

DECISION POINT

Connecting conservation policy
makers, researchers and practitioners

Issue #72 / August 2013

Ecosystems under threat

Which threats
do you tackle first?



**Seeking clarity over
seagrass & climate change**



**When does an ecosystem
become 'extinct'?**



**What is lost when the
cloud forest dries up?**

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

Climate change and the eucalypts of Oz
Fire management and reptile diversity
Global vs local threats to ecosystems
Introducing the IUCN Red List
of Threatened Ecosystems

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Sana Bau needs your help.



Our cover: Did you know that a hectare of seagrass sequesters a comparable amount of carbon dioxide to an equivalent area of rainforest? Unfortunately these 'blue carbon' ecosystems are one of the most threatened ecosystems on Earth. See page 14. Photo by Megan Saunders.

On the point

Framing threats to ecosystems

If a tree falls over in a forest but no-one sees it happen, does it matter? If an insect species (in that same hypothetical forest) goes extinct but science had never described it, will anyone notice it's gone? If climate change means the dominant tree species in that forest is likely to be unable to cope in twenty years time, should we give up on the forest because the local managers can't do anything about climate change? The answer to all these questions (like so many questions in conservation science) is 'it depends'.

No, this is not Metaphysics 101, this is Decision Point, and this issue contains a wealth of science on ecosystems, how we frame them and make decisions about the many threats they face.

Up front we discuss the IUCN Red List of Threatened Ecosystems (see page 4), a new risk framework that has been in development now over many years (and one that EDG has made significant contributions to). The fact is that unless we describe something and assess its risk in some formal, widely-accepted framework, then it's likely its decline will be overlooked (say goodbye undescribed 'insect'). The Red List of Species has helped in prioritising actions relating to species (the 'trees') but until now we haven't had a workable framework for ecosystems (the 'forest').

Then Rocio Ponce-Reyes analyses the extinction risk of individual species in our disappearing cloud forest ecosystems (page 6); Nathalie Butt examines what climate change means for eucalypts, our dominant tree species across much of Australia (page 8); and Annabel Smith looks at how fire management will hit reptiles in our mallee ecosystems (page 10).

Next we dive underwater with Megan Saunders who discusses local and global threats to seagrass ecosystems in Moreton Bay (page 14). Managers might not be able to do anything about climate change but they can do something about water quality. Will responses to local threats compensate for impacts from global threats? Chris Brown (with Megan) then point out it's the interactions between local and global threats that should determine what we should prioritise (page 12).

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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 (old and new) from EDG researchers. If you would like copies of any of these papers please visit:

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

Informative priors to improve management

Prior scientific knowledge inspires ecological research, hypotheses and debate but it's rarely used to explicitly formulate predictive models. Bayesian statistics provide a formal way to include informative priors and evaluate their influence on parameter estimates. In this study, Tara Martin and colleagues use case studies of the influence of overabundant deer on the abundance of bird species on the Gulf Island, San Juan and Haida Gwaii archipelagos of western North America. They demonstrate the utility of informative priors and Bayesian modelling to determine the consequences of overabundance. They found that by including informative priors about deer browsing impacts on bird species from a study undertaken in Haida Gwaii, the precision of estimates from a similar study undertaken in the Gulf and San Juan archipelagos could be significantly increased.

Uncertainty about regional ecological impacts underpins the failure of many agencies to take management actions. The researchers demonstrate that informative priors, when used logically and transparently, can be a highly cost effective way to increase understanding of ecological processes. In some cases, it may be the only way to inform decision-making when scarce resources limit long-term field research or the threat is so great that immediate action is required.

For several bird species examined here, the inclusion of informative priors strengthened the conclusion that their populations were negatively affected by changes in vegetation structure caused by deer browsing. Their findings suggest that deer browsing in these island archipelagos must be managed if the risk of local extinctions among native flora and fauna is to be avoided. 🍌

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Reference

Martin TG, P Arcese, PM Kuhnert, AJ Gaston & JL Martin (2013). Prior information reduces uncertainty about the consequences of deer overabundance on forest birds. *Biological Conservation* 165: 10-17.

Are Australia's MPAs representative?

Marine protected areas (MPAs) have become the cornerstone of many national and international strategies for halting the loss of marine biodiversity. Australia has made strong international commitments to increase its coverage of MPAs through the principles of systematic conservation planning and, in the last ten years, has rapidly expanded its MPA coverage using these principles.

This paper assesses Australia's progress in achieving a key principle of systematic conservation planning—representation—which states that MPAs will include the full range of marine ecosystems. Australia's progress in achieving representation is measured nationally and within seven extensive Commonwealth marine regions: the Great Barrier Reef Marine Park (rezoned in 2004), the South East Marine Regional Plan (2007), and the South West, North West, North, Temperate East and Coral Sea proposed plans (2011). State marine waters (within 3 nautical miles of the coast) are not considered. Results illustrate that, if the proposed marine plans are followed as set out at the time of this analysis, Australia will protect just over 36% of its marine jurisdiction in MPAs and over 13% in 'no-take' marine reserves. However, except for MPAs in the Great Barrier Reef (and the proposal for the Coral Sea marine park) the existing and proposed MPAs are far from representative. Importantly, only a small portion of the highest protection occurs on the continental shelf where activities potentially harmful to marine biodiversity are concentrated.

Despite having a strong and long-standing commitment to the principles of systematic conservation planning, Australia is not achieving the fundamental requirement of representation across most of its marine jurisdiction. The authors conclude that a failure to set quantitative targets is restricting the achievement of representative marine protection in Australia. Consequently, the 2004 rezoning of the Great Barrier Reef remains a model to emulate, not only in other countries, but in other parts of Australia's marine waters. 🍌

Reference

Barr LM & HP Possingham (2013). Are outcomes matching policy commitments in Australian marine conservation planning? *Marine Policy* 42: 39-48, ISSN 0308-597X, 10.1016/j.marpol.2013.01.012. <http://www.sciencedirect.com/science/article/pii/S0308597X13000213>

Does veg composition improve modelling?

Temperate woodlands in Australia have been disproportionately cleared following European settlement. Biodiversity decline in such systems may be reversed by restoring native vegetation on agricultural land. However, rebuilding functioning habitat will require an understanding of what determines the distribution of species in existing habitat.

Makysm Polyakov and colleagues used logistic regression of bird occurrence data from 240 sites across northern Victoria, to determine the probability of occurrence of 29 woodland-dependent bird species. They modelled occurrence as a function of both the extent (amount) and composition of native vegetation surrounding sites. The goal was to determine whether the predictive performance of models is improved by accounting for both extent and composition of native vegetation compared with models that characterise native vegetation by extent alone.

For nearly all bird species, accounting for vegetation composition in addition to extent (and weighting habitat variables by distance) improved the explanatory power of models, explaining on average 5.4 % (range 0–27.6 %) of the residual uncertainty in models that

accounted for extent alone. Models that incorporate variation in vegetation composition can not only provide more accurate predictions of species occurrence, but also guide more appropriate restoration.

The research highlights the need for restoration activities to incorporate sites with fertile soils that support productive vegetation types. These models of woodland birds will be used to inform a spatially-explicit optimisation model for restoring native vegetation cover on agricultural land in this region. The goal of this work is to achieve biodiversity gains while minimizing losses to agricultural production. 🍌

Reference

Polyakov M, AD Rowles, JQ Radford, AF Bennett, G Park, A Roberts & David Pannell (2013). Using habitat extent and composition to predict the occurrence of woodland birds in fragmented landscapes. *Landscape Ecology* 28:329-341. <http://link.springer.com/article/10.1007%2Fs10980-012-9831-3#>

A new list to frame biodiversity conservation

Introducing the IUCN Red List of Ecosystems

By David Salt (Australian National University)

Nature is in trouble. How do we (as in the general public) know this? Because conservation scientists and conservation managers are telling us that some of our best known (and loved) animals and plants are disappearing. The ranges of many species are contracting, some in spectacular fashion, and their population sizes are dwindling. For some species it's believed these declines won't lead to the loss of the species (for the foreseeable future) but for others it's believed they are close to becoming extinct.

What are we going to do about it? Well, we're going to try and save those species that are in trouble. Unfortunately, no government on the planet is prepared to invest anywhere near the amount needed because while people don't like threatened species going extinct, they also expect our governments to provide hospitals, schools and police forces. At the end of day, conservation is but one of a range of activities supported by the government.

So, many species are in trouble and governments don't invest enough resources to save them all. Choices have to be made. Which species do we allocate the limited resources too? Current policy (in most places around the world) favours expenditure on the most threatened species. No politician wants a species going extinct on their watch. A growing number of researchers (and this includes the EDG) would like to see available resources achieving the greatest good (and that might not be by only focussing on the most threatened species).

Okay, so far I've said nothing you wouldn't see in many stories appearing in *Decision Point*. The arguments above are central to much of EDG's work – ie, many species are in trouble, there are not enough resources, choices need to be made, and there are different ways of approaching how these decisions should be made (see the box on the species prism). I reiterate these points here because interwoven between them are a few underlying assumptions, and



The Aral Sea, pictured above, has been transformed from a large and thriving ecosystem to a dry and toxic wasteland. If it was a 'species' it would be a good example of what 'extinction' looks like because this ecosystem is not coming back, it's lost forever. However, while ecosystem collapse might be obvious (especially when viewed in hindsight), what does an 'endangered' ecosystem look like? And at what point might you transfer an 'endangered' ecosystem into a category of 'vulnerable'? The IUCN Red List of Ecosystems is grappling with these questions.

they are that conservation is largely viewed through a prism of the status of threatened species, and that different approaches to making a difference with our investments are judged by how it changes the status of threatened species.

The status of threatened species, therefore, is a cornerstone to biodiversity conservation. That's in part because species are 'units' that are relatively easy to distinguish and count. It's also in part because an international body, the International Union for the Conservation of Nature (IUCN), has developed a widely accepted list of threatened species that it updates each year. The IUCN Red List of Threatened Species assigns species to one of five risk categories (from 'least concern' to 'critically endangered') with robust criteria for how any described species moves from one category to another.

But the status of species is but one facet of the conservation problem. Scientists have become increasingly concerned that the habitats of species and the ecological processes that influence the relationships between species are not adequately considered. What we need (what we have long needed) is a Red List of Ecosystems, and this year the IUCN has delivered one. It's a risk assessment framework for ecosystems that lets the IUCN rank ecosystems as endangered, vulnerable or not threatened according to the risks they face.

One of the reasons we've had a species list for much longer than an ecosystems list is that defining, measuring and comparing ecosystems is a much tougher proposition than defining, measuring and comparing the status of threatened species (which is challenging enough in itself). It's easy to observe that the Aral Sea is a collapsed ecosystem; the sea itself has largely disappeared and with it many of its native animals and plants – never to return. In terms of area, composition and function, this ecosystem is gone.

“Attempting to classify the threat level to ecosystems is a truly daunting task given the range of factors involved and things that could be measured.”

The species prism in a nutshell

1. Species are in trouble

In 2013, the IUCN lists 20,930 species as critically endangered, endangered or vulnerable. That number was 10,533 back in 1996/98.

http://www.iucnredlist.org/about/summary-statistics#Tables_1_2

2. We don't spend enough to save species

A recent analysis in the journal *Science* of what it would cost to reduce the extinction risk of all threatened species came up with a figure of US\$4.76 billion each year, an order of magnitude more than current conservation funding.

<http://www.sciencemag.org/content/338/6109/946>

3. The change in status is one way of comparing investment options

An EDG analysis on bird conservation in Australia demonstrated that an annual budget of \$10 million (that's an average of \$37,000 per bird species of conservation concern) can be expected to reduce the number of threatened species in 80 years time by approximately 15% while limiting the number of extinct species to one. It should be noted that this level of spending is approximately three times what is being spent at the moment.

http://decision-point.com.au/images/DPoint_files/DPoint_23/dp23%20optimal%20investment%20macarthy%20p6.pdf

But what about the Coorong wetland in South Australia? It's suffering enormously from reduced freshwater inflows but recent heavy rains further up the catchment have enabled it to bounce back to some extent. As an ecosystem, what's its risk?

Or what about Florida's Everglades or Australia's Great Barrier Reef. Both are suffering, among other things, from nutrient inflows from nearby agricultural activity. These inflows are distorting ecosystem processes and species mix and thereby producing a raft of undesirable changes. Both ecosystems are under tremendous pressure but at what point should they be considered vulnerable as opposed to endangered?

Attempting to classify the threat level to ecosystems is a truly daunting task given the range of factors involved and things that could be measured. However, just as the Red List of Species has helped the basic framing of the problem of biodiversity decline and enabled a robust comparison of the various solutions, the conservation world desperately needs a framing for ecosystems, too.

The ecosystems framework that has been released by the IUCN is the product of many discussions and workshops between scientists (including many EDG researchers, and in particular Dr Emily Nicholson at the University of Melbourne, see [Decision Point #62](#)). It is very much a product of science and at this stage is a work in progress. The framework for a Red List of Ecosystems was recently published in a scientific study in the Public Library of Science journal, *PLoS ONE*. The article illustrates how the framework would work focussing on 20 case studies (Keith et al. 2013).

"The *PLoS ONE* paper is the culmination of years of work," says Emily Nicholson. "Particular credit goes to Professor David Keith from the University of New South Wales, the lead author. In it, we describe and provide the scientific basis for the criteria for the IUCN Red List of Ecosystems.

"So far we just have the criteria, applied to 20 illustrative case studies from around the world, but the aim is to have a complete assessment of the world's ecosystems by 2025 – which is going to take a lot of work! Currently the Americas are underway."

The Red List of Ecosystems assesses each ecosystem against five criteria. Two of the criteria relate to an ecosystem's distribution – how rapidly it is declining and its current extent. Another two of the criteria relate to functional characteristics of ecosystems. They measure how rapidly and how extensively the physical and biological components of an ecosystem are degrading, particularly the processes that sustain the ecosystem and its species. The fifth criterion allows multiple threats to an ecosystem to be assessed, as well as potential interactions between these threats.

"We assessed 20 ecosystems as part of the study," says David Keith. "The remote mountain ecosystems of the Venezuelan Tepui are among those at least risk of collapse. These are showing little evidence of decline in distribution or function in the past or near future. At the other extreme is the Aral Sea of central Asia, which collapsed during the 1980s and 1990s.

"The lessons from the Aral Sea assessment are sobering. Not only were a host of species lost forever as the sea became hypersaline and dried over much of its former extent, but the ecosystem collapse led to socio-economic disaster, including the closure of regional fisheries and shipping industries. Dust storms were generated from the dry sea bed and they continue to have major impacts on infant mortality and other indicators of human health."

Professor Keith believes that the methods underpinning the assessment of ecosystems for the Red List are a vital part of the scientific infrastructure needed to support evidence-based environmental management.

"For the first time, we have a scientifically robust risk assessment framework, which works across the full range of terrestrial, freshwater, marine and subterranean ecosystems," he explains.

"As an early warning system, the Red List of Ecosystems will help governments, industries and communities avoid ecosystem collapse and the associated socio-economic impacts by informing better environmental decisions.

"Red List assessments will better target the ecosystems most vulnerable to degradation and help determine which options for investment in environmental management will work best. Ultimately, better planning and management is needed to conserve our rich biodiversity and sustain ecosystem services that support our current standards of living."

So, while the state of biodiversity conservation around the world has up until now largely been framed by our perceptions of species loss, now we have a new and complementary prism to look through. And it's important to note that the Red List of Ecosystems doesn't diminish the Red List of Species. They work together.

"The ecosystem Red List focuses on biodiversity, habitats for species, as well as their interactions and dependencies, including food webs," says Keith. "The species Red List focuses on individual species, some of which may go extinct even though the ecosystems in which they live continue to remain functional.

"Together, the Red Lists for species and ecosystems will provide a more comprehensive view of the status of the environment and its biodiversity than either can on its own." 🍎

Reference

Keith DA, JP Rodríguez, KM Rodríguez-Clark, E Nicholson, K Aapala, A Alonso, M Asmussen, S Bachman, A Bassett, EG Barrow, JS Benson, MJ Bishop, R Bonifacio, TM Brooks, MA Burgman, P Comer, FA Comín, F Essl, D Faber-Langendoen, PG Fairweather, RJ Holdaway, M Jennings, RT Kingsford, RE Lester, R Mac Nally, MA McCarthy, J Moat, MA Oliveira-Miranda, P Pisanu, B Poulin, TJ Regan, U Riecken, MD Spalding & S Zambrano-Martínez (2013). Scientific foundations for an IUCN Red List of Ecosystems. *PLoS ONE*, 8(5): e62111.
<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0062111>

For more background on the Red List of Species see Emily Nicholson's blog at: <http://emilynicholson.wordpress.com/2013/05/10/scientific-foundations-for-an-iucn-red-list-of-ecosystems/>

or David Keith's editorial at The Conversation:

<https://theconversation.com/identifying-ecosystems-at-risk-the-new-iucn-red-list-14011>



Part of the process of developing criteria for the Red List of Ecosystems was the staging of six international workshops hosted by a variety of conservation groups and research networks. One of these was hosted by CEED in May last year (see [Decision Point #62](#)). This workshop, held at the University of Melbourne, focussed on the application of the draft criteria to marine systems, definitions of collapse (analogous to extinction for species), and ways of assessing change in ecological function as they move towards collapse.

Pictured above are the participants of that workshop.

Staying alive in a shrinking cloud forest

The story of the bird, the frog and the mouse

By Rocio Ponce-Reyes (University of Queensland)

Thanks to climate change and land conversion, Mexico's famous cloud forests are shrinking. By 2080 it's expected they may be a splinter of their former glory. The forests provide habitat for a disproportionate amount of the country's biodiversity (see the box: 'Head in the clouds') but the impacts of forest loss will be felt differently by different species. Understanding these differences will be important when forming conservation plans. How, for example, will a local bird cope as opposed to a frog or a mouse?

One of the main objectives of conservation planning is ensuring the persistence of species. One way to measure persistence is by estimating a species extinction risk – that is, the probability of a species becoming extinct during a time frame. Some ecosystems, like cloud forests, are more vulnerable to climate and land-use change than other ecosystems but this has different implications for different animals and plants. I recently led an analysis that calculated the extinction risk of three very different types of animal found in the cloud forests of Mexico (Ponce-Reyes et al. 2013).

Different animals

Researchers have developed a range of models to calculate the extinction risk of species in different situations. I used a metapopulations model that relates the extinction risk to the ecology of species. It incorporates factors such as the area they require to live (home range), the distance they are able to travel between fragments (dispersal distance) and their fecundity rate (number of offspring that make it to adulthood and reproduce). As a general rule, populations in fragmented landscapes are generally more susceptible to human-related threats than those in continuous landscapes.

The highly fragmented nature of the cloud forest lends itself to applying a metapopulation approach to calculate the extinction risk of its species. In this analysis we chose three very different animals to explore what a shrinking forest means for different life strategies. We looked at a bird, a frog and a mouse. The bird we selected was the resplendent quetzal (*Pharomachrus mocinno*), a famous species in this region (and Guatemala's national bird). Unfortunately, we couldn't find reliable population-ecology data on amphibians or mammals living in the cloud forests so we parameterized the model with similar vertebrate species found in other forest types. We used a frog based on the cliff chirping frog, *Eleutherodactylus marnockii*, and a mouse based on the deer mouse *Peromyscus maniculatus*.

A bird like the quetzal can fly long distances, however their home range is very large and the number of 'chucks' that make it to adulthood is very low. In contrast, the frog has a very small home range, but their dispersal ability is very low. On top of this, the number of froglets that survive and leave descendants is also low. Finally, the mouse's home range is small but can travel long distances and their fecundity rate is the highest of all three species.

Different regions

Cloud forests have different vulnerabilities to climate and land-use changes depending on where they are. We analysed two scenarios: 1. climate change as the only driver of habitat loss and fragmentation; and 2. climate change and land-use change outside protected areas as the drivers of habitat loss. In this second scenario we assumed that only the cloud forest-suitable areas that are currently in a protected area would remain, those outside of these areas will be converted to other uses.

We analysed both scenarios in three regions of Mexico with different landscape configurations: (a) a stable region of cloud forest (Oaxaca) with the largest total area, the least fragmented and few protected



A frog of the Mexican cloud forest. Climate change and land conversion may mean its days are numbered. (Photo by Omar Ordoñez.)

areas (around 4% of cloud forests at present); (b) the cloud forest region with the smallest total area of the three regions, although not very fragmented (Chiapas South) but heavily protected (about 72% of cloud forests in this region are currently in a reserve); and (c) a very fragmented region with about 7% of their cloud forests within a protected area (Chiapas North).

Our models predicted that the more drastic reduction of cloud forest suitable areas in Oaxaca would occur by 2080, with about 40% of the current total cloud forest area becoming climatically unsuitable for cloud forest when assuming only climate change as the only threat. However, if land-use change was assumed as well, around 2% of the currently suitable areas for cloud forest might remain in a single patch. This is because this region has the smallest proportion of their cloud forest under protection.

Chiapas South is currently not very fragmented, but we estimated that by 2080 the suitable areas for cloud forest will contract dramatically to around 3% of the forest's current extent (and this would be as two patches that are relatively close together). When we assumed that only the cloud forest within a protected area might remain our models predicted that the total area of protected forests in this region might decrease severely (by 98%) into only one patch by 2080.

For Chiapas North, we expect that only 16% of current cloud forest might remain in climatically suitable areas by 2080. Although the number of fragments in this area is only predicted to decrease slightly, the average size of these fragments will shrink dramatically (the mean patch size in 2080 will only be 16% of what they were in 2010). From the cloud forest currently within a reserve in this region, we expect that less than 0.5% might remain by 2080.

Different strategies, different outcomes

When only climate change is considered as a threat, the species with the highest extinction risk in the Mexican cloud forest are those with the short dispersal distances. In our case, this means the frog (fig 1b). This is because fragments will become more isolated in the mountains and species with low dispersal abilities will encounter problems in

“No matter which variant of our model you look at, the Mexican cloud forest's species do not have a promising future.”

colonising new fragments in case their original fragment becomes environmentally unsuitable. In fig 1b the probability of extinction of the frog seems to decrease for Chiapas South in 2080. This is because the metapopulations model does not predict the extinction risk of less than five patches accurately. For those cases, we estimated the 'joint probability of all populations becoming extinct' which only takes into account the home range of the species and the extent of the remaining habitat. The landscape configuration prediction for Chiapas South, in 2080 is of two relatively big fragments. Because the frog has a very small home range, the probability of all frog populations disappearing in this region is small (as they still have enough habitat remaining). However, if land-use change is added to the pool of threats, then species with big home range requirements are the most threatened (here, the quetzal, fig 1d).

The different vulnerabilities to threats of the cloud forests patches in each region affects the extinction risk of the species. When climate change was the only threat, the region where the species had the highest probability of becoming extinct was in Chiapas South (the currently most fragmented of the three, fig 1a-c) and again, the frog was the most vulnerable species.

But when we analysed the patterns within protected areas (climate and land-use change together as threats), Chiapas North always had the highest probability of extinction for all three species (fig 1d-f); with the quetzal having the highest extinction risk in this area. Although we predict that only one patch of cloud forest will remain protected for each of the three regions, Chiapas North is predicted to lose more of its suitable habitat (compared to the other two regions).

Modelling the future

Models for extinction risk provide a quantitative and process-based link between patterns of ecosystem change and species persistence, and form a sound basis for conservation decision-making. Unfortunately, no matter which variant of our model you look at, the Mexican cloud forest's species do not have a promising future. The loss and fragmentation of their habitat in the next 70 years under climate change is projected to be considerable, resulting in an increased extinction risk for most cloud forest species.

Our modeling approach, however, does reveal the relative risks of extinction from the combined impacts of climate change and land clearance. Approaches such as this have the potential to allow us to identify which regions and patches are more vulnerable to the threats, and potentially rank management strategies. 🍌

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Reference

Ponce-Reyes R, E Nicholson, P Baxter, R Fuller & HP Possingham (2013). Extinction risk in cloud forest fragments under climate change and habitat loss. *Diversity and Distributions. Special Issue: Risks, Decisions and Biological Conservation* 19: 518–529.

Head in the clouds

Tropical Montane Cloud Forests (TMCFs) are special places created by specific processes. They are found in the tropics, at mid-altitude on the windward slopes, where the clouds intersect with the mountains. The persistent cloud cover over the canopy of the forest maintains the high annual precipitation (500–1000 mm) and humidity. It also ameliorates intense sunlight, maintaining a mean temperature of 12–23°C.

Because of their specific environmental needs, TMCFs are naturally fragmented, much of their original extent has already disappeared and current protected areas are poorly placed with respect to the future distribution of cloud forest under climate change. Due to their high biodiversity and endemism, TMCFs are considered among the most threatened ecosystems of the world.

In Mexico, TMCFs are limited to a narrow strip between 600 and 3000 metres above sea level in the main mountain ranges, covering around 0.8% of the region. They are characterized by an archipelagic distribution and high biodiversity containing some 10% of all Mexican plant species and 12% of all Mexican terrestrial vertebrates with many endemic taxa.

Under conservative climate change scenarios it has been estimated that in Mexico suitable areas for TMCF will decrease by up to 70% by 2080. However, if cloud forest outside of current protected areas is transformed for other land-uses such as agriculture (and there are many examples of this), less than 1% of TMCF might remain (see [Decision Point #58](#)).



Though they only cover less than 1% of the land, Mexico's cloud forests contain more than 10% of the country's plant and vertebrate species. Their loss will result in a catastrophic loss of biodiversity. (Photo by Rocío Ponce-Reyes.)

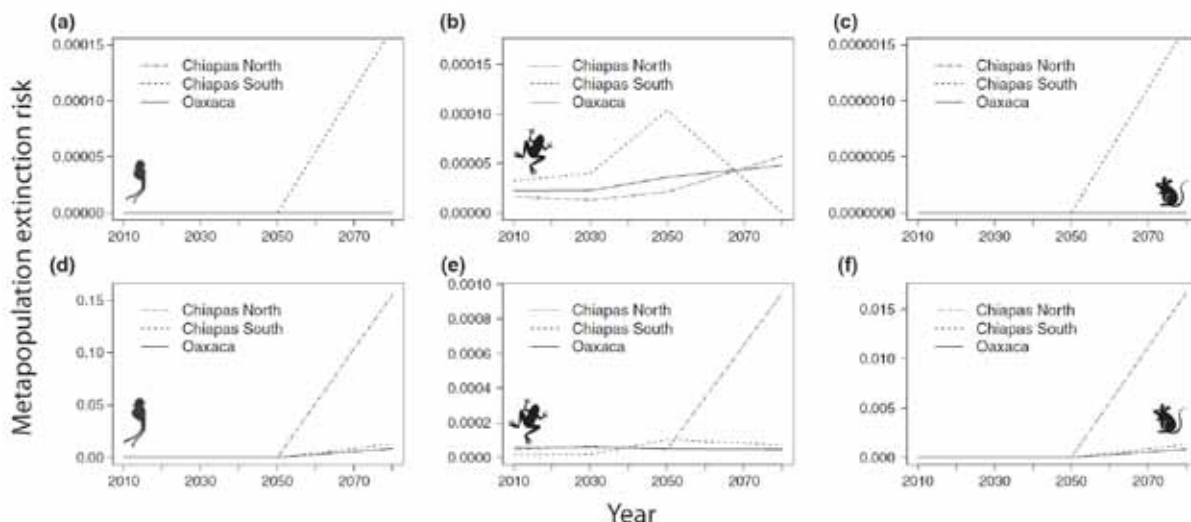


Figure 1. Annual probabilities of extinction of the metapopulations of the quetzal, frog and mouse in three regions of the Mexican cloud forests (a-c) and in the protected areas (d-f). (From Ponce-Reyes et al. 2013)

Give me a home among the gum trees

But what if those gum trees lose their home to climate change?

By Nathalie Butt (University of Queensland)

Eucalypts are iconic trees in Australian landscapes, and given the variety of treed landscapes that are found across Australia, that's an amazing thing to consider. There are around 800 species (eucalypt taxonomy is a moveable feast) of three genera, *Eucalyptus*, *Corymbia* and *Angophora* that together are known as eucalypts or gum trees, and these trees have dominance or co-dominance in most forest and woodland ecosystems in Australia. You'll find them in rainforests, up mountains and across the arid zone. And, in all these places, eucalypts are providing a range of essential resources for other animals and plants as well as generating ecosystem services such as climate regulation, water security and carbon sequestration and storage.

How will this important group of trees cope with climate change? Trees are among the first groups to be affected globally by climate change as they are particularly vulnerable due to long generation times and short dispersal distances. In the northern hemisphere there's been considerable research on the projected impacts of climate change on species and ecosystems but that's not the case with southern-hemisphere ecosystems.

Working with Laura Pollock (University of Melbourne) and Clive McAlpine (University of Queensland), I recently led the first comprehensive investigation into the vulnerability of eucalypt distributions to climate change across Australia. The findings of our analysis should be out soon but here's an overview of what we discovered.

While our findings focussed on Australian systems, they have important implications for many other southern hemisphere regions, such as subtropical and tropical savannas with seasonally variable rainfall. These occur widely across Africa, South America and the Asian subcontinent.

A continental-scale analysis

As those of us who live here are well aware, Australia's climate is unique in its high variability, with most of the continent water-limited (apart from during floods and rainstorms!). The additive combination of changes in temperature and rainfall will govern the likely impacts we will experience from climate change.

Climate projections indicate that fluctuations in temperatures and rainfall will increase over time. They will also increase the further

One country, many eucalypt-dominated ecosystems. Pictured below are examples of some of the shapes and forms of gum trees across Australia and the ecosystems they influence. Climate change could have profound impacts on many of them.

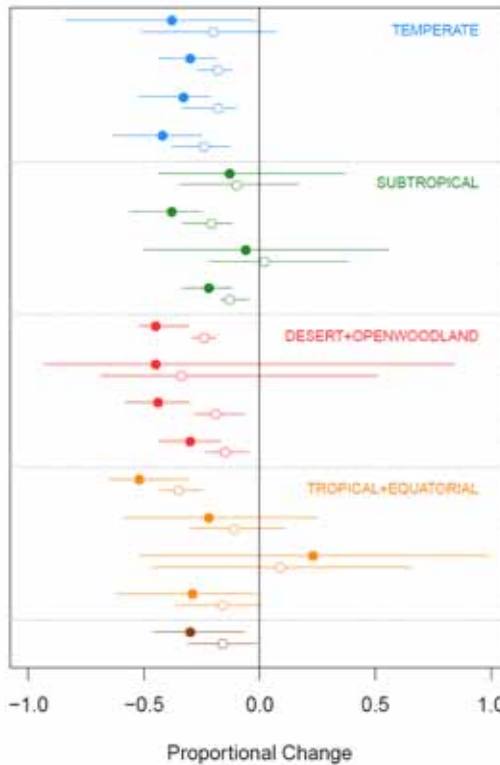


Figure 1: Proportional pixel losses and gains by climate regional group (each region includes four climate subgroups), calculated from the 2085 time step for both scenarios (moderate and extreme). The lines with solid circles represent group ranges and means for the extreme scenario; the lines and hollow circles show the group ranges and means for the moderate scenario.

you move away from the coast. This means that the continental interior will become hotter and drier faster than other areas. Available moisture is projected to decrease which will affect evaporation and evapotranspiration. This transition to a hotter and more drought-prone climate represents a major risk for Australia's ecosystems, particularly for those without the capacity to recover or adapt.

So, how best to carry out a continental-scale analysis, accounting for climate and geographical variation? We used the climate classes from the Bureau of Meteorology to identify four broad bio-geographical regions, each with four climate region sub groups. We selected representative eucalypt species for each climate region, each community role (where the species status is either dominant, typical or endemic) and each type of range breadth (wide/narrow/local). We also included a 'wide-range' group of species whose distributions were not closely linked to any of the climate regions (Figure 1).



This gave us a total of 108 species, to which we applied a bioclimatic modeling approach using Maxent and two newly available Representative Concentration Pathway scenarios developed for the 5th Assessment Report of the IPCC; a moderate and an extreme scenario. This allowed us to identify which groups of species will be affected by climate change, how the impacts will differentially drive changes in distribution through shifts in suitable climate space, and what are the consequences for biodiversity.

A shrinking climate space

Annual rainfall and two measures of seasonality, dry-quarter precipitation and wet-quarter temperature, were the key bioclimate predictors in the model. We calculated climate space loss and gain per pixel and found that:

- species ranges in the 'tropical+equatorial' group will shift further north and east,
- species ranges in the 'subtropical' group will shift further east and south,
- species ranges in the 'desert+openwoodland' group will shift primarily south and west, and
- species ranges in the 'temperate' group will shift south.

The wide-range species all showed an overall loss of suitable climate space, broadly in the north or west of their range, and some expansion south or southeast of their current range (Figure 2). All species showed some gain and some loss of suitable climate space pixels. However, gain was greater than loss for only ten of the 108 species we modelled. Only four of these – all of them savanna or grassland/open woodland species – showed a greater than 10% gain (Figure 1).

Overall, Eucalyptus species in the central desert and open woodland regions will be the most affected, losing 40% of their climate space under the extreme climate scenario. The least affected species, in eastern Australia, are likely to lose 20% of their climate space under the extreme scenario.

Continental limits

The net losses, and the direction of shifts and contractions in range, suggest that many species in the eastern and southern seaboard will be pushed towards the continental limit. That means that large tracts of currently treed landscapes, especially in the continental interior, will change dramatically in terms of species composition and ecosystem structure. The slow response times of trees means that they are unlikely to move quickly enough to keep up with climate change. There is evidence of this already happening in some eucalypt systems. In the northern savannas and the Murray basin, for example, there has been dieback due to drought.

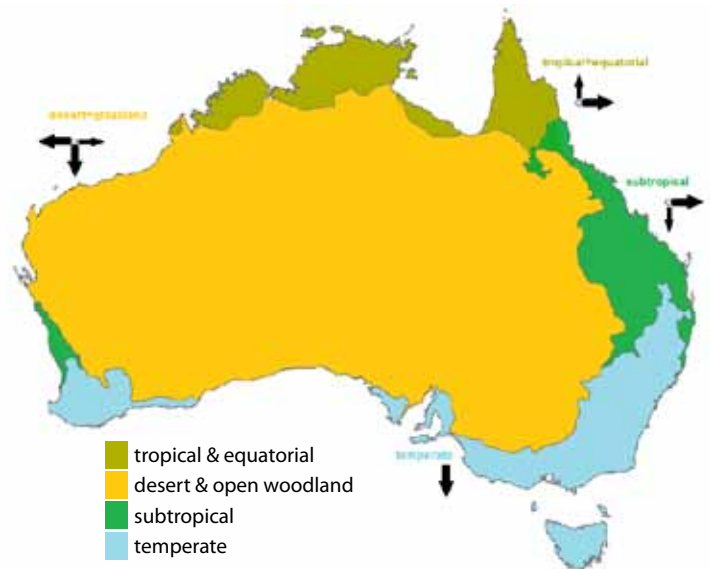


Figure 2: Large scale shifts in climate space under both moderate and extreme scenarios. Tree climate regions were broadly based on the Bureau of Meteorology climate classification, as above. The arrows indicate the overall direction and magnitude of climate space shift for the four general climate regions.

The projected range shifts of vulnerable eucalypts are more complex than the simple pole-ward adjustment; something assumed by most distribution-shift literature. Interestingly, we found lateral, east-west shifts in suitable climate space were more significant than the north-south shifts for the continent (Figure 2), and this reflects the strong influence of precipitation rather than temperature in central latitudes: arid-zone and open woodland species are especially threatened.

As well as the climate threat faced by the trees themselves, cascading impacts on eucalypt-dependent species and communities will be far-reaching. And that applies to the ecosystem services and landscape-scale bio-climate processes that eucalypt communities contribute to.

In terms of conservation planning, the results are also significant. Restoration efforts in particular may have to be reframed. Where areas set aside for restoration are currently climatically marginal, and in future will be no longer climatically suitable, the prospects of restoring such areas must be questioned. Establishing trees in such landscapes is extremely difficult and entails financial risk.

'A home among the gum trees' characterises much of Australia. Our studies suggest that climate change will have far reaching implications for the condition of that 'home' and the gum trees that frame it. 🌳

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Counting the cost: fire and reptiles

Are prescribed burning targets appropriate for reptile conservation?

By Annabel Smith (Australian National University)

Be careful when playing with fire. It's a message politicians know too well and after recent catastrophic wildfires in different parts of Australia they want to be seen as actively responding to the threat. One of the common responses is to raise the level of prescribed burning but what are the benefits and costs of this strategy?

Following the 'Black Saturday' wildfires in 2009 the Victorian Government introduced a 5% annual prescribed burning target to the entire public estate in Victoria. They are currently on track to deliver this target (see: <http://www.dse.vic.gov.au/fire-and-other-emergencies/planned-burning-an-introduction/fire-operations-plans-approved>). The South Australian Government has followed suit, also adopting a 5% prescribed burning target for high risk public land (see: http://www.environment.sa.gov.au/firemanagement/Fire_Planning).

At the same time that these policies are being implemented there is growing scientific evidence that such policies are unlikely to protect lives, built assets or to conserve biodiversity. Consider the study by Phil Gibbons and colleagues, for example, who found that prescribed burning was not the most effective way to protect houses in severe bushfires. (See [Decision Point #56](#))

Let's discuss one group of animals where it has been assumed prescribed burning has advantages. Prescribed burning is often assumed to be beneficial for reptiles because fire opens up the habitat, creating areas where reptiles can bask. However, this is not always true, and our research over the past nine years has started to reveal how reptiles may respond to changes in fire management, including increases in prescribed burning. This research is revealing how complex ecosystems and responses to fires can be; it's also demonstrating the value of long term research in unraveling this complexity.

Fire in the mallee

We conducted a study in the mallee vegetation of South Australia to determine 1) how reptiles respond to fire in their habitat; 2) if we can develop a predictive model of their responses based on ecological traits of species; and 3) whether commonly used short-term survey data (eg, collected in two year studies) are appropriate for making recommendations for fire management in areas of high reptile diversity.

The field effort involved in our study was enormous. We surveyed reptiles every summer for six years in two reserves on the Eyre Peninsula. Over 100 volunteers were involved in the field work, resulting in 100 unique experiences of pitfall trapping in the remote mallee wilderness. Our data set for this study included 4,796 individual reptiles collected during 32,246 trap nights.

Most common reptile species that we studied were 'successional specialists', meaning they were most abundant at a particular time after fire. For example, many 'early successional' species were common in the first year or two after fire, while a number of 'late

successional species' were most common in habitats that had not been burnt for more than 40 years.

Some species persisted in low numbers in their sub-optimal habitat. For example, the effect of time since fire on the southern shovel-nosed snake (*Brachyuophis semifasciatus*) was small. This species was most common 30 years after fire but it occurred in small numbers in all post-fire stages from one to 50 years after fire.

Other species were virtually absent from sub-optimal habitat. For example, the abundance of the early successional knob-tailed gecko (*Nephrurus stellatus*) declined to almost zero after 30 years since fire. The late successional skink *Ctenotus schomburgkii* was almost entirely absent from habitats that had been burnt in the last five years. Species with this kind of ecological response to fire will be most at risk of extinction under inappropriate fire regimes (eg, widespread prescribed fire or complete fire suppression).

Some ecological traits of the reptile species we studied were related to their fire response. Species that shelter in leaf litter were generally late successional, while species that use burrows for shelter were generally early successional. Understanding the shelter requirements of different species may therefore provide a way of predicting how a reptile assemblage will be affected by different fire regimes. However, our ability to predict fire responses from ecological traits was limited by the scarcity of biological information (eg, movement, dispersal and reproduction) on most reptile species. We are still a long way from having a mechanistic understanding of how reptile communities will respond to changing fire regimes.



A volunteer with a pit-fall trap to catch reptiles wandering through the mallee. The data set for this study included 4,796 individual reptiles collected during 32,246 trap nights. Volunteers were vital to the data collection. (Photo by Jana Bradley)

“These species may become threatened if the amount of fire in the landscape increases, for example by implementing high prescribed burning targets such as 5% per annum.”

Different surveys, different findings

A key discovery from our study was that many of the ecological responses to fire in reptiles were not found in previous studies that used smaller, although substantial, subsets of the same data. Two previous two-year studies at the same locations concluded that most common reptile species were not affected by post-fire succession. Our six-year data set suggested that this conclusion was premature and that many reptile responses to fire may not be detected using short-term data sets.

Importantly, a higher rate of late successional responses to fire went undetected in previous studies, while early successional responses appear easier to detect. We noticed a trend for sample size to be related to the point in the succession where a species peaks in abundance. This does not mean that early successional species are more abundant than late successional species, but that it is more difficult to accumulate samples to study late successional species.

The implication of these results is that we are probably unaware of the extent to which many reptile species specialise on old vegetation (eg, over 40 years old). It has previously been suggested that fire is beneficial for reptiles because they rely on basking to regulate their body temperature and fire increases habitat in which they can bask. Our study suggests that there may be a large suite of reptile species that need long unburnt vegetation for habitat. These species may become threatened if the amount of fire in the landscape increases, for example by implementing high prescribed burning targets such as 5% per annum.

Managing fire for reptile diversity

Management that is likely to be of greatest benefit to reptiles in mallee ecosystems would aim to protect long-unburnt habitat (eg, 40–50 years old, and potentially older) from fire because these post-fire habitat stages are uncommon. Actions to help achieve this include promoting small, patchy fires to prevent widespread wildfire and minimising the application of back-burning in long-unburnt habitat while fire-fighting. Implementing spatially targeted burns to reduce the risk that long-unburnt habitat will be burnt in a single fire is likely to be an important strategy but this needs to be implemented as an experiment because its efficacy is poorly understood.

Our study highlighted a risk that fire management decisions based on insufficient data may not accommodate the complex range of responses by animal communities to fire. Although long-term, intensive studies are not always possible, it is important that results from time- or sample-limited fire studies of reptiles are interpreted with the knowledge that many ecological responses may not have been detected.

While avoiding widespread frequent burning or complete fire suppression, it is important that responses to alternative fire regimes are monitored across a range of taxa, so that management practices can be updated in light of new information. 🍷

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Reference

Smith AL, Bull CM, Driscoll DA (2013) Successional specialization in a reptile community cautions against widespread planned burning and complete fire suppression. *Journal of Applied Ecology* DOI: 10.1111/1365-2664.12119.

Reptiles in the mallee: a. volunteer Catherine Whitehead holds a juvenile goanna (Varanus gouldii); b. the mallee skink (Ctenotus atlas) lives in spinifex grasses that take around 30 years after fire to reach their peak density; c. the spiny-tailed gecko (Strophurus assimilis) can be found in mallee of the northern Eyre Peninsula; d. the knob-tailed gecko (Nephurus stellatus) thrives in open habitats created by fire.

(Photos by Annabel Smith)



Some things I can do, some things I can't

But it's the interactions between these things that should guide my decisions

By Chris Brown and Megan Saunders (University of Queensland)

A common saying goes: "grant me the serenity to accept the things I cannot change; the courage to change the things I can; and wisdom to know the difference." It's a great piece of advice for any conservation manager struggling to deal with multiple threats with inadequate resources. However, in an age when our most important (and much loved) ecosystems are under growing pressure, we'd like to suggest that true wisdom lies not only in knowing the difference between the things we can and can't change, but also understanding how these things interact. Indeed, understanding the nature of these interactions should be central to the decisions we ultimately make.

Seagrass cans and can'ts

Managers tasked with protecting the health of ecosystems have to deal with multiple threats. Some of those threats have more to do with processes happening in and around the ecosystem they are attempting to protect. Some of them, however, operate at a much bigger scale; climate change, for example, is a threat operating at a global scale.

A good example of this is the plight of seagrass (discussed on pages 14,15). Seagrasses are under pressure from nutrients and sediments running off the land, and conversion as bays and harbours are dredged for commercial developments. These are big challenges but they involve stressors that have local causes. To some degree they can be remediated by local action.

But seagrasses will also be impacted by climate change. Increasing water temperature and rising sea levels will both impact on seagrass ecosystems but these stressors cannot be remediated by local action (not to any significant degree, anyway).

So managers at a local scale mostly cannot directly mitigate the effects of climate change but they can improve water quality with the aim of stopping declines in the health of seagrass ecosystems. The questions then become: should we improve water quality in places where the impacts of climate change are likely to be large or small? And, how much do we need to improve water quality to compensate for the impacts of climate change? To answer these questions, our new study shows that a manager must consider how the impacts of global and local stressors can interact to affect ecosystems (Brown et al. 2013).

Stressor on stressor

Stressors to ecosystems can interact additively, antagonistically or synergistically. An additive interaction means that the impact of two stressors in combination is simply the sum of their effects if they were acting in isolation. For instance, if warming increases the rate of seagrass decline by 8% and poor water quality by 4%, then we would expect that together they would increase the rate of decline

by 12%. Additive interactions are the typical assumption when ecologists have not been able to measure the type of interaction.

Stressors can also have synergistic impacts to ecosystems, which increase the rate of decline. Returning to our seagrass example, the two stressors in combination may increase the rate of decline to be greater than 12%, say 15%. Synergistic interactions occur when one stressor increases the susceptibility of the ecosystem to additional stressors. Synergisms have been a cause for concern because they imply the typical assumption of an additive interaction will underestimate the true rate of decline in an ecosystem. Consequently, many studies have focussed on identifying synergisms.

Antagonisms

This focus on synergisms has come at the expense of documenting antagonisms. Antagonisms imply a slower rate of decline for an ecosystem faced by multiple stressors, so in the past they have been of less concern for ecological studies. Antagonisms can take several forms, although there are two particularly important types: dominance antagonisms and mitigative antagonisms.



Threatened ecosystems, like seagrasses, face multiple threats. Managers have some capacity to address these threats where they occur locally to the ecosystem. That might be in the marine environment surrounding the seagrass beds or on land adjacent to the ecosystem. But managers have limited capacity to address global stressors such as climate change. That doesn't mean they can ignore impacts from climate change. What's important is how local stressors interact with global stressors. (Photo by Megan Saunders)

“Management that remediates local stressors in places vulnerable to climate change will have the greatest benefit if there are synergistic interactions between stressors.”

Returning to the seagrass example, the two stressors together may only cause seagrass to decline at a rate of 10%. This can occur if the first stressor, poor water quality, removes plants that are sensitive to stress. The first stressor has dominated. Then additional stressors have little additional impact, because only stress tolerant plants remain.

Antagonisms may also be mitigative if the actions of one stressor mitigates the impact of the other. Mitigative antagonisms are likely to be rare, however one example comes from certain coral species. Poor water quality and warming both kill corals, however combined together, poor water quality can reduce the effects of heat stress to corals, by shading corals from light stress.

Decisions around interactions

How important is it that we know the nature of stressor interaction? We examined two case-studies for managing a local stressor when there is an interaction with a global stressor. One case-study was for seagrass and another was for a coral reef fish community. In both case-studies we found consistent results.

Antagonistic interactions between local and global stressors may be more challenging to manage than synergistic or additive interactions. If antagonistic interactions occur then improving a local stressor, such as poor water quality, may have little benefit for an ecosystem impacted by global climate change. In rare cases, improving the local stressor may even worsen the impacts of climate change.

Conversely, while synergisms imply greater rates of decline, they also mean that management that mitigates a local stressor can be of greater benefit to the ecosystem. For instance, improving water quality will reduce its direct effect to seagrass, but will also mean seagrass is more tolerant of global warming impacts (as discussed on pages 14,15).

How can information about interactions inform the management of vulnerable ecosystems?

Deciding how to spend a budget to improve an ecosystem must consider the cost of different actions, but also the effectiveness of those actions. The effectiveness is determined, in part, by the type of interaction. If there are multiple local stressors impacting an ecosystem, management should try to remediate those stressors that interact synergistically with climate change. This will ensure the greatest benefits are obtained from management.

Choices around synergism and antagonism

If the choice is between places, then management that remediates local stressors in places vulnerable to climate change will have the greatest benefit if there are synergistic interactions between stressors. Alternatively, if there is an antagonistic interaction between stressors, management should seek to remediate local stressors in refuges from climate change impacts.

Unfortunately, we know little about what types of interactions occur in nature. Recent review studies indicate however, that antagonisms are likely to be just as common as synergisms. This suggests a cautious approach – management should try to remediate local stressors in refuges from climate change. That way, they are assured of a benefit to the ecosystem, regardless of the interaction type.

Our study also suggests that future ecological studies are needed to identify the types of interactions between stressors that occur in nature. In particular, we need more studies that consider interactions between local, manageable stressors and global unmanageable stressors.

So, sure it's wise to know the difference between what you can do and what you can't. However, before making your final decision,

make sure you know how all these things interact. It could be that some of the things you can do, may not be sensible choices after all.

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Reference

Brown CJ, MI Saunders, HP Possingham & AJ Richardson (2013). Managing for Interactions between Local and Global Stressors of Ecosystems. *PLoS ONE* 8(6): e65765. doi:10.1371/journal.pone.0065765
<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0065765>

Things we can do, things we can't do on the GBR

Late last year the Australian Institute of Marine Science put out a rather scary report on the state of the Great Barrier Reef. It said the Reef has lost half its coral cover in the last 27 years! The loss was due to storm damage (48%), crown of thorns starfish (42%), and bleaching (10%).

Basically, the big storms are coming more frequently than the reef can absorb, higher water temperatures are causing widespread coral bleaching and rampaging swarms of crown of thorns starfish are eating up huge areas of coral.

The scientists connected with the report said that more frequent storms and higher water temperatures were connected to climate change and were therefore beyond the capacity of reef managers to do anything about (and the expectation is that these factors will only get worse).

Crown of thorns outbreaks, however, are believed to be connected to nutrient inflows from agriculture based on the mainland. And this was something they could act upon.

The situation presented here is one that conservation managers are facing everywhere: multiple stressors to the ecosystem but only some of them can be addressed because some operate at a scale beyond the reach of the manager. While it's important to know the difference between what you can change and what you can't, managers need to also appreciate how global stressors interact with local stressors. This information could be critical to how local action is carried out.

The risk of catastrophic events such as coral bleaching or cyclones are particularly challenging for conservation decision makers. Weighing up how a network of marine protected areas might best deal with these risks was the topic of earlier EDG research (see [Decision Point #19](#)).

Reference

De'ath G, KE Fabricius, H Sweatman & M Puotinen (2012). The 27-year decline of coral cover on the Great Barrier Reef and its causes. *PNAS*. <http://www.pnas.org/content/early/2012/09/25/1208909109>



Barnards Reef after cyclone Larry. Big storms are hitting the reef with a greater frequency leading to coral decline. (Image: AIMS Long-term Monitoring Team.)



Seagrass and sea level rise

A little clarity may save an endangered blue-carbon ecosystem

By Megan Saunders (University of Queensland)

Like many important ecosystems, seagrasses will be hit hard by climate change. Some of those impacts relate to rising sea level. New research by a multi-disciplinary team at the University of Queensland has found that local action that improves water quality, and specifically its clarity, might go some way to compensating for rising sea level.

Seagrasses are marine plants that live in shallow coastal seas. They provide us with a range of valuable ecological services including the provision of habitat for fish and invertebrates, and food for turtles and dugongs. Seagrasses also filter the water as it runs off the land, thereby preventing sediments from smothering coral reefs, and they suck an astonishing amount of carbon dioxide out of the atmosphere. In fact, a hectare of seagrass sequesters a comparable amount of carbon dioxide as an equivalent area of Amazon rainforest. Protecting these 'blue carbon' ecosystems is important for our wellbeing on a number of scores.

Unfortunately, seagrasses are one of the most threatened ecosystems on Earth. Over the past several decades they have incurred staggering rates of loss. These losses have largely been due to local factors such as run off from land reducing water quality. But now seagrasses have the added stress of climate change, a 'super wicked problem' with the potential to affect seagrass at a global scale.

Local problems we have some capacity to deal with but climate change is another thing altogether. The big question is: can our management of local drivers of degradation offset the losses we might expect from climate change? To answer this question I worked with a multi-disciplinary team that included marine ecologists, engineers, remote sensors and modellers. We set out to discover how sea level rise in particular would affect seagrass in Moreton Bay, Southeast Queensland.

Moreton Bay is an internationally recognized Ramsar wetland site. It encompasses vast seagrass meadows, and supports a large number of vulnerable and threatened species, including green turtles and dugongs. It also lies right next to Brisbane, Queensland's capital city and the fastest growing 'mature' metropolis in the world. Urban and

The amount of carbon dioxide sequestered by a hectare of seagrass is comparable to that absorbed by a hectare of Amazon rainforest. Unfortunately, seagrasses are one of our most threatened ecosystems.
(Photo by Megan Saunders)

agricultural pressures have historically caused the loss of seagrass in Moreton Bay; how the bay might fare with the added stresses of sea level rise is an important question for conservation and the region's productivity.

Our study, published recently in the international journal *Global Change Biology*, used a species distribution model to predict the areas where habitat is suitable for seagrass now and where it would be suitable for seagrass in the future with a given amount of sea level rise.

We found that a sea level rise of 1.1 m by 2100 would result in a 17% reduction in area of seagrass in Moreton Bay. This was due to losses of seagrass at the deep edge of its range. As the water gets deeper, light decreases to the point where seagrass won't grow. If water quality were to deteriorate further, for example from increased sediment in water flowing into the bay, the decline would be even more pronounced.

But it's not all gloom. Local management could help stop, or even reverse, the expected decline in water quality. In this study, we found an improvement in water clarity of 30% could mitigate the losses of seagrass from 1.1 m sea level rise. The improvement would have to be greater for larger magnitudes of sea level rise. As a general rule of thumb, for each metre of sea level rise, water clarity, measured by secchi depth, would have to be increased by a similar amount to offset declines.

Water quality can be improved by upgrades to sewage treatment plants and by reducing the use of fertilizers. Reducing the pollutants and sediments that run-off into streams and beaches likewise

“We found an improvement in water clarity of 30% could mitigate the losses of seagrass from 1.1 m sea level rise.”

benefits seagrass. For example, planting vegetation in riparian zones and maintaining vegetated buffer zones around waterways can benefit seagrasses living in the nearby sea.

Seagrass will also benefit from management policies that allow for the migration of marine plants into newly inundated regions. In a scenario where roads, houses and other hard infrastructure were removed from inundated coastal areas, we found the decline in seagrass was reduced to only 5%. In an era of rising seas we will need to design green belts and buffer zones which allow room for the migration of coastal ecosystems. This will minimize the coastal squeeze that occurs when ecosystems are blocked by hard infrastructure such as sea walls and levees.

All of this emphasises that there are financial, logistical, and social considerations associated with coastal retreat. In many instances individuals and councils will prefer to defend infrastructure rather than promote the migration of wetlands. These decisions could, however, have unforeseen negative consequences such as loss of fisheries species which occupy coastal habitats. Identifying the trade-offs between different coastal adaptation policies should be a key priority for coastal management in the face of climate change.

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Dr Megan Saunders collaborates with members of CEED through her affiliation with the Australian Sea Level Rise Partnership (ASLRP). This group aims to find interdisciplinary solutions to the challenges of sea level rise in the 21st century. ASLRP is funded by an Australian SuperScience Fellowship and is based in the Global Change Institute at the University of Queensland.

Reference

Saunders MI, Leon J, Phinn SR, Callaghan DP, O'Brien KR, Roelfsema CM, Lovelock CE, Lyons MB, Mumby PJ (2013). Coastal retreat and improved water quality mitigate losses of seagrass from sea level rise. *Global Change Biology*
<http://onlinelibrary.wiley.com/doi/10.1111/gcb.12218/full>



Watching the grass grow: A multi-disciplinary investigation on the seagrasses of Moreton Bay has found that if water clarity could be improved, seagrasses will cope better with rising sea level. (Photo by Megan Saunders)

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 five bytes from recent issues. If you would like to receive the *Dbytes* eNewsletter, send an email to David.Salt@anu.edu.au

1. Biodiversity offsets locking in species decline?

A Conversation blog by Martine Maron (EDG, UQld) and Ascelin Gordon (EDG, RMIT): "In a recent interview, the Opposition environment spokesperson Greg Hunt promised to reverse biodiversity decline in five years if the Coalition wins the forthcoming election. Is this goal achievable? Not the way we're going. Our investment in enhancing biodiversity is not keeping pace with the factors driving biodiversity declines."

<https://theconversation.com/biodiversity-offsets-could-be-locking-in-species-decline-14177>

2. Russian roulette with Australia's national parks

Recent laws allowing hunting and logging in our parks are misguided. Our reserves protect biological diversity and shouldn't be used otherwise. This is a feature article in *The Guardian* with several EDG coauthors (Hobbs, Lindenmayer, McCarthy, Parris and Possingham).

<http://www.guardian.co.uk/commentisfree/2013/jun/17/national-parks-biodiversity-australia>

3. Repairing Aust's landscapes for global change

And why we must do much more: A report on an expert roundtable, held at the University of Melbourne in February 2013, to consider the question: What are the benefits of large-scale reforestation and revegetation, and how can they best be achieved?

http://australia21.org.au/publications/press_releases/13/Jun/8ac1231402f2dbbe78974729af8cfa74.pdf

4. Terrestrial Report Card 2013

The National Climate Change Adaptation Research Facility (NCCARF) has launched the Terrestrial Report Card 2013. The Card aims to summarise current information on known and expected impacts of climate change on terrestrial and freshwater biodiversity in Australia. The info presented is aimed at a wide audience, from managers, policy makers and scientists, to the general public. The Report Card also recommends adaptation options, and highlights current knowledge gaps in the field of climate change research.

<https://terrestrialclimatechange.org.au>

5. The MERI Strategy

DSEWPaC released the Monitoring Evaluation Reporting and Improvement Strategy: Caring for our Country and the Biodiversity Fund (The MERI Strategy). The strategy outlines how the monitoring and evaluation process relates to both the second phase of Caring for our Country (2013-2018) and the Biodiversity Fund (2012-2018).

<http://www.nrm.gov.au/funding/meri/index.html>

Improving communication & knowledge transfer

We need your help!

By Sana Bau (University of Melbourne)



Sana Bau wants your input on how knowledge is best transferred between science and policy/practice.

Biodiversity faces unprecedented challenges arising from habitat destruction and degradation, climate change and other stressors. Addressing these challenges compels conservation management decisions to be informed by science – the most comprehensive knowledge system in place to understand natural phenomena. But keeping up with today's science is a challenge in itself, the body of ecological knowledge is growing faster than ever before. In practice, there are many obstacles to incorporating scientific evidence into decisions (including common misconceptions about the theory or models used to inform decision making; a topic that will be covered in a future issue of *Decision Point*).

I am conducting an online study to explore how evidence influences judgement in conservation decision making. Your participation in this research will provide important information on the interplay between technical (science-based) information and value judgements in decision making for conservation, and help identify factors that can help or hinder effective incorporation of evidence into decisions. The findings will potentially contribute to the knowledge on how to improve communication and knowledge transfer between science and policy/practice.

This study will be of greatest interest to scientific experts, policy or decision makers, managers, or practitioners working in conservation, environment or related fields. However, anyone with an interest in these topics is encouraged to participate. Simply follow the link:

<http://bioqueries.com/Sana/Exp/1-Info.php>

What's the point?

1978 was a good year...

"1978 was a good year; I wasn't earning much but I felt happier." That's what your average global citizen might say after reading Kubiszewski et al. 2013.

Standard economic indicators like gross domestic product (GDP) are useful for measuring just one limited aspect of the economy—marketed economic activity—but GDP has been mistakenly used as a broader measure of welfare. A more comprehensive indicator would consolidate economic, environmental, and social elements into a common framework to show net progress. One such alternative indicator that has been commonly used is the Genuine Progress Indicator (GPI). While GDP is a measure of current production, the GPI is designed to measure the economic welfare generated by economic activity. A group of some of the world's top economists have compared GPIs from all around the planet and found:

1. Global GPI/capita peaked in 1978.
2. Globally, GPI/capita does not increase beyond a GDP/capita of around \$US 6,500/capita.
3. With more equitable distribution, current world GDP (\$67 trillion/yr) could support 9.6 billion people at \$7,000/capita.
4. Life satisfaction in almost all countries has also not improved significantly since 1975.

Reference

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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 ANU, the University of Melbourne, the University of Western Australia, RMIT and CSIRO.

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