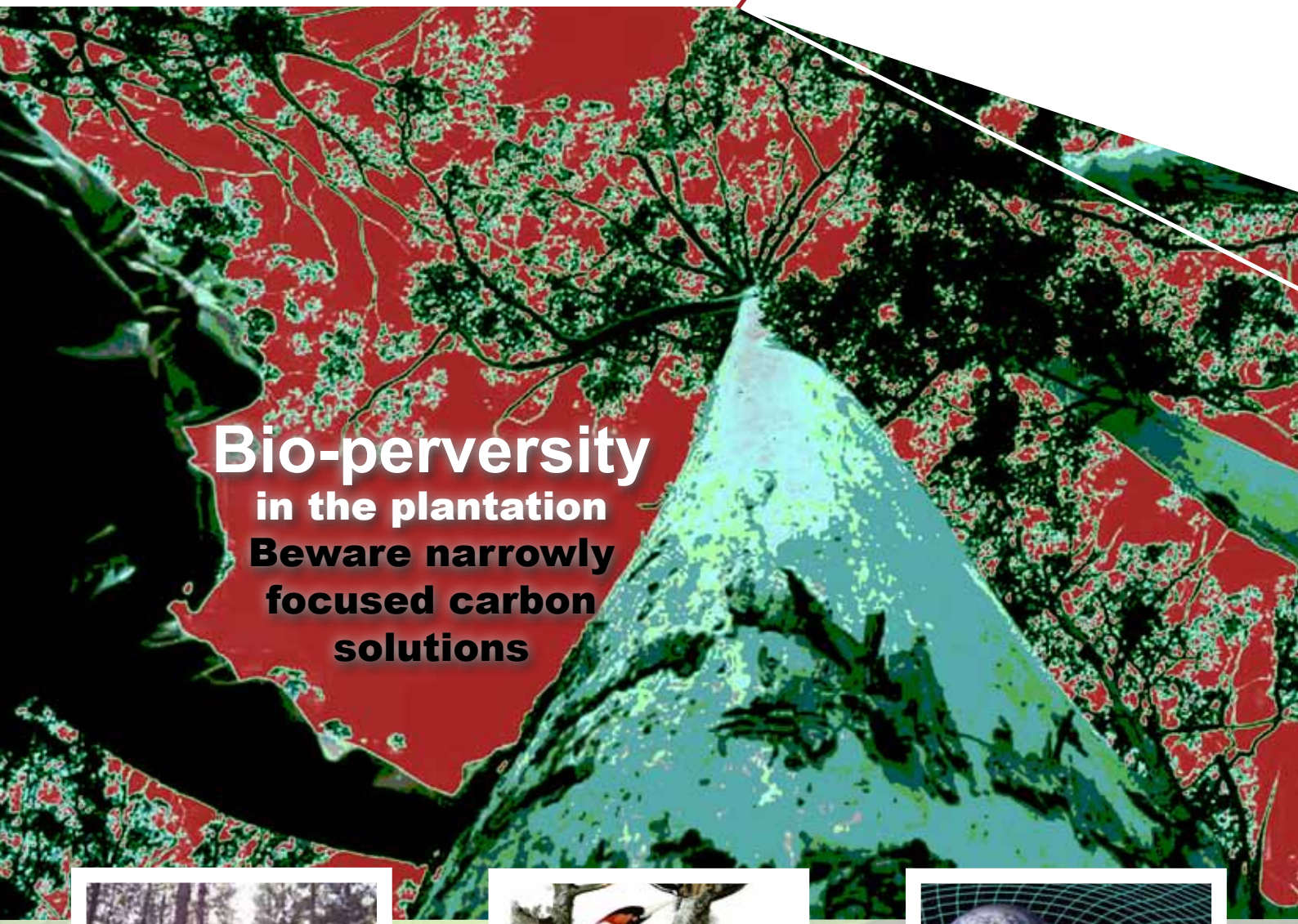
# DECISION POINT

*Connecting conservation policy makers, researchers and practitioners*

Issue #62 / August 2012

## Bio-perversity in the plantation Beware narrowly focused carbon solutions

**Resilience thinking vs decision theory? No contest**

**The case of the ivory-billed woodpecker - gone or not?**

**Monitoring in time and space - which gets priority?**

### 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

# DECISION POINT

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## Contents





*Our cover: Bio-perversities are bad outcomes from narrowly focused solutions. For example, it's what happens when you cut down native forests to establish carbon plantations. See page 6 for ways to avoid bio-perversity.*

## *On the Point*

### Bio-perversity and resilience

*What is bio-perversity? It's a term used by David Lindenmeyer and colleagues to describe negative biodiversity impacts arising from environmental 'solutions' that are too narrow in their focus. Their particular example of bio-perversity is the possible negative impacts on biodiversity arising out of carbon-focussed tree plantations (see page 6). 'Perversity' is a good term here because the potential impacts are neither planned for nor desired, it's just what can happen when too narrow a view is taken of the system you're working in.*

*And that's a nice segue into resilience thinking, which attempts to minimise perverse impacts from our management by better understanding the linkages across scales and domains (ecological, economic and social). Much of this issue of Decision Point relates to different aspects of resilience thinking.*

*Hugh Possingham and Duan Biggs come out punching when they take on the apparent tension between resilience thinking and decision science (see page 4). From their perspective, however, this debate is a straw man; there doesn't need to be a tension because the two approaches are perfectly complementary.*

*David Pannell adds a little economic nuance to dealing with thresholds, a central idea in resilience thinking by describing what happens when you throw in uncertainty to your decision making (see page 9).*

*And if you're a newbie to resilience thinking, maybe you'd better do a little reading because it's the word on everyone's lips. Consider its use in policy and vision statements (see page 5). To help you out, I offer a 'bluffer's guide' on page 10. It won't make you an expert but it should help you sound more like an expert when next the topic arises at the pub.*

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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

## Assessing species relocations in Australia

Species relocation programs are increasingly performed with the intention of establishing a self-sustaining population of threatened or declining native species. However, the use of experimental quantitative approaches in species relocation programs is still relatively uncommon, despite a number of international studies recommending clear guidelines and standards. This paper evaluates species relocation programs conducted within Australia to assess how programs performed in relation to such standards.

A search of the literature identified 54 species relocation programs. The majority of these were reintroductions (52%) and supplementations (30%). Less than half of the species relocation programs claimed success (25 programs, 46%). A lack of effective predator control was identified as contributing to the failure of 14 programs.

There was considerable variation in the quality of species relocation programs in relation to key features such as whether the program integrated experimental approaches with testable hypotheses, whether there were explicit statements of criteria for success, whether suitable habitat was identified for the release site and whether long-term monitoring was conducted.

Based on this analysis, the researchers proposed guidelines to improve scientific rigour and success rates of species relocation programs.

**Reference**

Sheean VA, AD Manning & DB Lindenmayer (2012). An assessment of scientific approaches towards species relocations in Australia. *Austral Ecology* 37: 204-215. DOI: 10.1111/j.1442-9993.2011.02264.x

> "Less than half of the species relocation programs claimed success."

## Uncertain sightings and declarations of extinction

The extinction of a species can be inferred from a record of its sightings. Existing methods for doing so assume that all sightings in the record are valid. Often, however, there are sightings of uncertain validity. To date, uncertain sightings have been treated in an ad hoc way, either excluding them from the record or including them as if they were certain.

The researchers in this analysis developed a Bayesian method that formally accounts for such uncertain sightings. The method assumes that valid and invalid sightings follow independent Poisson processes and use non-informative prior distributions for the rate of valid sightings and for a measure of the quality of uncertain sightings.

They applied the method to a recently published record of sightings of the ivory-billed woodpecker in the United States. This record covers the period 1897–2010 and contains 39 sightings classified as certain and 29 classified as uncertain. The Bayes factor in favor of extinction was 4.03, which constitutes substantial support for extinction. The posterior distribution of the time of extinction has 3 main modes in 1944, 1952, and 1988. The method can be applied to sighting records of other purportedly extinct species.

**Reference**

Solow A, W Smith, M Burgman, T Rout, B Wintle & D Roberts (2012). Uncertain Sightings and the Extinction of the Ivory-Billed Woodpecker. *Conservation Biology* 26: 180-184. DOI: 10.1111/j.1523-1739.2011.01743.x

## Modelling plant extinction risk under climate change

Models that couple habitat suitability with demographic processes offer a potentially improved approach for estimating spatial distributional shifts and extinction risk under climate change. Applying such an approach to five species of Australian plants with contrasting demographic traits, the researchers show that: (i) predicted climate-driven changes in range area are sensitive to the underlying habitat model, regardless of whether demographic traits and their interaction with habitat patch configuration are modeled explicitly; and (ii) caution should be exercised when using predicted changes in total habitat suitability or geographic extent to infer extinction risk, because the relationship between these metrics is often weak.

Measures of extinction risk, which quantify threats to population persistence, are particularly sensitive to life-history traits, such as recruitment response to fire, which explained approximately 60% of the deviance in expected minimum abundance. Dispersal dynamics and habitat patch structure have the strongest influence on the amount of movement of the trailing and leading edge of the range margin, explaining roughly 40% of modeled structural deviance.

These results underscore the need to consider direct measures of extinction risk (population declines and other measures of stochastic viability), as well as measures of change in habitat area, when assessing climate change impacts on biodiversity. Furthermore, direct estimation of extinction risk incorporates important demographic and ecosystem processes, which potentially influence species' vulnerability to extinction due to climate change.

**Reference**

Fordham DA, HR Akcakaya, MB Araujo, J Elith, DA Keith, R Pearson, TD Auld, C Mellin, JW Morgan, TJ Regan, M Tozer, MJ Watts, M White, BA Wintle, C Yates & BW Brook (2012). Plant extinction risk under climate change: are forecast range shifts alone a good indicator of species vulnerability to global warming? *Global Change Biology* 18: 1357-1371. DOI: 10.1111/j.1365-2486.2011.02614.x

## Is it extinct or not?

*The case of the ivory-billed woodpecker is a case of considerable recent interest (see the story on page 16). The last sighting of this species in the United States that is widely regarded as valid was in 1944. However, since 1944, there have been a number of sightings of uncertain validity, with one of particular interest in 2004. The certain identification of this species in the field is complicated by its co-occurrence with the superficially similar pileated woodpecker. Whether the ivory-billed woodpecker is extinct is not just of academic interest: the US Fish and Wildlife Service has drafted a multimillion dollar recovery plan for this species. Solow et al (2012) have extended an existing Bayesian method to analyse a recently published record of sightings of the ivory-billed woodpecker. The new method is the first to treat uncertain sightings in a formal way, neither simply excluding them nor simply treating them as valid. Their results support the conclusion that the ivory-billed woodpecker is extinct. For a full story on when is it best to declare a species extinct, see DPoint #38, p6.*

*Image Birds of America*

# Resilience thinking versus decision theory?

## No contest

*By Hugh Possingham and Duan Biggs (EDG, University of Queensland)*

There is much discussion about what is often perceived to be alternative paradigms for environmental management – resilience thinking and decision theory. Two recent papers In *Trends in Ecology and Evolution* (Fischer et al., 2009; Polasky et al. 2011) develop and, in different ways, partially resolve the apparent tension. However, we think there probably wasn't any tension to resolve in the first place.

For those with little time, the punch line is that resilience thinking is one approach to framing a problem - decision science solves it. There is no contest, it is apple sauce and pork – the two are completely different, indeed they probably go well together (unless you are vegetarian).

Resilience thinking (sometimes called resilience theory) is a perspective about how social-ecological systems work. It is a particular approach to building system models, qualitative and quantitative, of how the world functions. Resilience thinking emphasizes the importance of the social context; the links between social, economic and biophysical domains and the links across scales. It promotes social and management processes that enable the stakeholders of a complex system to navigate towards better environmental outcomes in the face of profound uncertainty and complexity. (David Salt describes some of the key aspects of resilience theory on pages 10 and 11).

On the other hand, decision theory is not a theory at all, which is why more recently we have preferred to use the term decision science. Decision science is the tool box for solving any problem. These tools include classical optimization, multiple-criteria decision analysis, information-gap theory which deals with uncertainty that is hard to quantify, expert elicitation and much more besides (see the box on tools of the trade).

This tool box ranges over all these areas right down to the proffering of an informed guess made behind closed doors (which is really just one form of expert elicitation). Truth be said, it is best if decision making doesn't take place behind closed doors because transparency and accountability are the keystones of good decision making in a modern democracy. This enables rigour and learning. Of course, in the real world, some important decisions have to be made behind closed doors so we can't ignore this approach.

Resilience thinking and decision science are complementary; they can coexist in perfect harmony and are not in competition. The discussion about whether decision science or resilience theory is a better paradigm for managing biodiversity is equivalent to arguing about whether raw materials or tools are better for house building. Both are essential so the argument is really a non-argument.

Flogging the metaphor a little further, we can see how this apparent dichotomy may have arisen. Some people might like steel houses – the ecological equivalent of a system built from rigid components, let's say deterministic differential equations describing how fish populations grow and how fishers generate net revenue. Classical decision science tools, like 'calculus of variations', can be used to find good strategies for managing system models like this. The approaches can even be extended to include some stochasticity. This kind of research, pioneered by researchers like Colin Clark (a personal hero of Hugh's) in the 60s and 70s, transformed some areas of natural resource management. They are still widely used and are expanding to include many complexities.

Resilience thinkers would like to make houses that are made from a diversity of materials, where all the people in the house (not just the

### Tools of the trade

The Environmental Decision Group expends considerable effort in building, testing and tinkering with tools to help decision makers make more effective decisions in conserving biodiversity. Here are some examples. Each works in different ways but, depending on the circumstances, each has the potential to contribute to solving problems identified through a resilience assessment. Furthermore, decision-making about complex conservation issues is best informed by multiple perspectives on a problem or question. The Environmental Decisions Group is developing an understanding of how tools such as those listed below can be integrated with tools and processes such as eliciting the mental models of stakeholders (see DPoint 53).

**Multiple-criteria decision analysis:** gives you the best outcome (or set of outcomes) given the need to maximise several criteria. Marxan, the world's most popular conservation planning software, aims to deliver a spatial plan that maximises conservation values for a minimum cost. But there are frequently multiple values in the areas being considered and these have to be traded off against each other. Marxan with Zones, one version of Marxan, was designed to specifically deal with these multiple uses (eg, recreational values vs conservation values).
See DPoint #27, p10.

**Expert elicitation:** is all about collecting and applying expert knowledge. It's much more than simply asking experts what they think about a topic. How you do it and apply it varies from situation to situation depending on what type of information you're after. Designing an appropriate approach to expert elicitation is reviewed by Tara Martin and colleagues in DPoint #58 (p12).

**Cost-effectiveness analysis:** helps decision makers choose between multiple options where available resources are inadequate for the task. It helps prioritise those things that will provide the best return on investment. INFFER (Investment Framework for Environmental Resources) enables environmental managers to set clear priorities and develop compelling project proposals by framing different projects in terms of their cost, likelihood of success and expected benefit (see DPoint #55, p6). PPP (Project Prioritisation Protocol) does the same thing but focusses on bundles of actions to save threatened species (see DPoint #29, p8).

**Classical optimisation:** typically solves the problem: What level (and type) of investment delivers the greatest returns. In DPoint #55 (p3) Wintle et al explored what combination of fire management and habitat protection best protected species in the South African Fynbos at different levels of investment. Contrary to popular opinion, it deals with uncertainty in models and parameters comfortably.

"Resilience thinking is one aproach to framing a problem - decision science solves it."

fishermen, greenies or the government) get to express their views and values. Further, they might argue that our view of the problem is too narrow and observe that the garden is also important so the indoor spaces and outdoor spaces need to planned and managed together. Like many other approaches, it embraces a more holistic way of defining and managing the problem and the system model that underpins the problem. Classical decision science tools may not be able to tackle this more complex problem; however there is an equally large raft of qualitative and/or semi-quantitative, and process-oriented decision science tools that can be brought to bear to find ways forward for building our resilient house and garden.

One reason why some resilience thinkers may not be enamoured with decision science is because many decision scientists have a favourite set of tools that they are experts in using. They wheel them along to every problem and try to make the problem fit their tool box.

Classical decision scientists may be uncomfortable with resilience thinking because its emphasis on social processes and multiple ways of knowing, poses challenges to the way in which optimisation, and other decision problems, are defined and solved.

By embracing a wider diversity of perspectives and tools, and expanding our relationships with social scientists, resilience thinkers, and organisations such as the Stockholm Resilience Centre, the Environmental Decisions Group is trying to make sure we keep expanding our tool box to deal with any system model or problem.

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References


Fischer J, Peterson GD, Gardner TA, Gordon LJ, Fazey I, Elmqvist T, Felton A, Folke C, and Dovers S. (2009). Integrating resilience thinking and optimisation for conservation. *Trends in Ecology and Evolution* 24:549-555.
[This article is discussed in *Decision Point #32*]

Polasky S, Carpenter SR, Folke C, and Keeler B. (2011). Decision-making under great uncertainty: environmental management in an era of global change. *Trends in Ecology and Evolution* 26:398-404.


*Brandon Bestylmeyer from the University of New Mexico discusses how they are using state-and-transition models to work with resilience and rangelands management in the United States. This was part of the CEED Resilience Workshop run at the University of Western Australia last year (See DPoint #56).*

> "Resilience thinking and decision science are complementary; they can coexist in perfect harmony and are not in competition."

## It's a vision thing

Anyone engaged with current debates on biodiversity, conservation and NRM will know that the word 'resilience' now abounds in vision statements, press releases and speeches. Below are some examples of where it crops up (we've added the bold white for emphasis). This is just a small selection of important policies/strategies related to biodiversity conservation at federal, state and regional levels.

The EDG has initiated several projects (under both CEED and NERP ED) to see how our various approaches to decision making might be deployed to help operationalise resilience thinking. An example of our thinking on where this might go can be found in the report on a CEED resilience workshop
(see page 13 of *DPoint #56*).

### Aust Biodiversity Conservation Strategy 2010-2030

Australia's biodiversity is healthy and **resilient** to threats, and valued both in its own right and for its essential contribution to our existence.

http://www.environment.gov.au/biodiversity/publications/strategy-2010-30/index.html

### Caring for our Country

Caring for our Country aims to achieve an environment that is healthy, better protected, well-managed, **resilient** and provides essential ecosystem services in a changing climate.

http://www.nrm.gov.au/about/caring/index.html

### Building Nature's Resilience: A Biodiversity Strategy for Queensland

Through a whole of landscape approach the Strategy seeks to build **resilient** ecosystems by building protected areas, conserving species and managing extent and condition.

http://www.derm.qld.gov.au/services_resources/item_details.php?item_id=208077

### The Vision of the Otway Coast Committee

(Victorian regional Committee of Management)

"Otway Coast Committee will conserve and enhance coastal biodiversity and **resilience** while encouraging community access"

http://www.apollobayrecreationreserve.com/index.php/about-us/vision-and-role

# Bio-perversity in the plantation

## Minimizing poor outcomes from carbon plantings

*Bio-perversity — negative biodiversity and environmental outcomes arising from a narrow policy and management focus on single environmental problems without consideration of the broader ecological context.*

Like it or not, the carbon economy is coming to town. No-one can predict exactly what it will look like but the bottom line is that one way or another emitting or capturing carbon is going to have a price. One of the expected consequences of this is that income from carbon offsetting will drive major land management changes. Land owners will be shifting land to higher carbon storage states by transforming the vegetation cover. Many people say this is a good thing with the potential to restore degraded land and better protect biodiversity. But a growing number of scientists are also advising caution, that a narrow focus on carbon storage has the potential to create significant negative environmental outcomes if the protection and enhancement of other values such as biodiversity are not explicitly considered. EDG researchers have even come up with a name for it – bio-perversity.

When it comes to locking up carbon, one popular strategy frequently put forward is the establishment of tree plantations – massive commercial-scale plantations transforming whole landscapes. Such ventures, it is proposed, lock up carbon while at the same time growing a valued commodity. The claim of other associated environmental benefits is also often thrown into the equation.

"Incentives to sequester carbon through establishing plantations are likely to increase as the impacts of climate change become more pronounced and intense," says Professor David Lindenmayer, the lead researcher on a recent EDG-led review of plantations for carbon sequestration and biodiversity (Lindenmayer et al, 2012). "We argue that harmful outcomes for biodiversity—what we term 'bio-perversities' — can arise as unintended consequences from a range of efforts to enhance forest-based carbon sequestration. Perhaps the greatest of the associated potential bio-perversities are those which may arise from ill-conceived or inappropriate large-scale plantation projects.

"Our purpose in writing this paper was twofold. First, we wanted to put up a red flag on the risks of rushing into plantation development with a narrow focus on carbon. Second, we're suggesting ways these risks can be avoided."

Broadly speaking, the researchers believe there are three areas of bio-perverse outcomes arising from carbon sequestration plantations:

(1) land clearing to establish tree plantations,

(2) the risks of plantation trees becoming invasive plants, and

(3) the potential for plantations to negatively affect key ecological processes and disturbance regimes.

These threats reflect some of the well-documented causes of global biodiversity loss; these being habitat loss, invasive species, and threats from human-altered ecosystem processes. What's more, each of these negative impacts associated with plantations have occurred in many places in the past, and that was before the emergence of the issue of climate change. So, if these threats are not explicitly dealt with when rolling out new policies on carbon plantations, there's a very real expectation they will occur again, but on a far greater scale.

"But we believe this doesn't have to be so," says Lindenmayer. "And we've proposed four strategies to mitigate the risk. These involve ecological risk assessments, full carbon accounting of ecosystems

"A narrow focus on carbon storage has the potential to create significant negative environmental outcomes if the protection and enhancement of other values such as biodiversity are not explicitly considered."

### Of carbon banks and trees

A carbon bank built on trees can yield rich biodiversity returns yet these returns come with significant risks. Consider the following stories

#### Hitching biodiversity to the carbon bank

"On the whole, carbon sequestration schemes as they currently operate provide little biodiversity benefit."

*Decision Point #20* p10

#### A bigger and safer carbon bank

"The green carbon in natural forests is stored in a more reliable stock than that in industrialised forests, especially over ecological time scales."

*Decision Point #22*, p6

#### Fire breeds fire – and the trap is sprung

"Management practices in Victoria's world-renowned mountain ash forests are creating a landscape trap that is promoting a greater likelihood of catastrophic wildfires. Scientists believe the ash forests themselves are at risk of disappearing. And when they go, they take with them many endangered animals and plant species, and one of the most effective carbon storage opportunities in the world."

*Decision Point #54*, p3

and proposed management activities, an examination of incentives used to stimulate the establishment of tree plantations, and the establishment of compliance and ecological monitoring programs to detect bio-perverse outcomes.

"Each of these four strategies would deal with the three areas of bio-perversity to differing degrees. For example, in considering the risk of land clearing to establish tree plantations, full carbon accounting assessment of areas being considered for conversion to plantations will be of particular importance. Such an accounting may demonstrate the carbon sequestration value of maintaining native forest or grassland compared with the establishment of a plantation. As an example, several studies have shown that monocultures of plantation trees may take longer to produce a net carbon gain and ultimately store less carbon in above ground biomass and soil organic carbon than native primary forests, secondary (regenerating) native forests, and multistrata agro-forestry plantings."

The risks of plantation trees becoming invasive plants is another real possibility of bio-perversity arising from carbon plantations. The most frequently used species in plantations are quick growing trees – pines, gumtrees and wattles for example – that are tolerant to a wide range of environmental conditions. When established outside their original range, some of these plantation tree species can become invasive. Bio-perverse outcomes include impacts such as biotic homogenisation, genetic swamping and altered ecosystem processes. These sometimes irreversible invasions can often become costly to manage and lead to significant biodiversity loss.

But the threat of invasives would be reduced with appropriate ecological risk assessment, a careful scrutiny of the types of incentives being employed to encourage plantation establishment and appropriate ecological monitoring, both within and outside plantation estates to provide early warnings of invasive were they to occur.

The modification of key ecosystem processes is another well recognized impact leading to biodiversity loss in many parts of the world and plantation establishment could play a key role in causing it. In particular, plantation establishment is suggested to have large impacts on hydrologic, geomorphologic and fire regimes both within plantations as well as in the surrounding landscapes.

Thorough, knowledge-based risk assessments of plantation projects and ecological monitoring will be essential for early detection and minimisation of potential bio-perverse outcomes such as altered hydrologic and geomorphic cycles and altered fire regimes. Some locations will be deemed unsuitable for plantation establishment as a result of these considerations. It is imperative that incentives schemes and reward systems have clear regulations to prevent the establishment of plantations in regions that are unsuitable.

"If the rush to plant trees and establish plantations for carbon sequestration results in a range of other environmental values being ignored, we expect big problems to follow," observes Lindenmayer. "A narrow focus on carbon may well exacerbate a range of existing environmental problems, contribute to further biodiversity loss, introduce additional obstacles to recovering or maintaining the ecological integrity of environments, and ultimately fail to mitigate the anthropogenic causes of climate change. And that would be a perverse outcome indeed of a venture that was intended to ameliorate the root cause of climate change."

**More info:** David Lindenmayer David.Lindenmayer@anu.edu.au

**Reference**

Lindenmayer DB, KB Hulvey, RJ Hobbs, M Colyvan, A Felton, H Possingham, W Steffen, K Wilson, K Youngentob & P Gibbons (2012). Avoiding bio-perversity from carbon sequestration solutions. *Conservation Letters* 5: 28–36.

## Four strategies to mitigate plantation bio-perversity

### 1. Ecological risk assessment

These would include:

(1) An evaluation of the risks to existing ecosystems. For example, how likely is a plantation to change fire regimes resulting in decreases in biodiversity both within and adjacent to plantations?

(2) An assessment of uncertainties in understanding of ecosystem processes. For instance, do we know how an introduced tree species will spread in a particular environment and location?

(3) An evaluation of tradeoffs between the ecosystem services gained and lost through plantation establishment. For example, are the benefits from carbon-offsets created on-site in a plantation balanced by the negative impacts on water regimes occurring on and off the plantation?

### 2. Full carbon accounting

This would include quantifying the amount of carbon to be sequestered in plantations relative to the ecosystems they replace. This would include an accounting for all emissions associated with plantation establishment (eg, land clearing, burning, tree propagation, transportation) and plantation management (eg, road construction and timber haulage).

### 3. Assessment of incentives

This includes anticipating the different strategies that might be adopted by plantation growers to a particular policy, and should involve collaboration with local and regional policy-makers as well as ecologists. One aim would be to create incentives that broaden plantation goals beyond carbon sequestration to include a range of ecologically desirable environmental outcomes, including the maintenance of biodiversity (eg, REDD+).

### 4. Compliance & ecological monitoring programs

Such programs should include both local level 'participatory' monitoring as well as regional and national level 'expert-based' monitoring. Both kinds of monitoring at different scales would be critical for providing feedback to policy-makers and investors to alter incentive schemes and management practices to limit the risks of bio-perversity.

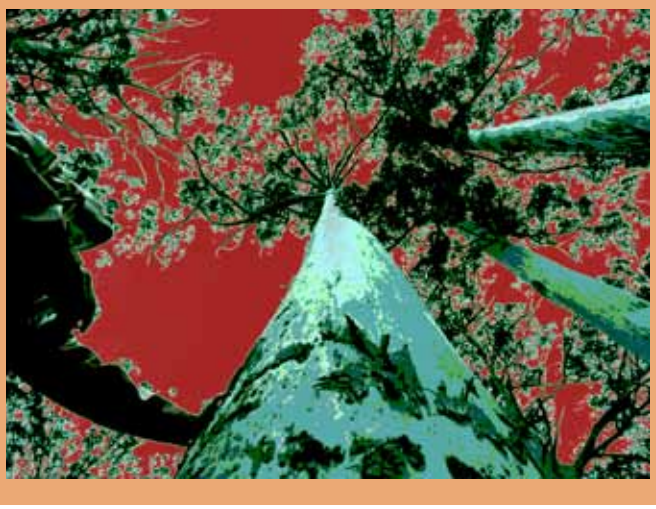

Image NASA

# Monitoring in the space/time continuum

## For effective ecological monitoring, do we preference time or space?

*By Jonathan Rhodes (EDG, University of Queensland)*

Long-term ecological monitoring is universally recognised as critical for understanding ecological systems, how they change over time, and for biodiversity conservation. But long-term ecological monitoring programs often look very different from each other.

At one extreme are programs, such as the International Long Term Ecological Research Network (ILTER, see box), that targets a few sites, but monitors them very intensively through time. At the other extreme are programs, such as the Birds Australia Bird Atlas (http://www.birdsaustralia.com.au/our-projects/atlas-birdata.html), that monitors a large number sites, but does so less intensively through time.

So which approach is right? Both programs have monitoring change through time as one of their core objectives, but go about achieving that objective in very different ways. It turns out that the best approach actually depends on the level of spatial and temporal correlation in the thing you're monitoring.

We explored this question for monitoring studies that have the objective to quantify trends in biological populations over time, but need to decide:

1. How many sites to monitor across space; and

2. How often to monitor each site through time.

If we have a fixed budget, then we must trade-off investment in surveying more sites against the frequency with which we monitor through time, and vice versa. Therefore, how much to invest in spatial replication versus temporal replication is a critical decision. And it's one that doesn't have an obvious answer and hasn't received much attention in the ecological literature to date.

We found three basic principles to help guide this decision. First, when the spatial correlation in abundances is low and the temporal correlation in abundances is high, it is best to sample many sites infrequently. Second, when the spatial correlation in abundances is high and the temporal correlation in abundances is low, it is best to sample a few sites frequently. And third, when abundances among sites are independent, it's best to maximise the number of sites sampled.

> "If we have a fixed budget, then we must trade-off investment in surveying more sites against the frequency with which we monitor through time, and vice versa."

These three principles provide simple rules of thumb for designing, or improving, monitoring programs where we have some prior information about correlations in abundances across space and time, or where this information can be gained as monitoring progresses. This work could also help to evaluate whether the very different approaches of existing monitoring programs (like the International Long Term Ecological Research Network and Birds Australia Bird Atlas) are the most appropriate strategies to pursue.

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**Reference**

Rhodes JR & N Jonzén (2011). Monitoring temporal trends in spatially structured populations: how should sampling effort be allocated between space and time? *Ecography* 34:1040-1048.

ILTER

### The network of networks

International Long Term Ecological Research (ILTER) is a 'network of networks', a global network of research sites located in a wide array of ecosystems worldwide that can help understand environmental change across the globe. ILTER's focus is on long-term, site-based research.

Australia's one LTER network registered with ILTER is TERN (The Terrestrial Ecosystem Research Network, http://www.tern.org.au/)

http://www.ilternet.edu/

TERN
Terrestrial Ecosystem Research Network

# What happens when an economist approaches a threshold?

## Ecological thresholds, uncertainty and decision making

*By David Pannell (EDG, University of Western Australia)*

The concept of thresholds features prominently in ecology and resilience theory. The idea is that if a variable crosses a threshold value, an ecological system can change abruptly and substantially. How this affects decisions made by rational environmental managers can depend greatly on how uncertain they are about the value of the threshold.

The Resilience Alliance has an online database of 'Thresholds and Alternate States in Ecological and Social-Ecological Systems'. It contains many examples including:

- Coral bleaching on the Great Barrier Reef when temperature rises beyond a threshold level.
- Hypoxia (reduced oxygen concentration dissolved in water) in the Gulf of Mexico when the concentrations of nitrogen and phosphorus (largely originating from agricultural fertilizers) exceed thresholds.
- A switch from woodland to grassland in the Chobe National Park of Botswana when elephant numbers exceed a threshold.

Thresholds are often talked about as if they are pretty black and white. If the variable is on one side of the threshold, the probability of a bad outcome is zero, whereas, if it is on the other side, the bad outcome is certain to occur (figure 1). If you know that you are close to such a threshold, the benefits of taking action to avoid crossing it could be very high.

For example, the decision might be, should we invest in actions to stop the management variable increasing slightly (moving to the right in figure 1). If we know for sure that the variable currently has a value just below the threshold (eg, 0.49 in this example), the benefits of investing in actions look high, as we can totally avoid the bad outcome.

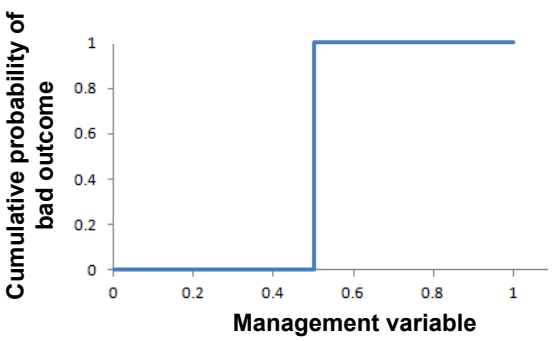
In reality, though, when thinking about a decision that needs to be made about future management, we usually don't know for sure whether there really is a clear-cut threshold, and even if we are willing to assume that there is one, we don't know its value.

Instead, we might feel that there is a range of values that the threshold might take, and that these different values have different probabilities of actually being the threshold. In other words, we may be able to subjectively specify a probability distribution for the threshold.

To illustrate, figure 2 shows how the cumulative probability of a bad outcome might look for a case where we believe there is a sharp threshold and our best-bet value for the threshold is 0.5, but we have high uncertainty about what the threshold value really is. In this case, the cumulative probability of a bad outcome increases smoothly and steadily until it reaches 1.

Decision theory was developed for just such a case. It's a way to account rigorously for uncertainty about a variable when trying to make a decision about what to do. It says that we should weight the outcomes of our decisions by their probabilities of occurring, and base decisions on the 'expected value' of the outcomes. 'Expected value' means the weighted average, allowing for different possible outcomes and their probabilities.

*Figure 1: A step-change threshold*




### What is a 'threshold?'

A threshold is defined as a point between alternate regimes in ecological or social-ecological systems. When a threshold along a controlling variable in a system is passed, the nature and extent of feedbacks change, such that there is a change in the direction in which the system moves. A shift occurs when internal processes of the system (rates of birth, mortality, growth, consumption, decomposition, leaching, etc.) have changed such that the variables that define the state of the system begin to change in a different direction, towards a different attractor. In some cases, crossing the threshold brings about a sudden, large and dramatic change in the responding variables, whilst in other cases the response in the state variables is continuous and more gradual.

http://www.resalliance.org/index.php/thresholds_database

If we apply that to a case where we are uncertain about what the threshold is (like figure 2), then the expected value of avoiding a small increase in the management variable is not large, even if its current value is just below the best-bet value for the threshold. For example, in the numerical example in figure 2, preventing an increase in the variable from 0.49 to 0.51 would reduce the probability of a bad outcome by only 4% (compared to 100% in figure 1).

If allowing for uncertainty about the value of the threshold means that the estimated benefits of a management decision are very different, then the optimal decision about what to do could be quite different too.

Interestingly, even if you believe that there really is a sharp threshold, the effect of allowing for uncertainty about the value of the threshold is to smooth things out, so that the decision is no longer black and white, but is a shade of grey. The result is that the decision problem is rather similar to what it would be like if there wasn't a sharp threshold at all, but a smooth transition between good and bad states.

To my mind, recognising realistic uncertainties about thresholds reduces their potency as an influence on decision making. It may result in reasonable decision makers choosing to take more measured actions than they would feel compelled to take if they believed that the problem was black and white.

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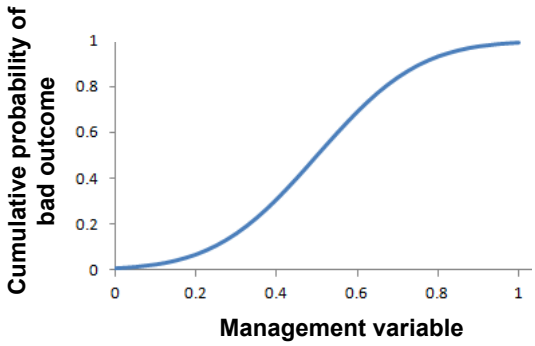
*This discussion originally appeared as an editorial on David Pannell's blog, Pannell Discussions (see http://www.pannelldiscussions.net/2012/02/). You're recommended to visit that blog if you have an interest in this topic because it kicked off a lively discussion thread that explored many of the facets of thresholds and uncertainty (but which is too long to include here). For example, the situation of thresholds and uncertainty was explored using the metaphor of collecting berries near a cliff edge in a fog.*

*Figure 2: A step-change threshold incorporating uncertainty about the location of the threshold.*



# What is this thing called 'resilience'?

## A bluffers guide to resilience thinking

*Editor's note: As everyone with an interest in NRM and biodiversity conservation knows, there's a rising groundswell of interest in the concept of resilience thinking. But what actually is it? In recent years I have been involved in two books that have sought to engage the wider public with the ideas underpinning resilience thinking (this was work done outside of the EDG). The first was called Resilience Thinking. The second, just released, is titled Resilience Practice. The following article is an edited excerpt from the introductory chapter of the new book. It attempts to distil some of the key ideas surrounding resilience thinking and is a good place to begin for anyone wanting a little more background on the topic.*

The word 'resilience' is now common in many vision and mission statements. But ask the people who use these statements what they think it means and you get a range of different answers, most of which relate to how something or someone copes with a shock or a disturbance.

Concepts of resilience are used in all sorts of disciplines, but it has four main origins – psycho-social, ecological, disaster relief (and military), and engineering. Psychologists have long recognised marked differences in the resilience of individuals confronted with traumatic and disastrous circumstances. Considerable research has gone into trying to understand how individuals and societies can gain and lose resilience.

Ecologists have tended to describe resilience in two ways; one focused on the *speed of return* following a disturbance, the other focused on whether or not the 'system' *can* recover. People engaging with resilience from the perspective of disaster relief or in a military arena incorporate both aspects (ie, speed and ability to recover). Indeed, there is a lot of commonality in the understanding of resilience in the three areas of psychology, ecology and disaster relief.

In engineering the take on resilience is somewhat different. Indeed, engineers more commonly use the term 'robustness' with a connotation of designed resilience. It differs from the other three uses in that it assumes bounded uncertainty – that is, the kinds and ranges of disturbances and shocks are known and the system being built is designed to be robust in the face of these shocks.

### Resilience thinking

The 'resilience' that is being invoked in vision and mission statements relating to Australia's environment (see a list of examples in the box titled 'It's a vision thing' on p5) is largely based on the idea of ecological resilience, and it's all about the ability to recover. The science underpinning our understanding of ecological resilience is often referred to as resilience thinking. The definition of resilience here is: the capacity of a system to absorb disturbance and re-organize so as to retain essentially the same function, structure and feedbacks – to have the same identity. Put more simply, resilience is the ability to cope with shocks and keep functioning in much the same kind of way.

> "First and foremost, resilience thinking requires that you recognize and appreciate that the systems we depend upon are complex adaptive systems."

A key word in this definition is 'identity'. It emerged independently in ecological and psycho-social studies, and it is both important and useful because it imparts the idea that a person, a society, an ecosystem or a social-ecological system can all exhibit quite a lot of variation, be subjected to disturbance and cope, without changing their 'identity' – without becoming something else.

The essence of resilience thinking is that …

1. The systems we are dealing with are complex adaptive systems
2. There are limits to a system's self-organising capacity (thresholds)
3. These systems have linked social, economic and bio-physical domains
4. Self-organizing systems move through adaptive cycles
5. Linked adaptive cycles function across multiple scales
6. There are two related dimensions to resilience: specified and general resilience
7. Working with resilience involves both adapting and transforming
8. Maintaining or building resilience comes at a cost
9. Resilience is not about knowing everything
10. Resilience is not about not changing

### The building blocks

First and foremost, resilience thinking requires that you recognize and appreciate that the systems we depend upon are complex adaptive systems (often also referred to as self-organising systems). All the things that most resource managers are interested in (for example, farms, landscapes and fishing grounds), but also things like your body, your family and your business, are all self-organizing systems. You can change bits of the system but the system will then self organise around this change. Other bits will change in response to your control. Sometimes you have a good idea how the system will respond to your actions, sometimes it's difficult to predict, and sometimes the response comes as a complete surprise.

Most of the time the system can handle the changes it experiences, be it human management or some external disturbance (like a storm). By 'handling it' we mean the system absorbs the disturbance, re-organizes and keeps performing in the way it did – it retains its identity.

But sometimes the system can't cope with the change and begins behaving in some other (often undesirable) way. Sometimes a fishery crashes and doesn't come back when fishing pressure is removed. Sometimes an agricultural catchment becomes salinized as the water table rises and is no longer productive, even if the water table drops. Even with the best intentions, our management sometimes turns our most precious ecosystems from valuable assets to expensive liabilities.

Resilience thinking is the capacity to envisage your system as a self-organising system with thresholds, linked domains and cycles. Points 1-5 in our list are the basic building blocks of the resilience concept (self organisation, thresholds, linked domains and linked adaptive cycles across scales).

Specified and general resilience

Points 6 and 7 discuss aspects of resilience that inevitably arise when you begin to consider how you might apply the thinking.

Specified resilience, as its name suggests, is the resilience of some specified part of the system to a specified shock; a particular kind of disturbance. General resilience is the capacity of a system that allows it to absorb disturbances of all kinds, including novel, unforeseen ones, so that all parts of the system keep functioning as they have in the past.

One of the aims of resilience thinking is to identify possible thresholds beyond which the system takes on a new identity. In managing the system you want to prevent it from crossing these thresholds by controlling the state of the system or by influencing the position of the threshold. In doing so, you are working on the capacity of the system to deal with a specified threat. You are therefore attempting to increase its specified resilience.

When you prepare your system for a specific disturbance, in a sense you're optimising your capacity for a specific threat. In so doing, you may be eroding your system's general capacity to absorb other kinds of disturbances. In other words, there is a trade off between specified and general resilience. Channelling all your efforts into one kind of resilience will reduce resilience in other ways. So it is necessary to consider both.

What are the things that enhance general resilience? Studies of a variety of social-ecological systems suggest diversity, openness, reserves, tightness of feedbacks, modularity and redundancy are all important characteristics of systems with high levels of general resilience.

## Adapt and/or transform

When it comes to managing resilience you can either aim to maintain the identity of your system; in other words adapt and build up the resilience of the current state of your system. Or, if the system is in an undesirable state, you can try to get back into the desirable state by reducing the resilience of the undesirable state. But sometimes that's impossible. When that happens, you can aim not to adapt but to re-imagine your system as something else, to transform – in other words, become a different system.

Adaptability is the capacity of a social-ecological system to manage resilience – to avoid crossing thresholds, or to engineer a crossing to get back into a desired regime, or to move thresholds to create a larger safe operating space.

Transformability is the capacity of a system to become a different system, to create a new way of making a living. An example comes from South Eastern Zimbabwe where, in the 1980s, ranchers transformed their cattle ranches to game hunting and safari parks when the livestock industry proved unviable.

On the surface, it may appear there's a tension between adapting and transforming. Should you adapt or transform? But the tension is resolved when you consider the system at multiple scales, because making the system resilient at a regional scale, for example, may require transformational changes at lower scales. Adapting and transforming are actually complementary processes, and adaptability and transformability (the capacities to adapt or transform) are complementary attributes of a resilient system.

> "Holding a system in exactly the same condition actually erodes resilience because the capacity to absorb disturbance is based on the system's history of dealing with disturbances."

## Misperceptions

Points 1-7 are about what resilience thinking is. The last three points deal with what it's not; that is, commonly held misperceptions surrounding resilience thinking.

The first (point 8) is that resilience thinking is not some magic wand. There are costs and hard decisions involved. Building resilience isn't free; it comes with both the direct costs of the actions you take and the indirect costs of opportunities lost by not using your resources in some other way.

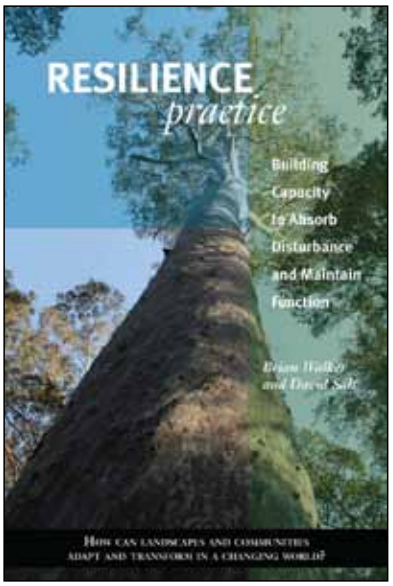
The second is it's not about knowing everything about your system. You do have to know quite a bit about your system. You do have to develop an idea about its thresholds, scales, cycles, feedbacks and domains. But everything is not connected to everything else, and you don't have to know everything about everything. A key phrase in resilience thinking is 'requisite simplicity' – as simple as possible, but not too simple. Resilience thinking aims to help you identify the minimum but sufficient information you need to effectively manage your system for the values that you hold to be important.

And the final point relates to a misperception that sometimes arises that being resilient is about keeping things the same or bouncing back to exactly the same condition. Resilience is not about not changing. Being resilient requires changing within limits – in fact, probing those limits.

A resilient coral reef is one that can reassemble after the battering of a cyclone. A resilient rangeland is one that recovers its productivity after a fire, or a drought. A resilient forest is one that can regrow back to the same kind of forest after a pest outbreak. A resilient business is one that can absorb a market shock and return to profitability. In each of these situations the basic identity of the system stays the same though each system is changing all the time – by changing, it enhances its resilience.

Holding a system in exactly the same condition actually erodes resilience because the capacity to absorb disturbance is based on the system's history of dealing with disturbances. So, for example, prevent savannas from occasional burning (through grazing management or fire control) and they lose their resilience to fire – they become vulnerable to it. A savanna that is never burned eventually loses its species that are adapted to fire, and when a fire eventually (inevitably) occurs it has devastating results. The only way to maintain the resilience of a savanna to fire is for that savanna to be periodically burned.

Staying exactly the same is actually a prescription for the loss of resilience because the system loses its capacity to deal with change and disturbance. Traditional approaches to resource management, based on ideas of optimal sustainable yield, often fall into this trap. They attempt to hold a system in a configuration that achieves the greatest productivity, without acknowledging the dynamic nature of the system they are attempting to control.

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**Reference**

Walker B & D Salt (2012). *Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function*. Island Press. Washington.

# Marxan out of the 'box'

## More than a sales pitch

*By David Salt (EDG, ANU)*

"Marxan is the most widely used software in the world for supporting the design and implementation of marine and terrestrial reserve systems." That's a line many readers would have seen in several stories on Marxan appearing in *Decision Point* over the years. While it's demonstrably true, this line is increasingly sounding like a glib sales pitch, possibly because it's so often repeated. People hear 'Marxan' and they switch off. I would even confess to being in this camp. I'm told there's a particular conservation planning challenge, the black box called Marxan is wheeled out, data is fed in, solutions are spat out, end of story!

Last month I was invited to observe an 'Introduction to Marxan' workshop being run at the University of Queensland. Watching a fresh cohort of conservation researchers and practitioners going through the Marxan driving course has changed my mind. A one-line sales pitch simply doesn't do justice to Marxan. To make amends for my earlier cynicism, I'm going to try and convince you of that, too.

### Where to begin?

The core value of Marxan is that she finds a range of good solutions to a well-defined problem (Hugh Possingham, one of Marxan's original authors, always refers to Marxan as a 'she'). That has to be the beginning and the end point for Marxan because anyone using the software is obliged to engage with their conservation challenge as a defined problem with a range of solutions to choose between. In this sense, they have then placed their challenge into a decision framework. This step in itself is often the biggest challenge in conservation.

But what makes Marxan so special (as opposed to a range of other conservation software tools)? Well, Marxan is an efficient, repeatable, transparent and equitable process for making conservation decisions (though other conservation software tools also share these attributes). Marxan is also relatively straightforward to use and cheap – actually it's free, and you can't get much cheaper than that. All of this is good but possibly what makes Marxan both special and increasingly popular is her community of users. They come from all over the world, they use Marxan to solve a whole range of conservation challenges (not just reserve selection), they help each other overcome problems, and they're constantly coming up with new add-on tools that do different things with the solutions that Marxan produces.

### Diversity of users and uses

This diversity of uses and users was readily apparent at the Marxan workshop I attended. While most participants were Australians based at universities, some were using Marxan for research, some for teaching in conservation planning and others for NRM management. Several conservation practitioners had come from distant shores including Canada, the UK, Brazil, South Africa and Japan.

*Hugh Possingham launches another 'Introduction to Marxan' course at the University of Queensland.*

*Mariana Fuentes (foreground) gets some assistance from trainer Vic Tulloch on working with Marxan.*

And while some were looking to use Marxan for reserve selection, many were looking at applying the software to assign management priorities. For example, Mariana Fuentes from John Curtin University was thinking of using Marxan to prioritise areas for pig baiting along the shores of the Gulf of Carpentaria to protect turtle hatcheries. Rob Armstrong, a conservation officer from the NSW Office of Environment and Heritage, was interested in exploring the problem of assessing placement of wind farms in relation to the impact on bats. And Katrina Davis, an economist at UWA, was looking at using Marxan to explore transaction costs connected to reserve planning along the Chilean coast. So, it's not just about deciding where to plonk a nature reserve.

### Not a black box

Another myth quickly dispelled at the workshop is that Marxan is a black box. A black box is any unit which does something useful but users never really see how it's done (ie, the workings of the box). A computer is a black box, even one in a silver casing. Marxan uses a computer to come up with solutions but the basic way she functions is simple and out in the open for anyone to see. She simply applies a mathematical formula to come up with a score for a particular solution to a conservation challenge.

For example, that challenge might be to identify what marine areas along a coastline should go into a network of marine reserves. The purpose of the network is to protect a range of biodiversity values and managers want the reserves in places where they cause minimal disruption to other coast users (commercial and recreational fishing for example). Choices are made on what are appropriate natural targets for the reserve network, the coastline is split up into spatially explicit planning units (1km x 1km for example), available data is brought together on what's actually present in each of these planning units, as well as data on the costs of incorporating any unit.

Each possible network of units is a different solution, and the number of solutions is astronomically large. This is where Marxan comes in. It adds up the cost of each possible configuration and provides a range

> "What makes Marxan both special and increasingly popular is her community of users."

of the cheapest solutions that meet the conservation targets.

### Cost + compactness + penalty factor

It's a little more complicated than this because it's not just the total cost of independent units that's important. The way these units fit together is important too. Ideally you want the network to be as compact as possible so individual units are well connected. But compact reserves are harder to set up around the other interests impacted by the establishment of the reserve (eg, fishing). So, there's a trade-off between compactness and reserve useability that needs to be factored in.

And if the network can't meet all conservation targets for an acceptable cost, you can also weight how much penalty should be paid for missing conservation targets.

So what Marxan does is score each solution by adding up its cost while incorporating in a compactness factor and a penalty factor for missed targets.

It's not a black box because users can see how the program is working the inputs. The compactness and penalty factors are knobs to be tuned, allowing for specific circumstances. Marxan users can 'play' with Marxan to produce solutions that are better aligned to the needs of the various stakeholders in the reserve.

### Supporting decisions, not making them

Users can also ask Marxan to produce as many different optimal solutions as needed. This is really just the amount of time users are prepared to wait as the computer grinds through multiple iterations of different configurations.

And, with the solutions in hand, there are a range of techniques (tools) to help determine which sets of solutions best suit the needs of the stakeholders.

Importantly, Marxan doesn't produce a single answer. It doesn't make the decision. It provides sets of solutions for decision makers to choose between.

So what does all this mean in terms of decision support for users (and stakeholders)? Marxan helps translate the goals and objectives of a reserve network (or conservation plan) into something that is spatially explicit. And, because it provides many good solutions, there is flexibility to enable stakeholder engagement. Comparing the good solutions identifies areas that occur across the range of solutions, thereby identifying 'key' locations that take on a high priority for inclusion. But it also identifies areas that are optional enabling a negotiation to take place.

If Marxan was a black box then all of these benefits would be harder to demonstrate to sceptical stakeholders because they could always claim they don't understand how the solutions were acquired ("data in one side, bull dust out the other"). But because Marxan's innards are simple and on show, and the process of generating solutions can be examined and shared – and if necessary, adjusted and rerun – the only real challenge is communicating what's happening in a way everyone appreciates.

If you've heard a little bit about Marxan and wondered what all the buzz was about, maybe it's time to investigate a little further.

**More info:** http://www.uq.edu.au/marxan/
(And see 'the many faces of Marxan' on page 14.)

## Train the trainer

Marxan is not the world's only conservation planning software, far from it. It is, however, one of the most popular with over 1,700 users from more than 100 countries and at least 1200 organizations. A big part of Marxan's success is her committed community of users which provides support for people having problems with Marxan as well as generating a constant stream of innovative new ways of using Marxan. One way of investing in that community is by building a capacity to train people to train others in how to use Marxan. At the University of Queensland a 'train-the-trainer' course is run every time an 'introduction-to-Marxan' workshop is held. These trainer trainees work over the Marxan course notes the day before the introduction course familiarizing themselves with how to teach Marxan while ironing out any bugs that inevitably arise as the software is run on new computers and different operating systems.

This year there were six trainer trainees including Azusa Makino, a PhD student at UQ, who will be involved in teaching Marxan in Japan (in Japanese); Virgilio Hermoso, a research fellow at Griffith University, who will be involved in teaching Marxan in Spanish in Latin America; and Alistair Becker, a lecturer in conservation biology at the University of New South Wales, who will be teaching Marxan to graduate students at UNSW.

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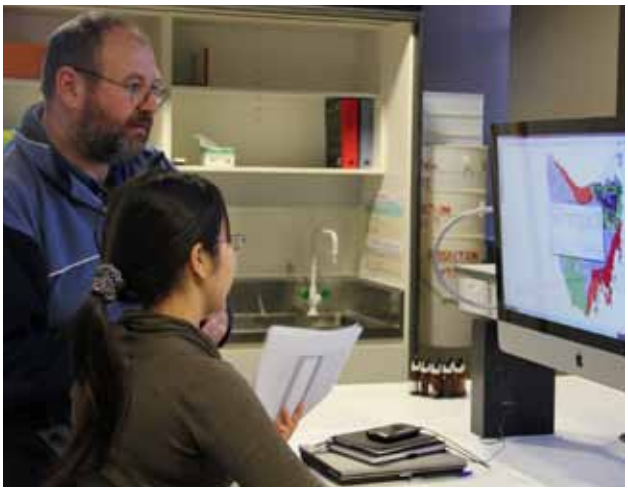

*Matt Watt goes over a training exercise with Azusa Makino during the train-the-trainer day.*

"The core value of Marxan is that she finds a range of good solutions to a well-defined problem."

## Five Marxan myths exploded

### 1. Marxan is not just about selecting reserves

It's about guiding decisions on the amount we should invest in any conservation action in any place.

### 2. Marxan is not a black box

How it works is on display for the world to see (and engage with).

### 3. Marxan is not just about marine conservation planning

While one of its first applications was in helping to zone the Great Barrier Reef, Marxan is just as applicable to terrestrial systems and freshwater systems, and has been used extensively above the high tide mark.

### 4. Marxan doesn't make decisions

It provides a range of solutions for decision makers to choose between. It supports decision making.

### 5. Marxan is not technically demanding

While basic computer literacy and some GIS experience are a prerequisite, Marxan does not require a strong maths background.

# The many faces of Marxan

## One of the secrets of her success

*By Matt Watts (EDG, University of Queensland)*

Marxan is a command line interface (CLI) program written in the C programming language. Versions are available for Windows, Mac OSX and Linux. It doesn't have a graphical user interface (GUI). What does that mean? Basically that, by herself, Marxan is faceless. She accepts inputs as numbered data and she outputs solutions as numbered data.

That's a bit of a problem because most people need some form of graphical interface – a face – to be able to make sense of the solutions offered by Marxan. However, it's also turned out to be one of Marxan's winning advantages because a range of Marxan faces (GUIs) have been developed by organisations from around the world. Each has its own specific applications and strengths, but the diversity they offer has been a major factor in Marxan's ongoing strength and popularity.

I've illustrated this by describing some of these faces below. However, given Marxan's constant evolution and widespread use, it's possible I don't even know all of them. So, if I've missed any that you know of, please let me know.

Oh, another thing I should point out. In the past, Marxan was dependent on expensive commercial Geographic Information System (GIS) software. The majority of tools were created for commercial ESRI GIS software. Now, it is possible to use Marxan with free software thanks to Zonae Cogito and Qmarxan.

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### Zonae Cogito

This software is a graphical user interface for the Marxan software. It provides a simple way to edit input parameters, run Marxan and view the results. It uses MapWindow open source GIS so users don't need to buy commercial GIS software. It's used extensively around the world in support of marine and terrestrial planning with Marxan. There is an article about Zonae Cogito in *Decision Point #28*.

### Qmarxan

This new software was released in 2012 and is a plugin for the Quantum GIS open source GIS. It provides a simple way to create Marxan datasets from GIS map layers and import Marxan results into Quantum GIS for viewing output spatially.

### Conservation Land Use Zoning software – CLUZ

CLUZ is a plugin for ESRI ArcView 3 GIS. It builds Marxan datasets, runs Marxan, and displays the results. It has been widely used for conservation planning in the past. The ArcView 3 software is not as widely used now as it was in the past, which limits how many people can use CLUZ.

### Protected Area Tools (PAT) for ArcGIS

The Nature Conservancy developed this software for use with Marxan and ESRI ArcGIS 9 and 10. It is an interactive decision support system that supports the design of protected area networks.

### Land Change Modeler

The Land Change Modeler is commercial software that was developed by Clark Labs. It is available for the IDRISI and ESRI ArcGIS 9 commercial GIS systems. The software has extensive functionality, including a Marxan interface.

### The C-Plan Conservation Planning System

C-Plan was the gold standard conservation planning system prior to the introduction of Marxan. It is free software. It is an interactive decision support system that supports the design of protected area networks. The original version required ESRI ArcView 3. It was the first GUI available for Marxan. It no longer requires ArcView due to provision of a Zonae Cogito interface.

### Protected Area Network Design Application (PANDA)

Mappamondo GIS developed this software for use with ESRI ArcGIS 9. It is free for non-profit used. It is an interactive decision support system that supports the design of protected area networks.

### NatureServe Vista

NatureServe developed this free software for use with ESRI ArcGIS 9 and 10. It is an interactive decision support system that supports the design of protected area networks.

### ABPmer Boundary Tool

ABP Marine Environment Research developed this free software for use with ESRI ArcGIS 10 to create Marxan boundary length files.

### JNCC Boundary Tool

Andrew Cottam from Joint Nature Conservation Committee developed this free software for use with ESRI ArcGIS 9 to create Marxan boundary length files.

### ArcInfo Boundary Tool

Wayne Rochester from CSIRO developed this script to create Marxan boundary length files. It is free software and is an Arc Macro Language script for ESRI ARC/INFO GIS.

| Software | Author | Website | Commercial GIS Required | Operating System |
|---|---|---|---|---|
| Zonae Cogito | University of Queensland | www.uq.edu.au/marxan | No | Windows |
| Qmarxan | APROPOS Information Systems | http://aproposinfosystems.com/ | No | Windows, Mac OSX, Linux |
| CLUZ | University of Kent | www.kent.ac.uk/dice/cluz/ | ESRI ArcView 3 | Windows |
| PAT | The Nature Conservancy | http://gg.usm.edu/pat/ | ESRI ArcGIS 10 | Windows |
| Land Change Modeller | Clark Labs | www.clarklabs.org | IDRISI or ESRI ArcGIS 9 | Windows |
| C-Plan | NSW National Parks & Wildlife Service | www.edg.org.au | No | Windows |
| P.A.N.D.A. | Mappamondo GIS | www.mappamondogis.it | ESRI ArcGIS 9 | Windows |
| NatureServe Vista | NatureServe | www.natureserve.org | ESRI ArcGIS 10 | Windows |
| ABPmer Boundary Tool | ABP Marine Environmental Research | www.abpmer.co.uk/newsarticle/38 | ESRI ArcGIS 10 | Windows |
| JNCC Boundary Tool | Joint Nature Conservation Committee | www.uq.edu.au/marxan | ESRI ArcGIS 9 | Windows |
| ArcInfo Boundary Tool | CSIRO | www.uq.edu.au/marxan | ESRI ARC/INFO | Windows, Unix, Solaris |

# A Red List of Ecosystems

## CEED Workshop (Melbourne, May 2012)

*By Emily Nicholson (EDG, University of Melbourne)*

The IUCN Red List of Ecosystems was inspired by the success of the IUCN Red List of Threatened Species, which informs governments and society about the current status and trends of species-level biodiversity. The Red List also provides data for the prioritisation of management strategies.

While the Red List of Threatened Species is valuable, there's long been a need for assessments that incorporate higher levels of biological organisation. Over the years a variety of national and regional listings of ecosystems, communities and habitats has emerged in both Australia and overseas (Nicholson et al. 2009). However, there's never been an accepted international protocol. Hopefully, that's about to change.

An international scientific team has developed draft Red List criteria for ecosystems (Keith et al. 2012). The criteria are up for endorsement at the 5th World Conservation Congress in September this year (see box). This new protocol is based on assessments of trends in ecosystem distribution and function, and provides a rigorous international standard for better alignment of listing processes for ecosystems around the world.

In May, some 32 people from all around the world met at the School of Botany, University of Melbourne, at a CEED-sponsored workshop on the IUCN Red List of Ecosystems. The focus of the workshop was 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.

It was a very successful workshop, with many fruitful and constructive discussions. Outputs will include new collaborations and papers reviewing conceptual and quantitative models for understanding change in function and framing assessment, and exploring the definition of collapse.

There will also be further engagement in a series of IUCN meetings, such as the World Conservation Congress, and workshops in Senegal in July on data-poor systems.

The workshop was organised by myself and Tracey Regan (both from the University of Melbourne), David Keith (UNSW & NSW Office of Environment and Heritage) and Jon Paul Rodriguez (the Center for Ecology at the Venezuelan Institute for Scientific Investigations [IVIC] & Provita & IUCN).

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"There's long been a need for assessments that incorporate higher levels of biological organisation."

*Participants at the end of the workshop (looking a little tired and relieved).*

## The 5th Congress

The IUCN World Conservation Congress is held every four years. It claims to be the world's largest and most important conservation event.

The 2012 World Conservation Congress will be held from 6 to 15 September 2012 on Jeju Island, South Korea. It will bring together government leaders and representatives from the public sector, NGOs, businesses and UN agencies to discuss, debate and hopefully decide on pathways towards more effective conservation. Between 6,000 to 8,000 delegates from over 150 countries are expected to attend.

The Congress theme this time is Nature+, a simple slogan that aims to "capture the fundamental importance of nature and its inherent link to every aspect of our lives". And, because the concept resilience has been raised in several places in this issue of *Decision Point*, we can't resist quoting the IUCN press release (http://iucn.org/about/union/members/resources/news/?7030/Nature) on the connection between Nature+ and resilience: "Nature+ is about boosting the resilience of nature – improving how quickly nature and people adapt to change. Better use of the inherent robustness of nature leads to healthier natural systems, better results from ecosystem and biodiversity restoration, and healthier people, communities and economies." (Which may, or may not, help you get a better handle on what resilience is.)

**More info:** http://www.iucnworldconservationcongress.org/about/

*The 2012 World Conservation Congress logo. The logo is supposed to evoke a flower and a bird, while incorporating traditional indigenous Korean patterns.*

***The sad demise of the ivory-billed woodpecker***

*Many believe the ivory-billed woodpecker went extinct in 1944. Prior to this, heavy logging exacerbated by hunting by collectors devastated populations of the bird. It was generally considered extinct in the 1920s when a pair turned up in Florida. This pair was then shot for specimens. By 1938, an estimated 20 individuals remained in the wild, some 6-8 of which were located in the old-growth forest called the Singer Tract in Louisiana, where logging rights were held by the Chicago Mill and Lumber Company. The company brushed aside pleas from four Southern governors and conservationists that the tract be publicly purchased and set aside as a reserve, and clearcut the forest. By 1944 the last known Ivory-billed Woodpecker, a female, was gone from the cut-over tract. Recent sightings have reignited the debate over whether the species is extinct.* *See the story on page 3 (and the story below).*

*(Painting by John James Audubon, Birds of America)*

## What's the point?

### Of extinction and entrepreneurs

The bird is probably gone but its memory still attracts a tourism buck. In economically struggling east Arkansas, speculation of a possible return of the ivory-bill woodpecker has served as a great source of commercial activity, with tourist spending up 30%, primarily in and around the city of Brinkley. A woodpecker 'festival', a woodpecker hairstyle (a sort of mohawk with red, white, and black dye), and an 'Ivory-bill Burger' have all been featured locally. Unfortunately, the lack of confirmed proof of the bird's existence, and the extremely small chance of actually seeing the bird even if it does exist (especially since the exact locations of the reported sightings are still guarded), have prevented the explosion in tourism some locals had anticipated. Arkansas has made license plates featuring the ivory-billed woodpecker and the bird also appears on a stamp (see below). All for a bird which most experts believe is extinct.

http://en.wikipedia.org/wiki/Ivory-billed_Woodpecker


# 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.

The EDG is jointly funded by the Australian Government's National Environmental Research Program and the Australian Research Council's Centre of Excellence program.

*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.

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http://ceed.edu.au/ or
http://www.nerpdecisions.edu.au/

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