with these measures in place, the impact of the freeway on movement is only partially mitigated. What we need to know next is: Is this reduced movement enough to maintain viable populations and gene flow? If so, is it more cost-effective to install canopy bridges, glider poles or simply leave tall trees in the centre median?

We'll answer these questions using before-after-control-impact monitoring. We'll investigate changes in population size, survival rates, breeding patterns and gene flow because it's not enough to know that animals use crossing structures. To justify the cost of these efforts we need to know that mitigation is producing results significantly better than no mitigation. If none of the methods effectively reduce impacts of roads on glider populations, we'll need to look into alternatives.

It's unrealistic to expect we will stop using these major roads (or that the building of roads will not increase), but it's unacceptable that our need for road transport comes at the expense of continued species extinction. Mitigating the impacts of major roads on squirrel gliders is but the first step in the much bigger process of creating wildlife-friendly landscapes. 🍷

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Soanes K, M Carmody Lobo, PA Vesk, MA McCarthy, JL Moore & R van der Ree (2013). Movement re-established but not restored: Inferring the effectiveness of road-crossing mitigation for a gliding mammal by monitoring use. *Biological Conservation* 159, 434-441.

van der Ree R, S Cesarini, P Sunnucks, JL Moore, A Taylor (2010). Large gaps in canopy reduce road crossing by a gliding mammal. *Ecology and Society* 15.

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### • How effective a solution?

- Mitigating the impacts of roads on wildlife is a major problem
- all around the world. Scientists working on this issue have even
- carved out a new discipline – road ecology. Millions of dollars are
- being spent on crossing structures helping everything from turtles
- to elephants safely cross roads. Many road agencies now rely on
- crossing structures to mitigate the impacts of construction projects
- on threatened species and meet regulatory requirements.
- However, for the most part, we simply don't know how well these
- mitigation measures really work because monitoring programs
- evaluating population-level impacts are rarely conducted.
- Long-term studies using before-after-control-impact population
- monitoring are required to truly evaluate the impacts of mitigation
- on population persistence. (See [Decision Point #64](#), page 4 -
- Measuring the effects of conservation management.)
- It's important to comprehensively evaluate these projects to ensure
- that successful strategies are widely adopted and unsuccessful
- ones are not repeated. If we're going to rely on these structures for
- conservation, we need to be very sure that they work.

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# Building bird-friendly cities

## How should we grow Australia's cities to minimize their biodiversity impacts?

By Jessica Sushinsky (EDG, University of Queensland)

Should we build our cities up or out? That's the question we asked when we considered the challenge of how a growing city can retain its wildlife. While it's unrealistic to believe city living can co-exist with a full complement of biodiversity, we wondered if there were differences in impact between different growth strategies.

With half of the global population already living in cities, and predictions of increasing urban population into the future, this is far from an academic question. While the urbanization that accompanies the movement of people into cities is one of most ecologically damaging and fastest growing of any land uses, little is known about how we should design the growth of our cities to minimize their ecological impact.

Australian cities are among the lowest density in the world. While this makes them liveable, being characterised by large backyards and leafy streets, such a style of development means the city takes up a very large area for a given population size. Using the city of Brisbane as a case study, we asked whether a more compact type of urban growth, where new housing is concentrated within existing city borders, would be better for conservation.

### A model of city growth

Urban growth in Brisbane has historically been of a sprawling character with a very low density of houses. However, in the face of recent rapid population growth, the state government has adopted a strategy of more compact urban growth in an effort to reduce land conversion. To test what the impact of the two strategies might be on biodiversity, we modelled the effects of compact and sprawling urban growth on distributions of bird species in the city.

We made models of the current distributions of birds based on 636 bird surveys across the city. Then, using relationships between bird occurrence and key features of the urban environment (including housing density, extent of green space coverage, and vegetative cover), we projected those models forward under two alternative urban development scenarios.

Both scenarios considered what would happen if 84,642 dwellings were added to the city. In the compact scenario these dwellings were added through infill and subdivision of existing residential areas. The sprawling scenario directs these extra dwellings into areas of open space outside already developed areas as low density development. This sprawling



Brisbane's growth over recent decades has been characterised by a low-density suburban sprawl. Further growth along these lines will come at the cost of many urban-sensitive species of bird. (Photo by Cyron Ray Macey, Creative Commons)

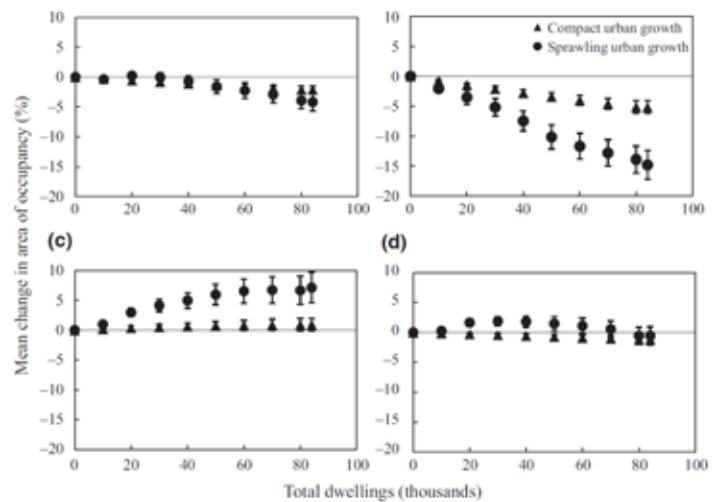


Figure 1: Mean per cent change in species' predicted area of occupancy across the city under compact (triangles) and sprawling (circles) urban growth scenarios for (a) all species, (b) urban-sensitive species, (c) non-native species, and (d) urban-adapted species. (From Sushinsky et al. 2013)

“Urban sprawl results in the disappearance of many urban-sensitive birds and leads to an increase in feral birds.”

scenario reflects a continuation of the pattern of urban growth that has gone on in Brisbane over the past few decades.

To measure changes in bird distributions under each urban growth scenario we calculated the change in area of occupancy for each bird species between the current model and the two growth scenarios. We also measured how our experiences of birds would change – how many local extinctions would occur around where we live, and how would the two urban growth strategies change people's access to green spaces and backyards?

### The consequences of growth

Our analysis revealed that both scenarios of urban growth reduce overall bird distributions. However, compact development substantially slows these reductions at the city scale (figure 1). Urban-sensitive species in particular benefit from compact development because large green spaces were left intact. Under the sprawling development scenario, urban-sensitive species declined sharply and non-native species expanded. Overall, sprawling development resulted in significant changes in species' distributions and major shifts in assemblage structure, while the impacts of compact development were much less pronounced.

Urban sprawl, therefore, results in the disappearance of many urban-sensitive birds – birds that only live in areas where there is native vegetation, such as parklands and woodlands. And it leads to an increase in feral birds such as the common myna or the spotted turtle dove, as they tend to thrive in low density suburbs.

On the other hand, compact development retains more birds, including species such as Lewin's honeyeater, grey shrike-thrush, red-backed fairy-wren and striated pardalote. This is because it keeps more of its parks and green areas.





## A tale of three birds

Different growth trajectories will have different impacts on different species. For example:

The Australian magpie (above on the left) is an urban-adapted species that is commonly found across the city in a variety of habitats. They are most often associated with low-density suburbs containing large backyards. Magpies increase their range under sprawling development as this habitat type increases and are relatively unaffected by compact urban growth.

The striated pardalote (centre) is a habitat specialist and requires high quality green spaces with vegetation and tall trees to do well. It is

particularly sensitive to any form of urban growth. This species declines under both compact and sprawling urban growth but these declines are minimized under compact urban growth because high quality green spaces are preserved.

The superb fairy-wren (right) is a habitat specialist but can be found in backyards and small strips of vegetation around the city that have dense patches of low-growing shrubs. While this species declines under both compact and sprawling urban growth, compact development helps to minimise this species' decline because it preserves the areas of dense vegetation this species requires to do well.

(Photos by Richard Fuller)

The proximity of local biodiversity and green spaces to people also differed markedly between the two growth scenarios. Under compact development, bird species richness in newly developed residential areas was slightly higher than under sprawling development, and people maintained greater access to public green spaces around their home. However, compact development necessarily resulted in smaller backyards, which impacts opportunities for people to experience nature close to home. Compact development has the overall effect of maintaining provision of public green spaces and proximity of local biodiversity to people, but reducing the size of private backyards.

### Trade-offs in the city

Our results suggest that cities built to minimize per capita ecological impact are characterised by high residential density, with large interstitial green spaces and small backyards. However, there are important trade-offs between maintaining city-wide species diversity and people's access to biodiversity in their own backyard (figure 2).

While compact development means smaller backyards, it can also make our entire cities more biodiverse. The study shows that we should hold on to our green spaces instead of clearing them for sprawling development.

This is the first time science has modelled the effects of different urban growth strategies on birds. Statistical models like these are important

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## A tale of 1000 cities

- Richard Fuller will be extending this work globally during his ARC Future Fellowship (which commenced in December 2012). Cities vary enormously in their environmental impact, yet we do not understand what causes much of this variation. Richard wants to discover general rules for optimising the design of cities to minimise their environmental impacts while maintaining their economic performance and human quality of life. He will collect data on the performance of more than 1000 cities globally, and develop new theory to discover answers to this question. At the heart of this research program is an opportunity to learn how city growth should best be managed to achieve efficient use of environmental resources at a time of peak global demand.

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because they help decision makers understand the ecological consequences of a particular decision. And decisions on possible trajectories of city growth are confronting major cities all around the world.

If well planned, compact urban growth can preserve large intact green spaces and maintain an ecologically heterogeneous city which supports a large variety of bird species. However, without careful planning, increased residential density may just as easily result in the loss of these large green intact spaces and a loss of biodiversity. The choice is ours. ●

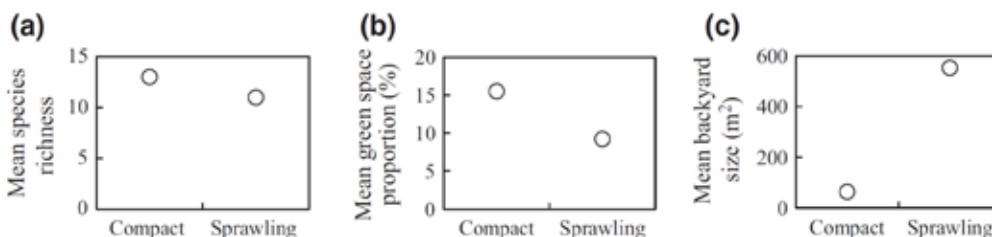


Figure 2: Opportunities for people to experience local biodiversity under the two urban growth scenarios; (a) mean species richness per 200 m pixel in all pixels where one or more new dwellings has been added, (b) mean proportion of green space coverage within a 1.5 km radius of each residential property, and (c) mean backyard size (m<sup>2</sup>) of the newly added dwellings. Compact development can provide more green space and species for everyone but at the cost of individual backyards. (From Sushinsky et al. 2013)

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# Principles of population viability analysis (PVA)

## A checklist of the basics

By Brendan Wintle (EDG, University of Melbourne)

Population viability analysis (PVA) is a model-based protocol for characterising and predicting future fluctuations in a species' abundance. PVA is a potentially powerful tool for predicting a species' response to natural and anthropogenic impacts and for evaluating management options in terms of their contribution to a species' long-term persistence. PVA can be based on models as simple as a single parameter population growth model through to quite complex simulation models that incorporate stochastic landscape and ecological processes, usually involving estimation of many parameters.

In its simplest form, a population growth model characterises the rate of change in the population using a single parameter called the *finite rate of population growth*  $R$ , so that the population size ( $N_t$ ) at a time  $t$  is equal to  $R$  multiplied by the population size in the previous time step ( $t-1$ ):

$$N_t = R * N_{t-1}$$

In most applications of PVA, we usually decompose population growth into four components; births, deaths, immigrants, and emigrants. We then model those processes separately. In doing so, we are able to incorporate the range of natural and anthropogenic influences on those four processes separately and attempt to analyse how each might impact on the long-term persistence of a species. This checklist outlines some of the key considerations and challenges involved in analysing a species' viability using population models.

## Constructing a basic population model

### 1. Vital rates

Often we decompose  $r$  into estimates of birth and death rates. At the population level, birth rate (fecundity:  $f$ ) is defined as the average number of births in a given time period, and death (or mortality:  $m$ ) rate is defined as the average number of deaths in a given period. Estimation of *fecundity and mortality* (often termed the *vital rates*), and predicting how these rates vary under a range of environmental conditions is at the heart of PVA. Poor estimates of vital rates lead to poor PVA. For most listed threatened species, estimates of vital rates are published in the literature. Nonetheless, uncertainty about vital rates is often substantial due to natural/geographic/temporal variability, variation arising from environmental (including anthropogenic) forces and interspecific competition, and challenges associated with measuring these rates in the wild (especially for death rates of rare, long-lived species such as large forest owls). Note that it is often desirable to explicitly model variation in vital rates within a population (among individuals) because differences in responses of individuals (or groups of individuals) to environmental changes or anthropogenic impacts can be very important in determining the fate of a population or species. For this reason, it is common to describe mortality as the probability that an individual will die during a given time period, and fecundity as the number of offspring expected to arise from any individual during a given time

“Population viability analysis is more than ticking a series of boxes. However, if you can't tick all the boxes presented here there could be serious holes in what you find.”



period. For convenience, *survivorship* ( $s$ ); the probability that an individual will survive a given time period (equal to  $1 - \text{the mortality probability}$ ) is often used in PVAs instead of mortality.

Check: **Estimates of vital rates should be based on published demographic data. Where published data are not available, it is appropriate to derive estimates from unpublished data, expert opinion and even collect new data for the specific purpose. Clear documentation of how vital rate were estimated is crucial. Temporal and geographic variation in vital rates and uncertainty around vital rate estimates should be documented. The sensitivity of PVA to uncertainty about vital rates should be included in PVA model reporting (see 12).**

### 2. Initial population size

Population models require an initial population size ( $N_0$ ) at a starting time (usually the present or some relevant reference time;  $t_0$ ). A relevant starting time might be some 'pre-impact' state, if the aim of the analysis is to understand the role of an anthropogenic stressor on the long-term viability of the species. For extremely well-studied species with known distributions and good population monitoring data,  $N_0$  may be relatively easy to obtain (eg, the orange-bellied parrot). However, for more widespread populations of species with low detectability, for which there exists little reliable population-level monitoring data (eg, southern brown bandicoot),  $N_0$  may be very difficult to estimate. For such species, a defensible strategy for estimating  $N_0$  is to utilize a species distribution model (SDM), in combination with an estimate (or observations) of the population densities at varying levels of habitat suitability, ranging from best habitat to marginal habitat in an average year.

Check: **A defensible estimate of the initial population size should be provided, based on a clearly described estimation method.**

### 3. Carrying capacity & density dependence in vital rates

The carrying capacity ( $K$ ) of a population describes an upper limit on the number of individuals an area can support due to resource limitations such as food, space (in the case of territorial species), or shelter availability (eg, number of hollows for denning).  $K$  may be estimated on the basis of knowing how a limiting resource is distributed in space and time; however, it is more common to estimate  $K$  based on observed maximum densities in the wild and then model how  $K$  varies with habitat quality (usually defined using a species distribution model; SDM). Depending on the biology of a species and how individuals compete for resources,  $K$  may serve as a hard upper-bound population size, or it may be used to define how vital rates change as a population approaches  $K$ . When vital rates are based on the relationship between  $N$  (population size) and  $K$ , this is known as 'density dependence in vital rates'. There is guidance in the literature about how to define  $K$  and density dependence in vital rates given basic details about a species' biology.

Check: **Estimates of  $K$ , the approach used to characterise variation in  $K$  as a function of habitat quality, and density dependence assumptions should be supported by published evidence.**

#### 4. Life stage

For most organisms, fecundity and mortality vary depending on their age, or life-stage. For example, most large mammals have low (or zero) fecundity and high mortality rates in the early years of life, high fecundity and low mortality rates around the age of sexual maturity, and then declining fecundity and increasing mortality in the later years of life. This variation in vital rates can be modelled by using a stage-based population model where each stage is modelled separately (using its own vital rates). Stages can be defined very flexibly. In some instances it is convenient to define vital rates for species as a function of age in years (or months or days), while for other species, stages are defined using uneven numbers of years (eg, the commonly used human stages of newborns, toddlers, juveniles, and adults all imply age-categories of differing lengths).

Check: **The stage (or age) structure of the model and the vital rate estimates for each stage should be justified according to published accounts of the species' biology and vital rates.**

#### 5. Variation over time

$K$  and the vital rates vary over time in response to changes in habitat availability and quality, weather, and other stochastic processes such as disease, fire, and predation. This variation is known as 'environmental stochasticity' which can be explicitly modelled using sub-models such as those described in sections 9 and 10 below. 'Demographic stochasticity' is another source of variation in vital rates that results from random differences among individuals in survival and reproduction. If explicit analysis of those stochastic processes is not relevant to the planned use of the model it is still necessary to incorporate stochastic variation in  $K$  and vital rates because it does influence extinction risk. It is reasonable to implicitly incorporate observed temporal variation in  $K$  and vital rates using Monte-Carlo analysis (see supporting documentation). In the absence of data to support estimation of temporal variation in  $K$  and vital rates, it is reasonable to input a range of estimates and report on how sensitive the overall viability assessment is to uncertainty about natural variation in vital rates (see 12).

Check: **Temporal variation in  $K$  and vital rates should be included in the PVA either by explicitly modelling the drivers of variation or by using estimates of variance based on population monitoring data. In the absence of data to estimate temporal variation, check that a range of values has been tested with sensitivity analysis.**

#### 6. Genetic variation

Periodic reductions in population size and fragmentation of habitats have been shown to lead to impacts on genetic variation, which in turn may impact on the long-term viability of populations and a species due to inbreeding depression or genetic bottlenecks that restrict adaptive potential. It is possible to characterise the impacts of restricted genetic variation using PVA, though formal analysis of genetic variation in PVA is not very common and tends to be important only when population sizes are very small. One of the challenges associated with incorporating genetic analyses into population viability is that it is expensive and time consuming to characterise population-level genetic variation, and then relate genetic variation to variation in vital rates. However, if appropriate genetic data are available, then it may provide valuable insights into the impacts of habitat and population fragmentation and reduction resulting from land-use decisions.

Check: **The modelled relationships between population size and genetic influences on vital rates such as inbreeding or bottlenecks should be supported by published data.**

## Dispersal dynamics model

#### 7. Immigration and emigration rates

Populations that are completely isolated from other populations of the same organism are known as *closed populations*. If it is not defensible to assume a population is closed, then immigration and emigration rates must be estimated because they may have a strong influence on the long-term viability of populations, especially small ones. The process of migrating from one population to another is commonly referred to as *dispersal*.

Check: **Where assumed, the assumption of population closure should be justified. Otherwise immigration and emigration rates should be explicitly estimated (or modelled) using a meta-population approach (see next section).**

#### 8. Meta-population dispersal

A meta-population is defined as a set of populations that are connected by dispersing individuals but which are separated by a geographic distance or barrier that precludes contact between individuals during normal *home-range* movements. Habitat fragmentation resulting from habitat destruction or alteration can turn a single population into a meta-population if the process of fragmentation creates gaps between suitable habitat patches that cannot be traversed in the course of normal range movements of a species. Determining whether a species' viability should be analysed as a single-population, a meta-population, or a set of closed populations requires explicit analysis of the home-range movement and dispersal distances of a species. A meta-population model includes home-range and dispersal distance estimates, which help define the probability that individuals will disperse between populations at each time step. How the probability that an individual will disperse between two patches varies as a function of the distance between the patches is usually represented using a graph called a 'dispersal kernel'. Advice on collecting and analysing range-movement and dispersal data, defining a meta-population structure, and calculating dispersal probabilities is widely available.

Check: **Home range and dispersal distance estimates should be provided, including a description of the method of calculation. The approach to calculating meta-population dispersal probabilities should be clearly documented, including analysis of geographic barriers to migration between populations.**

## Landscape change & disturbance models

#### 9. Landscape change

The distribution of suitable habitat for a species (and hence, the spatial variation in  $K$ ) varies over time in response to predictable landscape changes such as forest growth, succession and disturbance. Disturbances include the predictable (manageable) disturbances such as timber harvesting and prescribed burning, and less predictable, stochastic processes such as wildfire. The influence of predictable changes in the landscape on  $K$ , vital rates and dispersal (meta-population structure) can be represented using GIS maps of planned activities. These maps can be used to modify estimates of  $K$ ,  $s$ ,  $f$  and dispersal at specific locations and future times, enabling explicit inclusion within the population model. It is often analysis of the impact of these planned management activities such as timber harvesting or prescribed burning on species viability that is being assessed with the PVA. There are numerous published examples of how to go about incorporating planned alterations to habitats in PVA in a spatially explicit way. A particular type of

*Continued on page 12*

## Principles of PVA

Continued from page 11

unplanned, but predictable environmental change that may impact on species viability via changes to  $K$  and vital rates is long-term changes in weather brought about by climate change. Examples of how to model the impacts of climate change on species viability are now readily available in the peer-reviewed scientific literature.

Check: **Planned management activities or unplanned environmental changes that alter  $K$  and vital rates should be incorporated in the PVA model in a way that is supported by published precedents.**

### 10. Unpredictable events

Many of the disturbances that impact on species viability through changes to  $K$  and vital rates are highly unpredictable (stochastic) events such as wildfire, disease, and drought. These sort of impacts on  $K$  and vital rates can be handled implicitly (section 5) or explicitly using stochastic simulation models. It is possible to incorporate such processes in a PVA because, while it is not possible to know exactly where and when the next unpredictable catastrophe will occur, it is possible to analyse the statistical properties of catastrophes, such as the mean and variance in the time interval between fires, and the mean and variance of wildfire sizes for a particular region. These statistical properties can be used to simulate multiple future landscape scenarios, providing a picture of the likely fate of a species that is subject to random disturbance events. The value of PVA based on landscape scenario models that integrate both predictable disturbance (e.g, timber harvesting) and unpredictable disturbance (eg, wildfires) is that the synergistic or additive impacts of multiple disturbance types on viability can be assessed.

Check: **The range of possible stochastic impacts on a species' viability should be considered and included using methods justified by published precedents. When modelling unpredictable disturbances using simulations based on statistical properties of disturbance such as mean and variance, it's important to have a large number of model simulations in order to adequately characterise the uncertainty in PVA predictions resulting from stochastic disturbance.**

## Outputs

### 11. Standard outputs

PVA models produce a range of standard outputs including the probability of population or meta-population extinction within a particular time period, the minimum population size that the population is expected to reach within a particular period, or the predicted population size at the end of the simulation which is usually considered in relation to the initial population size ( $N_0$ ). Graphical outputs include plots of how the population size is predicted to change over the simulation period, predicted changes in  $K$  over the simulation period. The result that is most highly emphasized depends on the purpose of the model and the extinction risk status of the species in question. It has been demonstrated that the expected minimum population size (EMP, also known as expected minimum abundance: EMA) is a relatively robust statistic for use in comparing the outcomes of management options. Low extinction probability over a specified period does not equate to low impact; a population might be reduced by 75% in 20 years but still have a low probability of extinction within that period. Predictions of extinction risk or time-to-extinction are seldom reliable because small population sizes are highly susceptible to stochastic disturbances, which are by their nature quite difficult to predict. This is another reason to focus reporting on EMA.

Check: **The choice of model outputs should be justified with respect to the aim of the study. When the aim of the PVA is to compare management options, the expected minimum abundance (EMA) is a good basis for comparison. Comparison of impact scenarios should be made directly against some universally understood reference or baseline such as a scenario that represents the status quo or one that includes minimal anthropogenic impacts.**

### 12. Sensitivity analysis

Sensitivity analysis provides a picture of how robust PVA model predictions are to uncertainty about model parameters. For example, if there was concern about the reliability of the survivorship estimates used in a PVA for the powerful owl, then it would be reasonable to see how much owl EMA varied under the highest and lowest plausible estimates of survivorship. If the difference in EMA obtained using the high and low estimates of survivorship were trivial, then a reviewer could be confident that the findings of the PVA were not sensitive to uncertainty in the estimate of survivorship. A similar logic can be applied when considering how sensitive ranking of management options is to uncertainty about estimates of key parameters. If the ranking of management options (based on EMA) do not change across plausible values of a particular parameter, then it is fair to assert that the ranking is not sensitive to that parameter estimate. When uncertainty about parameters is found to be critical in determining the ranking of management options, then the result is said to be sensitive to uncertainty about that parameter. In this case, it may be necessary to (i) invest in obtaining a better estimate of that parameter, or (ii) utilize a decision strategy that accounts for the uncertainty in the parameter estimates (beyond the scope of this checklist!).

Check: **Sensitivity analyses should be undertaken across all uncertain parameters, and the sensitivity of the findings to uncertainty in parameters should be described in the report.**

## A few good references

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# Conserving biodiversity in expanding cities

## Planning for biodiversity and development in the urban fringe

By Sarah Bekessy (EDG, RMIT University)

Biodiversity near and within urban areas brings many benefits but its maintenance involves complex trade-offs between competing land uses. We recently demonstrated how these trade-offs can be better described to facilitate more transparent, efficient and democratically derived urban planning (Bekessy et al. 2012).

Conservation planning has come a long way in recent years (with EDG researchers making significant contributions to the field). It has helped managers and policy makers create effective and efficient networks of nature reserves however the reserve design tools of conservation planning have rarely been applied in the urban fringe.

We used reserve design tools in a novel way to identify priority development sites. The approach is based on a synthesis of ecological, social and economic data. Then trade-offs between biodiversity conservation and other key development objectives were quantified. Other key development objectives included transport planning, flood risk and food production. And we demonstrated how all this can be done using a case study of changes in land use across the City of Wyndham, a local government west of Melbourne.

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

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

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

“The reserve design tools of conservation planning have rarely been applied in the urban fringe.”

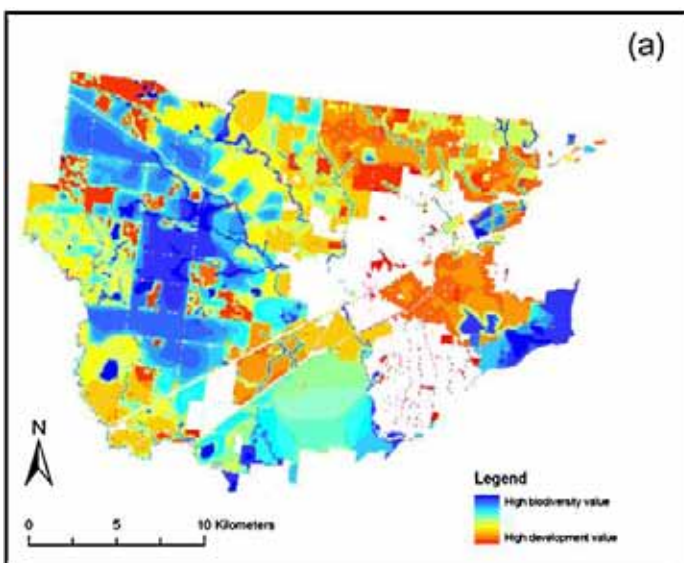


Figure 1. A map of the study area showing its biodiversity value (a). (b) shows areas representing the lowest ranked 10% of the landscape in terms of biodiversity value. If biodiversity was your only consideration when it came to development then the areas in pink are places you would develop. Of course, in the urban zone there are many other considerations such as proximity to



In Australia, over 50% of threatened species occur within the urban fringe and accelerating urbanization is now a key threat. Biodiversity near and within urban areas brings much social and ecological benefit but its maintenance involves complex trade-offs between competing land uses. (Photo by Phil Gibbons)

The tool provides powerful visual representations of the planning scenarios (eg, fig 1) that can be used to integrate objectives and explore tradeoffs. The spatially explicit, visually compelling output from the model addresses an identified need in urban biodiversity planning.

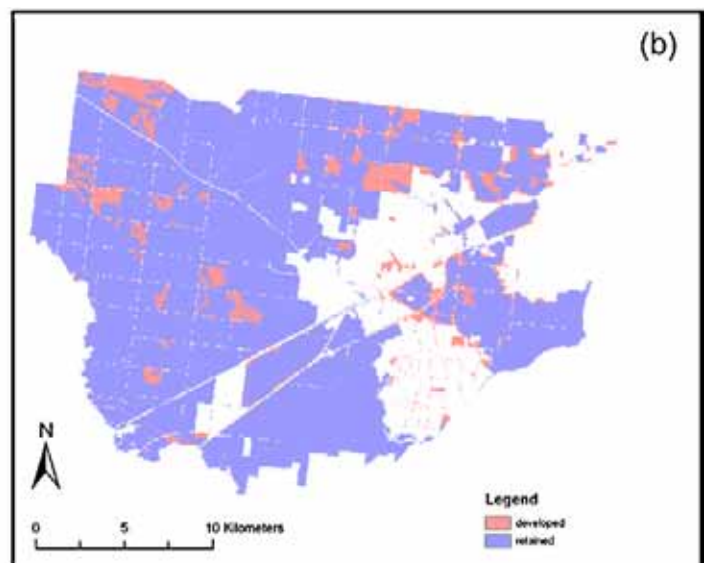
While this tool provides a transparent mechanism for articulating trade-offs in urban planning, it does not indicate whether decisions are ultimately 'acceptable'. The decision to clear habitat to meet competing objectives is a social one, but should be made acknowledging the risks to other concerns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

Nevertheless, the method proposed here is a step towards adapting conservation planning methods to planning of urban development zones. The approach is novel in that it uses 'reserve design' tools in an inverse manner to identify areas of least impact on biodiversity assets that are preferable for development and then to explore trade-offs between ecological, social and economic objectives. 📍

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### Reference

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transport and flooding risk. The researchers explored multiple scenarios where these other considerations are also factored in to demonstrate it is possible to optimise urban planning taking into account multiple considerations. (From Bekessy et al. 2012)



# Is nature good for you?

## And, if so, what kind of nature counts?

By Richard Fuller (EDG, University of Queensland)

*Editor's note: Richard Fuller has long been intrigued by the issue of what's the value of nature and biodiversity in our urban spaces. His lab has pioneered many studies in this realm including the modelling exercise on how we might build bird-friendly cities (see page 8). Underpinning this research is the broader question of what nature does for us. Do we need a full complement of biodiversity or does a picture of a pot plant provide the same benefit? Here Richard discusses a review of this challenging topic that was led by his colleague Lucy Keniger. Space does not allow us to include a full list of references for the case studies he mentions but the original journal article is freely available to the general public. Just follow the link in the reference.*

Like many of us, I live in a small suburban unit with a backyard the size of a postage stamp. While this is arguably a good urban design for minimising biodiversity impacts (see 'Building bird-friendly cities' on page 8), there is mounting concern that our modern urban lifestyle disconnects us from nature. This is worrying because nature experiences seem to provide important benefits to many aspects of our lives, including our mental and physical health, social relationships and even our spiritual well-being. However, much of the evidence for these benefits is correlative. If we are ever to reach the stage where we can value the benefits as ecosystem services, or design therapeutic landscapes, we need to understand what the benefits are and how they operate. To take stock of what we do know, and what we do not, we recently reviewed the benefits to people of interacting with nature (Keniger et al. 2013).

### I see a tree

Some of the most fascinating studies in this area are experimental or quasi-experimental. For example, a 1984 analysis of Pennsylvanian hospital patients recovering from having their gall bladder removed found that patients in rooms with a view of trees spent less time in hospital, required fewer strong painkillers, received fewer negative evaluative comments from nurses and had fewer post-surgical complications than patients whose rooms overlooked a brick wall. More

*Children raised in nature-deficient areas may be less likely to appreciate and support conservation initiatives in adulthood. But how much nature in terms of quantity and quality is needed to create a nature-loving child? (Photo by Richard Fuller)*

recently, work in the UK and The Netherlands has shown that people living near green spaces have lower than expected disease loads and death rates.

As well as physical health benefits, the restorative properties of nature can improve cognitive function. Here's how it works. In busy urban environments, our attention must be directed towards avoiding potential hazards and coping with noise and visual stimuli. This directed attention requires sustained effort to inhibit or address these stimuli and this can lead to mental fatigue, resulting in reduced ability to concentrate and perform cognitive tasks.

The extent to which different environments restore our ability to perform these tasks can be measured quantitatively. For example, one study measured cognitive performance with a backwards digit span task, in which participants listen to a sequence of numbers and repeat them in reverse order. The task was performed more accurately after the participants had walked through a tree lined arboretum in comparison with a walk through a busy city street.

### I see a plant

These benefits are not just restricted to the great outdoors. A study in Japan found that indoor plants had a similar beneficial effect on cognitive performance, though in this case only for male participants. The female participants showed higher task performance than the males regardless, and the presence or configuration of indoor plants had no additional effect on their cognitive performance.

Even photos of indoor plants can deliver measurable benefits. A study in Taiwan used electromyography and electroencephalography to test participants' responses to photographs of office environments with different configurations of indoor plants and natural views. Physiological condition improved when viewing a picture of an office

“Nature experiences seem to provide important benefits to many aspects of our lives, including our mental and physical health, social relationships and even our spiritual well-being.”

with a view of nature and indoor plants, suggesting a reduction in the physiological effects of stress. However, another study showed that cognitive performance declined with increased density of indoor plants. Such conflicting results are not unusual in this field, and many additional unmeasured factors are undoubtedly at work.

Physiological measures of stress can also be used to measure the restorative effects of nature. In an experimental study in China, researchers measured salivary amylase activity as an indicator of stress before and after exercise in either a forest or an urban environment. Enzyme activity was significantly reduced only after exercise in the forest. A related study in Switzerland found that physical activity in parks reduced stress-induced headaches. Interestingly the effect was consistent for park and forest environments, despite the very different biological characteristics of those environments.

### I experience green space

The benefits of having nature around where we live and work also extend to wider society. Violence and aggression in Chicago are significantly lower in buildings with higher densities of surrounding vegetation. A possible causal pathway for this effect is that urban vegetation restores attentional function, reducing the occurrence of aggressive behaviour and indirectly contributing a social benefit to the broader community. This fascinating Chicago-based work has not—our knowledge—been replicated in any other study system; it would be great to discover whether these results generalise to other locations, not least because there are myriad social consequences of nature benefits in urban settings. For example, how much could the crimefighting or mental health budget of a major city be influenced by some carefully targeted urban green space provision?

Being close to nature could also improve your bank balance. A study in Castellon, Spain, discovered that house prices increase with the proximity of the nearest green space, even when many additional variables are taken into account. A fascinating twist on this story is that there is a negative effect of proximity to green space in Baltimore neighbourhoods where crime rates are high, suggesting that green space can be viewed as a liability in some situations (eg, where criminal activity takes places under the cover of dense vegetation!).

### The child within

Some benefits are far less tangible. Wildlife tourists in Spain and California reported that viewing wildlife evoked a feeling of awe and wonder and created a temporal experience in which all their concentration was focused on the moment.

Children raised in nature-deficient areas may be deprived of early interactions with nature and may therefore be less likely to appreciate and support conservation initiatives in adulthood, though the evidence surrounding this is still rather equivocal. While this is not necessarily a benefit *per se*, there is real potential for significant conservation outcomes if we can understand how attitudes and behaviours that are positive toward nature develop during our lives.

Overall, the evidence for most benefits remains correlational, and although there are several experimental studies, little as yet is known about the mechanisms that are important for delivering these benefits. Perhaps most importantly, we do not know which characteristics of natural settings (eg, biodiversity, presence of key species, level of disturbance, proximity, accessibility) are most important for triggering a beneficial interaction, and how these characteristics vary in importance among cultures, geographic regions and socio-economic groups. These are key directions for future research if we are to design landscapes that promote high quality interactions between people and nature in our rapidly urbanising world.

In the meantime, I will continue to wander frequently into the backyard with our baby daughter so she can enjoy the nature that we do have! 🌿

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### Reference

Keniger LE, KJ Gaston, KN Irvine & RA Fuller (2013). What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, 10, 913-935. Freely available from <http://dx.doi.org/10.3390/ijerph10030913>

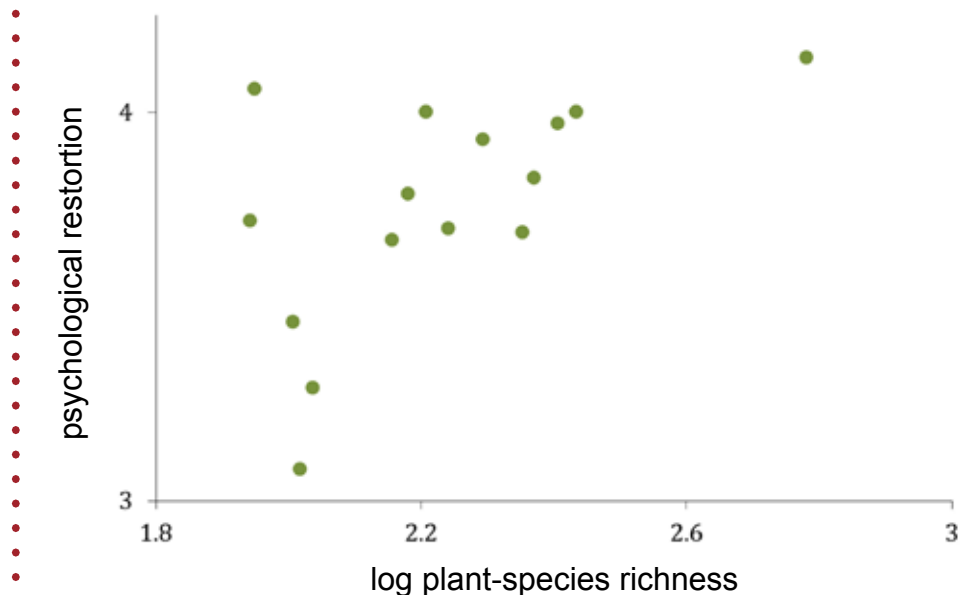
## Does more biodiversity lead to more benefits?

We found evidence for six main types of benefit of interactions with nature: psychological well-being, cognitive function, physical health, social function, spiritual well-being and tangible economic outcomes. Social scientists have by far been the most active researchers in working on the benefits of interacting with nature, with very few biologists being engaged. As a result, we have only a rudimentary understanding of which features of the natural environment are important in delivering the benefits. One study I carried out in Sheffield found correlative evidence that the psychological well-being of urban park

users increased with plant species richness in 15 parks measured across the city (Fuller et al. 2007). This remains one of only a tiny handful of studies testing whether more biodiversity leads to more benefits, and we don't know how widely these results generalise.

### Reference

Fuller RA, KN Irvine, P Devine-Wright, PH Warren & KJ Gaston (2007). Psychological benefits of greenspace increase with biodiversity. *Biology Letters*, 3, 390-394.





## Restoration, NERP and SEWPaC

Pictured above is Professor Richard Hobbs addressing a packed house in the 'Bunker' lecture theatre over at the Department of Sustainability, Environment, Water, Population and Community (SEWPaC). He was giving a lecture on the many challenges of ecological restoration at scale, a topic that the department is having to grapple with on a number of fronts (for example, the wildlife corridors and carbon sequestration initiatives). Richard is one of Australia's foremost experts on ecological restoration and a co-author of the recent *Science* paper on restoration at scale (see his editorial on page 4). What made this lecture noteworthy was that within days of that *Science* paper coming out, SEWPaC knew about it through its NERP program (via the Scientific Research and Information Section that runs NERP); Richard, being a key researcher with NERP ED, was asked if he might give a presentation to SEWPaC, to which he agreed; and the lecture took place in weeks to a packed audience. "It's the fastest response from policy people I've ever had to a paper," quipped Richard before the lecture. Which all suggests that NERP is connecting real and real-time science to policy in ways that have rarely been done in the past. ●

## What's the point?

### The spider and the city

Many animals are losers in urban environments but that's not the case for golden orb-weaving spiders (*Nephila plumipes*). Research by PhD student Lizzy Lowe from the University of Sydney has found that orb weavers in urban parks do better than orb weavers in bush remnants and national parks. The urban spiders are bigger, heavier and had a higher lipid composition. She believes it probably relates to urban lighting bringing in more insects (food) and man-made structures like car parks radiating heat which speed up spider development. Which just goes to show, spinners are grinders. ●



## ENVIRONMENTAL DECISIONS GROUP

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 and CSIRO.

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*Decision Point* is the monthly magazine of the EDG. It is available free at: <http://www.decision-point.com.au/> If you would like to contact *Decision Point*, see page 2.

To contact the EDG please visit our websites at: <http://ceed.edu.au/> or <http://www.nerpdecisions.edu.au/>

