Decision Point

Issue 40 / June 2010

Connecting conservation policy makers, researchers and practitioners

Smart science for wise decisions

Mixing science and practice to save species

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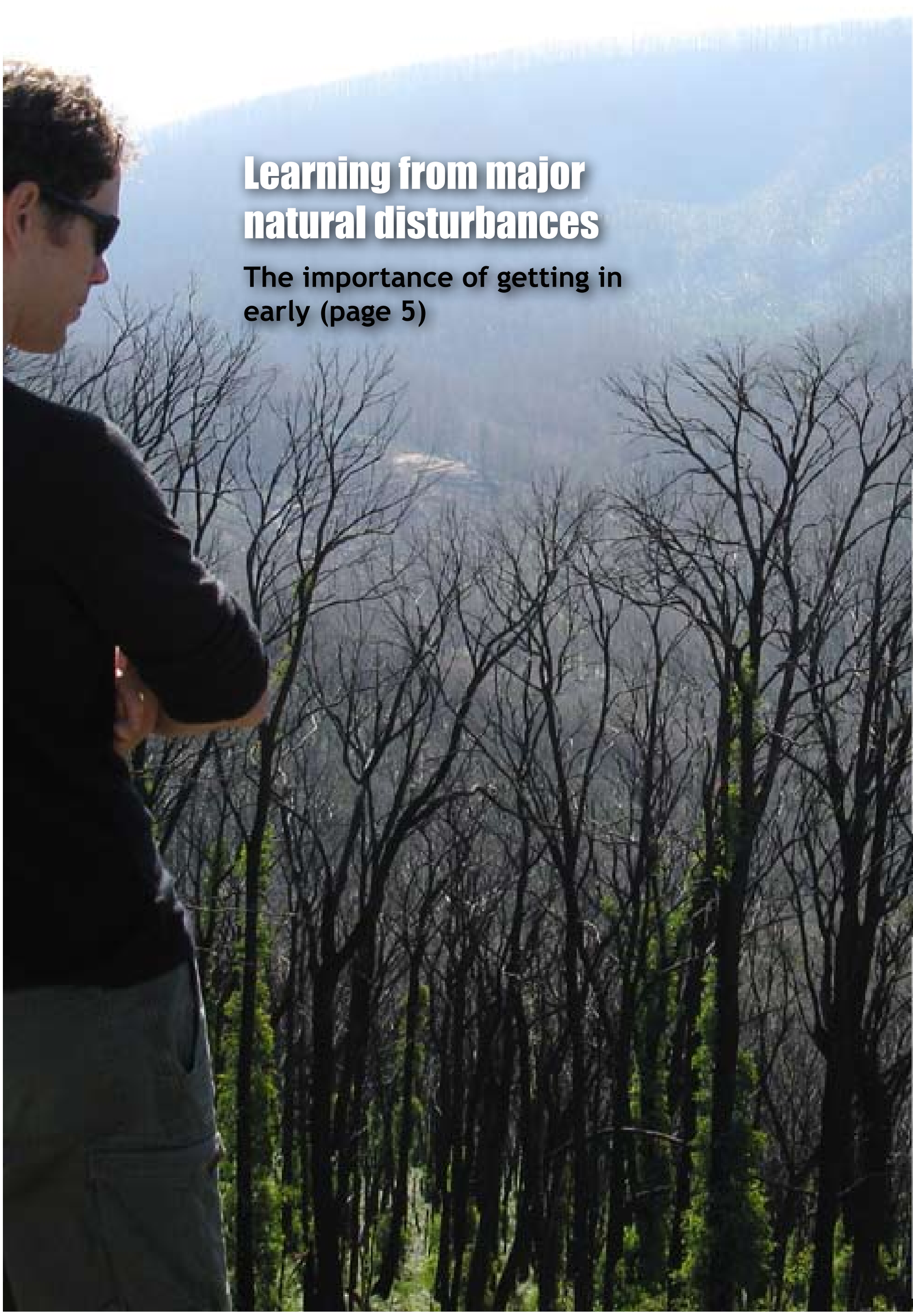

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Decision Point

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What do greenies want?

Has the Australian conservation movement failed to set clear objectives?

The Dpoint editorial

By Hugh Possingham (Director, AEDA)

Earlier this year I attended and spoke at the Queensland Growth Management Summit, an initiative of Queensland's Premier, Anna Bligh. The summit was a bold move to start the dialogue on the why, how much and where, of population growth in Queensland. There were many impressive presentations from people with diverse views and backgrounds.

Undoubtedly the most impressive speaker was Bernard Salt <http://www.bernardsalt.com.au/> – one of Australia's more high profile demographers. His morning presentation on how demographic projections influence our economy was lively and filled with data and models (yummy).

At the dinner Bernard spoke in a debate – again very passionately about the merits of growth. He also asked one very fundamental question, a question that had clearly preyed on his mind because he asked it twice with emphasis "What does the environmental movement want?"

My feeling was that he was sick and tired of the conservation movement saying "no" to things other members of society wanted: you can't have that dam/road/port facility because there is a little brown frog there; we can't have any more people because we consume too much water/land; stop expanding forestry and agriculture and mining because it destroys native habitat. And I agree with his sentiment, in part. I think the conservation movement is often too busy stopping others getting what they want, and doesn't spend enough time trying to make its own progress.

In general it's true that prevention is better than a cure (and definitely cheaper), and I along with my colleagues have worked hard to stop many of the biggest threats, like broadscale land clearing. However, maybe it is time to go onto the front foot. Maybe it's time to create a clear set of objectives with plans on how to deliver those objectives.

In the mid 90s I met with South Australia's ministers for environment and agriculture to discuss just such a proposal. (At the time I was representing the Nature Conservation Society of South Australia and with me was Peter Day, the executive officer of the South Australian Farmer's Federation – which represented a fairly important collaboration between farmers and conservationists.)

Peter and I proposed 'Biodiversity Development Plans' which we intended to be precursors to NRM/CMA plans. A Biodiversity Development Plan would be a costed plan to achieve a net improvement in regional biodiversity. It would be a plan about aggressive and proactive actions – a forward thinking plan to sit beside and compete with the plans of other industries.

> "Even when we set a clear national target for a reduction in the rate of species loss we have invested so little in achieving the goal that we can't even measure the progress of our failure."

Now the two very capable ministers we presented to were very enthusiastic, but what happened? Well, the plans became biodiversity inventories – lists of assets (species and habitats) and their threats. But here's the kick, like so many so-called biodiversity plans these inventories did not include costed actions. I say 'so-called' because without costed actions I don't think you can claim a process is a plan. A plan, after all, is something you intend to do and that means it must have dates and costs.

Some parts of the green movement are getting on and taking action – Bush Heritage Australia, Australian Wildlife Conservancy, The Nature Conservancy, Pew Charitable Trusts and Trust for Nature, are all aggressively pursuing options. Now we need state governments to invest in proactive biodiversity conservation and we need NRM and CMA boards with the funds and plans to secure and then restore biodiversity.

But back to the population debate at the Queensland Growth Management Summit. The second time Bernard Salt asked "What do greenies want?" (or words to that effect) I was goaded into yelling a response (past the ear of the environment minister and over the head of the premier sitting in the table in front of me). "No species loss," I cried. I really meant "No background rates of species loss" but the subtlety may have been lost on the 200 dinner guests sloshing back their wine.

If 'a growing GDP' is the bottom line for Australia's economy, then surely 'no background rates of species loss' is our conservation bottom line. They (the economists) have succeeded; we (the conservationists) have failed. Indeed, even when we set a clear national target for a reduction in the rate of species loss (and this would be the goal we promised to achieve when signing on to the Convention on Biological Diversity 2010) we have invested so little in achieving the goal that we can't even measure the progress of our failure.

Take home messages: 1) Don't give professors free champagne before dinner debates. 2) Set quantifiable biodiversity targets, invest in actions that cost-effectively maximize the chance of achieving those targets, and measure progress towards meeting the targets – it aint rocket science, most working people do it every week.

> "He was sick and tired of the conservation movement saying "no" to things other members of society wanted: you can't have that dam/road/port facility because there is a little brown frog there; we can't have any more people because we consume too much water/land..."

How valuable is nature?

If it's priceless, how can we save it?

How valuable is nature? Or Kakadu National Park? Or Tasmania's beautiful but endangered spotted handfish? Very valuable? How about priceless?

Claiming that something is 'priceless' or that it holds infinite value is sometimes done in the belief that such a valuation would provide it special protection; that such a thing must be given absolute priority. And yet, the opposite might be true. Such proposals could paralyse conservation efforts. A new investigation by AEDA researchers has described the serious problems that arise when the environment is attributed as having infinite value.

"Invoking infinite values is very common," says Professor Mark Colyvan, the AEDA researcher leading the investigation. "Such approaches take there to be absolute, non-negotiable duties and obligations in conserving something. However, problems arise when we try to reconcile such obligations in formal and informal decision frameworks or indeed anywhere where trade-offs need to be made.

"It arises from a sense of duty to conserve nature that is not negotiable and not over-ridden by economic concerns. Many would have some sympathy with such motivation, but assigning infinite values to the natural environment is not the way to realize the ambitions in question. Attributing infinite value to anything, let alone the environment, would incapacitate decision making."

The case against infinite values

According to the researchers, there are three basic problems associated with the use of infinite value. The first is that it lacks discrimination. For example, if some habitat is assigned infinite value (eg, mangrove forests), attributing meaningful values to larger or smaller regions of that habitat is problematic because, according to standard accounts of infinite value, all infinitely valued items are equal.

"Once something is assigned infinite value, no better outcome is possible," observes Colyvan. "But in real-world applications this is clearly mistaken. A region of a specific habitat may be highly valuable but, all else being equal, saving more of the habitat is surely more valuable, as numerous studies of relationships between reserve area, biodiversity representation, fragmentation effects, and population viability have confirmed. Assigning infinite value precludes such finer discriminations."

The second problem is that infinite value swamps probabilities. If an outcome (eg, protection of threatened habitat) is assigned infinite value, the expected value of actions that have the slightest chance of producing that outcome is infinite. This occurs because the result of weighting an infinite value by a non-zero probability is infinite as well. For example, if persistence of an endangered species is considered infinitely valuable, actions with any non-zero chance of ensuring its survival will have infinite expected value. In particular, actions with high and actions with low probabilities of species survival would have identical expected value. This would imply indifference about actively protecting endangered species and passively doing nothing, and this is patently the wrong result.

And the third issue is how you can know that something has infinite value. Infinite value must be intrinsic or instrumental. If it were intrinsic, it would be unclear how such values could be known. The intrinsic value of something is independent of its utility to valuers, such as humans. As such, it is non-relational—it does not depend on other things—and thus would seem to be unknowable by us.

"As an ethical basis for conservation, accounts of intrinsic value of any kind are seriously flawed," says Colyvan. "And there's no evidence to suggest that infinite value is considered instrumental. People do not act as though they attribute infinite value to anything. If they did, they would sacrifice any finite amount of money, goods, or well-being for even a miniscule chance at achieving what they infinitely value."

As trade-offs between safety and convenience, efficiency and profit in numerous contexts demonstrate, even human life is not taken to have infinite value. People do care about the probabilities and this only makes sense if the values in question are finite. In the environmental case, people (rightly) hold that actions increasing the chances of endangered species survival are worthwhile, and they do not hold that different-sized patches of identically suitable critical habitat are equally valuable, all else being equal.

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"The problem with traditional cost-benefit approaches to environmental decisions is not that such approaches "sell out on nature", but rather that they do not faithfully represent the value of nature."

The pink handfish is known from only four specimens and was last recorded off the Tasman Peninsula in 1999. Handfishes are small, often strikingly patterned or colourful, sedentary fish that tend to 'walk' on the seabed on hand-like fins. Fifty million-years ago, they 'walked' the world's oceans, but now they exist only off eastern and southern Australia. Nine new species of handfish have just been described by CSIRO. So, how valuable are handfishes? What about the pink handfish in particular? Priceless? (Photo by Karen Gowlett-Holmes) For the full story see http://www.csiro.au/news/New-species-for-disappearing-handfish-family.html

The Snares penguin is a medium-small, yellow-crested penguin only found on a group of islands off the southern coast of the South Island of New Zealand. It's currently rated as vulnerable by the IUCN because while there the current population is estimated at around 30,000 breeding pairs its breeding range is restricted to one small island group. What's its value and how much resource should the New Zealand Government devote to its conservation? What about another endangered bird, the South Island saddleback (see page 10)? It's believed there are only 650 birds left in this population. Deciding on resources between these two bird species are difficult at the best of times but they're impossible if their value is considered infinite. (See page 10 for a story on how the New Zealand Government is considering balancing this trade off.) (Image by Liana Joseph)

How valuable is nature?

(*Continued from page 3)*

Moreover, people are generally unwilling to forgo large finite payoffs (such as lifetime earnings) in exchange for survival of endangered species.

If you accept these arguments on infinite value then three inescapable conclusions follow:

(1) the claim that aspects of the environment have infinite value is empirically implausible; (2) assigning infinite value to the environment would produce highly counter intuitive advice about conservation decisions; and, (3) this advice would cripple conservation management because it precludes making reasonable value prioritisations in decision making.

Selling out nature

Infinite value is invoked by those who feel nature is often short changed in real world decision making, something with which the researchers have some degree of sympathy.

"Advocates of infinite value are right about one thing: we shouldn't sell nature short," says Colyvan. "The value attributed to nature must not be based on indefensibly narrow economic or market measures. With sensible and realistic valuations, environmental decision making can be approached via familiar cost–benefit analyses.

"The problem with traditional cost–benefit approaches to environmental decisions is not that such approaches 'sell out on nature', but rather that they do not faithfully represent the value of nature. Nature is often undervalued. While formal cost–benefit analyses have gained traction in environmental decision making, adoption of comprehensive approaches to environmental valuation that include more than economic, market, or narrowly defined biodiversity measures has not kept pace. Attempting to correct for this, however, by inflating nature's value to infinity is a mistake that would cripple conservation efforts.

A question of value

Protecting the natural environment involves, among other things, recognising what's valuable and the type of value at issue. Things of high value are sometimes described as having *intrinsic, infinite or incommensurable value*.

Intrinsic value, if it exists, is simply value that is independent of valuers; the value something has irrespective of its utility in pursuing further goals. Some think that the natural environment has such value, others don't. In contrast, something's *instrumental value* is its value to particular valuers, typically for specific purposes. Money is a clear example: it is useful in pursuing other valuable things, but has little or no value in itself.

Something with *infinite value* is more valuable than anything of finite value. All infinite values are regarded as equal. Comparing two outcomes, where at least one has infinite value, is therefore straightforward: if one outcome is finitely valued, the infinitely valued outcome is more valuable; if both values are infinite, then they are equally valuable (according to the standard accounts of the relevant mathematics).

Finally, the values of two things are *incommensurable* if they are incomparable: one is not more valuable than the other, nor are they equally valuable. For example, quantities in different units are incommensurable when there is no conversion between them (eg, is 1 kg larger than a 1 metre?). Although they are commonly confused, incommensurable and infinite values are distinct. Infinite values are comparable, so they are not incommensurable. Whether there are genuinely incommensurable values is controversial, but some claim that trade-offs between financial reward and human life are impossible because of an underlying incommensurability of value.

Claiming that aspects of the natural environment (biodiversity, ecosystems, etc.) are infinitely valuable is not the same as claiming they are incommensurable or intrinsically valuable. When properly distinguished, we see that these three kinds of values are not only different, each is motivated by independent considerations. Values are indispensable in both formal and informal decision making. Formal decision making relies on structured mathematical decision rules to arrive at a decision whereas informal, or behavioral, decision making does not necessarily rely on repeatable decision rules or quantification. The former is based on maximizing expected values in all decisions. Expected values are values weighted by probabilities, and decisions therefore depend on both probabilities and values. This formal approach is widely used in economics, risk analysis, and elsewhere, and has had numerous applications in conservation biology.

"The key to valuing nature lies in greater interaction across disciplines that have traditionally been viewed as irrelevant to the practice of conservation biology. Disciplines such as history, political science, economics, philosophy, geography, psychology, and anthropology all have something to contribute. While interdisciplinary endeavours present many challenges, such synthesis is necessary for comprehensive evaluations of nature that go beyond narrow economic measures. And only after such comprehensive evaluations are in place, can we implement sound conservation policy."

More info: mark.colyvan@sydney.edu.au

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Understanding major disturbances

The key is rapid response

Large-scale natural disturbances have enormous impacts on human populations and landscapes. They are a critical part of long-term ecosystem dynamics but to really understand their far reaching consequences it's important to begin studying them immediately after they have taken place. Despite the importance of such research, there are few funding programs that facilitate rapid research responses to major natural disturbances. Now a call has gone out, lead by AEDA's David Lindenmayer, in the *Frontiers of Ecology and the Environment* to rectify the situation.

"Following major natural disturbances there are many opportunities to gather valuable ecological information if studies are initiated quickly," says Professor Lindenmayer. "Unfortunately, many learning opportunities are being lost or only partially realised because we lack a rapid response research capacity following large-scale natural disturbances. We believe it's imperative to remedy this deficiency quickly."

Examples where rapid responses are important include ice storms, windstorms and soil freezing where hydrological and biogeochemical cycles and soil erosion can be severely impacted. However, to understand these impacts measurements need to begin as soon as possible after the disturbance. Another example is documenting fire severity at fine scales after wildfires. This requires post-disturbance measures of scorch effects on understory and overstory plants immediately after the fire.

Initiating research early is essential for quantifying the dispersal mechanisms used by organisms in ecological recovery. It's also valuable for determining the extent to which biological legacies influence ecological recovery and alter the nature of the post-disturbance environment. For example, early post-disturbance studies following the 1988 Yellowstone wildfires and the 1980 Mount St Helens volcanic eruption led to the recognition of rapid 'nucleated' recovery from within the boundaries of disturbed areas, rather than from dispersal of propagules originating from outside the disturbance perimeter.

Prompt initiation of research is essential for quantifying how immediate post-disturbance conditions shape the trajectory of succession and ecosystem recovery. It's also crucial for understanding the importance of early successional environments, given that some species are found exclusively or primarily in such places.

Early initiation of scientific studies after major natural disturbances can also lead to ecological 'surprises'. After the 1988 Yellowstone wildfires, for example, quaking aspen trees established by seed rather than via clonal root sprouting in some areas. Other plant species exhibited different regeneration strategies in the post-fire ecosystems as compared with those in fire-free areas .

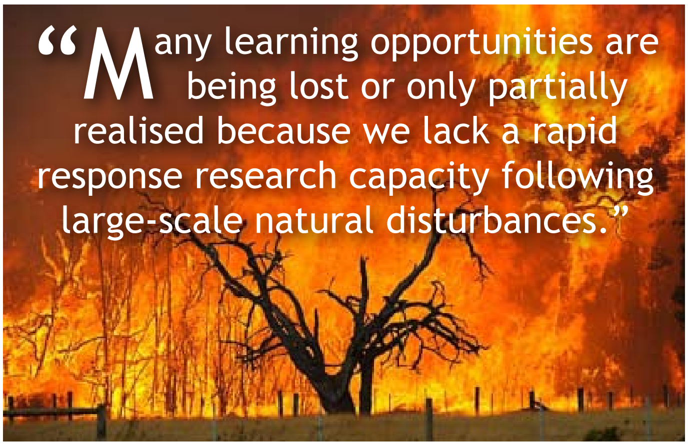

Photo by Phil Gibbons

Research conducted immediately after a wildfire in 2003, in NSW's Booderee National Park, revealed that the highly endangered eastern bristlebird, which was previously thought to be highly fire-sensitive, recovered quickly after the conflagration. Populations of this avian species proved to be more sensitive to predation by feral animals, such as the red fox, rather than vulnerable to the effects of wildfire, as suggested by earlier investigations.

"If we are to realise the learning opportunities that follow major disturbance events, we believe three things need to happen," says Lindenmayer. "First, funding programs need to be established specifically to support studies of ecosystem recovery after such disturbances. Dedicated post-disturbance research programs are essential, because research funding during the immediate post-disturbance period can be difficult to obtain in a timely fashion.

"And researchers need to do some thinking on the kinds of opportunities that might arise following a disturbance, even if the timing of that event is unknown. Anticipation of, and scientific planning for research before major natural disturbances could improve the ability to capitalise on the research opportunities that major disturbances provide. Scenario planning, for example, can be used to create generic plans for rapid ecological research responses, particularly in disturbance-prone areas.

"Support for research planning before an event is extremely rare in the field of ecology, but is well established in other fields, such as management of pandemic human diseases and human aid relief after natural disasters. Thus, despite uncertainties in the timing, precise location, and severity of future disturbances, advance planning can produce hypotheses and appropriate sampling designs, and will reduce the chances of implementing poorly conceived studies.

"And finally, creation of scientific infrastructure dedicated to disturbance-related research is another way to improve our ability to study major natural disturbances. This proposal is similar to investing in infrastructure to fight wildfires or monitor earthquake activity and tsunamis."

Lindenmayer and colleagues believe that the need to improve our capacity to initiate rapid, post-disturbance studies of ecosystems – and, where appropriate, to sustain those studies for long periods – is pressing. This is especially so given forecasts of increased disturbances (both in number and frequency) related to climate change. Programs are needed that will provide financial resources promptly after disturbances, will support development of research response plans and teams before major disturbances, and will fund the acquisition and operational support infrastructure.

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

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Deciding on boundaries

Efficiently locating conservation boundaries

Conservation managers are obsessed with boundaries. Boundaries define the extent of a new animal disease; the remaining distribution of an endangered species; and the burgeoning spread of an invasive pest. Boundaries are therefore crucial tools for management. If you don't know where a boundary is, it becomes much more difficult to know where to act. George Goyder famously demonstrated this in 1865, by presciently identifying the transition in vegetation between mallee scrub and salt-bush as the furthest extent of South Australia's arable land.

Conservationists inherited their boundary obsession from biogeographers, who are fascinated by the abrupt demarcations between biological provinces (an example being Indonesia's Wallace line which separates the Asia and Wallacea ecozones). However, while ocean straits mark the Wallace line, and Goyder was able to identify his boundary by visual inspection, other boundaries can be quite difficult to spot, and this is often the case in threatened species conservation. Rare and endangered species can be difficult to find, and their ranges are often quickly contracting, or shifting in response to a variable environment.

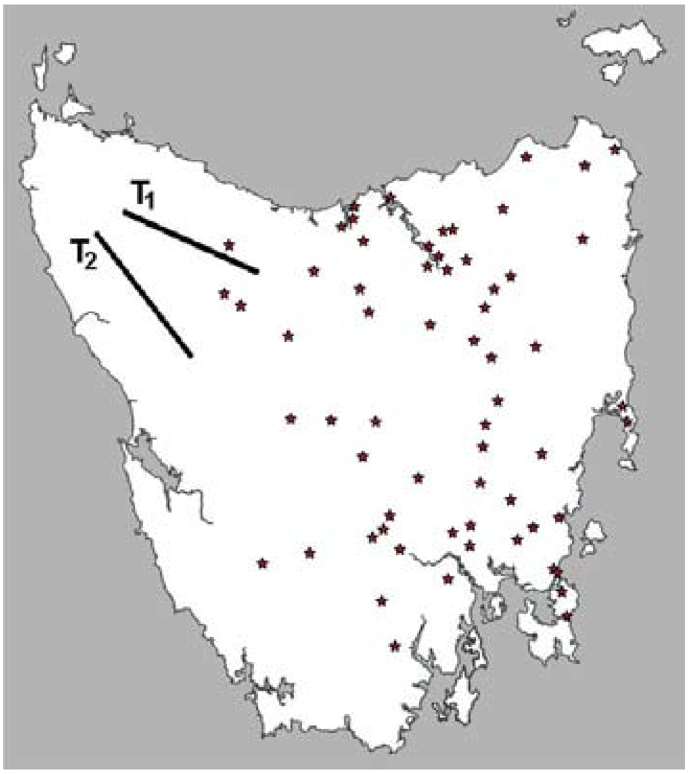
Ecologists have developed a set of tools capable of locating cryptic boundaries, and these have been adopted by conservation scientists. Unfortunately, their approaches don't consider the crucial issue of efficiency (eg, cost-benefit). For example, to find the boundary that represents the extent of an endangered species' range an ecologist would draw a transect between somewhere the species is known to be, and somewhere it's known not to be. They then survey at equal distances along that transect. This might be okay if you can afford to undertake twenty surveys, but what if you can only afford two? Sampling isn't cheap, particularly if a manager needs to find multiple boundaries over large areas (such as is the case for a set of invasive species).

Further, these methods don't have clearly stated objectives. This is a problem because we need different boundary location methods for different jobs. For example, when drawing a line around a threatened species, we want to know where most of the individuals are. If that line excludes a single individual in a remote area, that might not be a huge problem. On the other hand, if we're trying to contain the outbreak of an invasive species, we want to be sure that every pest individual is included within our boundary. To begin to understand how clear objectives and constraints should be incorporated into conservation boundary location, AEDA has recently published research on how one could go about efficiently locating conservation boundaries.

Putting a boundary on DFTD

"The idea of efficiently locating boundaries arose from discussions about the Tasmanian Devil," explains Dr Michael Bode, lead author on the research. "The Tasmanian devil suffers from a lethal infectious cancer known as Devil Facial Tumour Disease (DFTD). The disease was first seen in the north-east of Tasmania, and quickly spread down the entire east coast. At present, it's moving west across the island's north coast.

> "A false-negative is going to make you believe you're in a disease-free region, when you're actually behind the front.



So where's the disease front? The map above shows verified cases of DFTD in Tasmania. It represents the known information about the extent of the disease. The two black lines in the north-west of the island represent example transect locations, along which managers will send trapping expeditions to search for infected devils.

"Hamish McCallum, an expert on DFTD, has calculated that if current trends continue the whole island will be infected by 2013. What's more, without successful intervention, there's a strong possibility that the wild devil population will be extinct within the next 30 years. As a consequence, it's now listed as Endangered – and this was a species that was in robust shape until this decade. On the mainland, this would be like seeing the Brushtail Possum on the IUCN Red List.

"One response has been the creation of insurance populations on offshore islands called 'ark' populations – using individuals from uninfected regions. Because infected animals are not immediately symptomatic, the only safe source of devils is the regions that are not yet infected, and so it's critical to locate the boundary between uninfected and infected animals: the 'disease front'. The ark managers need to know where this boundary is so that they can source devils from as large an area as possible, to increase the genetic variability of the populations."

Some boundaries are obvious. Many conservation related boundaries aren't so easy to spot.

The Tasmanian devil disease is a new disease, an infectious cancer, that is restricted to Tasmanian devils. No affected animals were reported among the 2000-plus Tasmanian devils trapped by wildlife biologists between 1964 and 1995. Once the cancer becomes visible, it always appears to be fatal - usually within three months. Small lesions, or lumps, in and around the mouth quickly develop into large tumours on the face and neck (and sometimes other parts of the body). Tasmanian devils with facial tumours find it difficult to eat. Death results from starvation and the breakdown of body functions.
More info: http://www.tassiedevil.com.au/

A framework for setting a boundary

So locating the disease front is a critical management task. However, as is usually the case, there's only a limited amount of resources available to send out trapping expeditions to search for this conservation boundary.

"It's a wide front," says Bode. "They can probably only afford to send out two trapping expeditions per transect. So, to assist them we've devised a decision theory framework to efficiently guide sampling for the disease front. The method we've applied used dynamic optimisation techniques within a Bayesian framework.

"Ecologists are interested in accuracy, not cost-effectiveness. So we needed to devise new methods. We realised that managers weren't going to be able to zero in on the boundary with unlimited surveys. They needed to reduce the uncertainty as much as possible, given the surveys they could afford."

And there are other complications besides the funding constraint. If the disease has just reached an area, it's not going to be immediately obvious.

"To begin with, the symptoms don't show themselves for a couple of weeks at least, probably months," explains Dr Brendan Wintle, a co-author on the research. "On top of that, if the disease has only just reached a population, and only one or two individuals in a population are sick, you might survey at a location and not trap those few infected individuals. This sort of false-negative is going to make you believe you're in a disease-free region, when you're actually behind the front.

"A decision-theory approach lets us take this probability

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Boundary comparison

So how else might you figure out where the disease front is? The Australian Veterinary Emergency Plan advises that to determine the extent of disease spread: "animals could be sampled in a radial pattern, at fixed distances from the known infected location".

Since the restricted budget of the devil managers only allows for two trapping expeditions along each transect, where would they choose to make them using this approach? Logically you might reasonably choose the 99% confidence interval of our prior distribution (13 km west of the site of known infection), and halfway to this point (6.5 km west). The researchers simulated this approach (and called it the "fixed-distance" approach to front location).

The manager's uncertainty can be measured by the standard deviation of their belief distribution. The smaller the standard deviation, the more they know about the location of the disease front. The researchers found that the posterior belief distribution that results from using the fixed-distance approach has an expected standard deviation of r = 1.81, reduced from r = 2 (the standard deviation of the original belief distribution).

In comparison, for the same sampling budget the decision theory approach yields an expected belief distribution with an expected standard deviation of r = 1.65, a substantial improvement compared with a fixed-distance approach. (These results are based on expeditions that trap 20 devils over 5 trapping days.)

This sort of analysis demonstrates another benefit of a decision-theory approach to boundary location. It allows you to compare the benefits of alternative strategies. In doing so, managers can compare the benefits of different samping budgets. For example, the current budget allowed for sampling the DFTD front will reduce our uncertainty about the location of the devil front by approximately 17%. By predicting the likely outcome of optimal trapping, managers can decide whether the budget allocated to boundary detection is sufficient to achieve their desired goals.

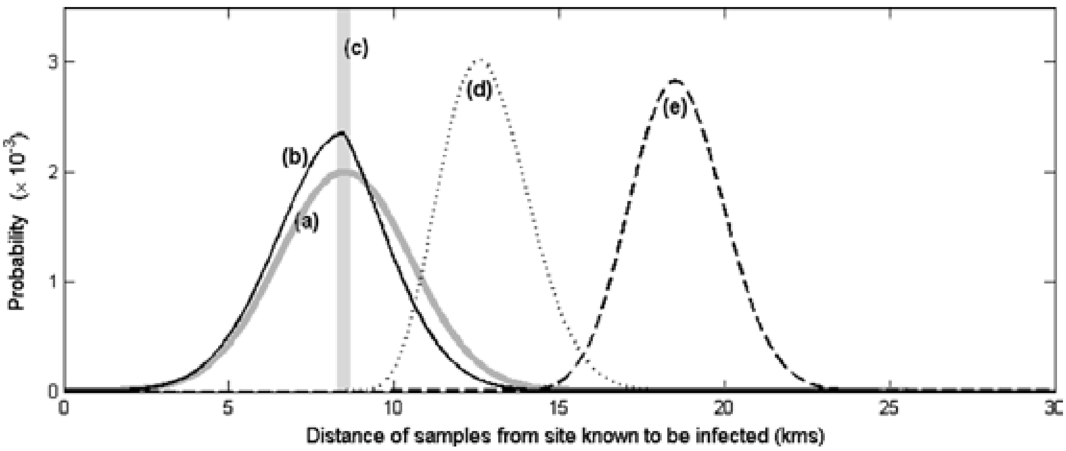

Figure 2: Belief distributions before and after a single trapping expedition. The informative prior distribution is indicated by the thick grey line, (a). The single trapping expedition took place 10 km from the known extent of the disease, indicated by the vertical line, (c). The dotted line, (d), indicates the posterior belief distribution if 5 of the 25 trapped devils were infected. The dashed line (e) indicates the posterior belief distribution if all the trapped devils were infected. The solid line (b) indicates the posterior distribution if no diseased individuals were trapped.

Deciding on boundaries

(Continued from page 7)

into account. It also allows us to synthesise the sampling data with our previous observations about the disease spread. It's a solid framework within which to apply optimisation techniques that ensure the surveys minimise your uncertainty given your constrained resources."

Efficient searches

Efficiently searching for ecological boundaries is conceptually quite simple. Given the speed at which the disease has spread over the last couple of years, there is *a priori* information available about where the front is likely to be. Each of the survey expeditions is then going to yield more information about the front location. If we sample a location, and it contains a large proportion of infected devils, it's likely to be a long way behind the front. If there are only a few infected animals, it's probably closer to the boundary.

"But you have to be careful." says Dr Tracy Rout, another author on the paper. "You don't necessarily want to send a trapping expedition to the boundary itself. It's unlikely that you'll find an infected animal, because the disease hasn't had much time to infect a lot of devils. You're probably going to only catch uninfected animals, but that's not going to reduce your uncertainty much, because you don't know whether there aren't any infected animals there, or if you just didn't trap any of them."

The decision-theory method considers the influence of each of these issues, then searches through all the possible sampling methods, searching for the most effective decision.

"One of our key findings is the importance of being adaptive," emphasises Bode. "You don't send out your sampling expeditions to pre-arranged locations on the transect, which is what most current methods recommend. Instead, you only decide where the second trapping expedition should go after you see the results of the first

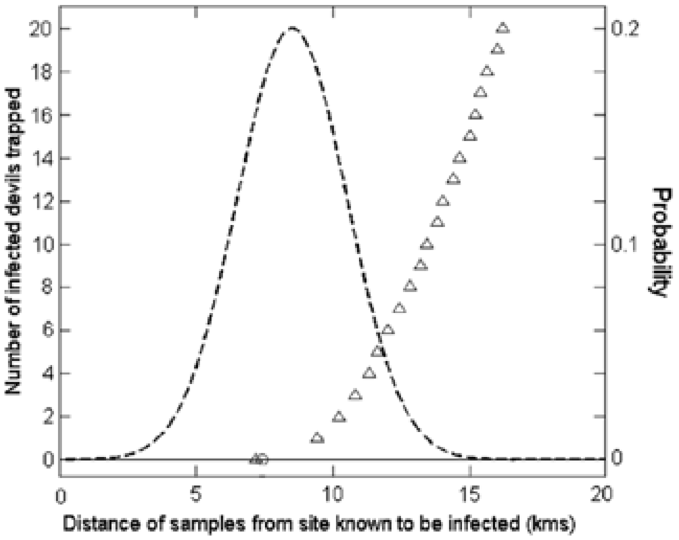

Figure 3: Optimal location for the two trapping expeditions. The dashed line shows the prior belief distribution (scale at right) of the front location; the most likely front location is 8.5 km from the site of known infection. The first trapping expedition is sited at the solid markers below the x-axis. The site of the second expedition depends on how many trapped individuals were diseased, indicated by the markers (scale at left). Triangles correspond to high devil density (we expect to catch 20 devils), circles correspond to low density (we expect to catch five devils). For example, if we caught 20 devils, of which 15 were diseased (indicated by the arrow), we should site the second trapping expedition at 15 km from the site of known infection. If only two were diseased, we would site the second expedition at approximately 10.5 km.

expedition. Your subsequent decision will not just depend on whether you observe the disease or not, it will be influenced by how many infected animals you sample."

> "Our conservation decisions are going to be scrutinised very carefully if the devil goes extinct in the wild. Transparency and defensibility are almost as important here as cost-effectiveness."

Beyond the devil

"Our results show that, given a fixed budget, applying a decision theory approach yields a more precise understanding of the front location," says Wintle. "However, such an approach has several other benefits as well.

"A decision theory approach gives decisions that can be rationally defended, and they're based on our best current understanding of the ecological situation. We don't waste any information.

"Also, weighing up the value of different survey results is very hard to do intuitively. For example, trapping infected individuals is more useful than sampling only uninfected, because of the detectability issue. If intuitive sampling decisions made by different experts conflict, it's difficult to determine what factors have driven the divergence of opinion. If you spell everything out mathematically, everyone is on the same page, and it's easier to identify where people disagree."

Bode and colleagues are quick to acknowledge the DFTD boundary problem is a simple example of how this method might be applied but that the lessons are equally valid for more complex situations.

"In reality, ecologists and conservation biologists routinely deal with more complicated problems," he comments. "For example, a transition of interest might be between habitat types defined by multiple factors. The cost of sampling at different locations may also vary, depending on road proximity, or the negotiability of the terrain.

"However, despite the resultant increase in complexity, these factors should still be dealt with in a decision theory framework. Actually, the more complicated the problem, the more important it is that you approach it using a rigorous, transparent framework."

"Faced with increasing complexity, intuitive approaches become less justifiable. The ability of a manager's ecological (and economic) intuition to optimise complex, sequential and uncertain boundary location problems is severely limited."

In the case of the Tasmanian devil, Australia is faced with losing one of its most iconic and recognisable species of wildlife. The species is considered charismatic on a global scale, and despite our best efforts, the population is still dropping precipitously.

"Our conservation decisions are going to be scrutinised very carefully if the devil goes extinct in the wild," predicts Wintle. "Transparency and defensibility are almost as important here as cost-effectiveness."

More info: Michael Bode <bodem@unimelb.edu.au>

Reference

Bode M, C Hawkins, T Rout, B Wintle (2009). Efficiently locating conservation boundaries: Searching for the Tasmanian devil facial tumour disease front. *Biological Conservation* 142: 1333–1339.

CATERing for multiple values

Carbon sequestration & biodiversity conservation

By Rod Fensham (Qld Dept of Environment & Resource Management / Uni of Qld)

The Queensland Government has established CATER (Carbon Accumulation Through Ecosystem Recovery) to facilitate carbon sequestration through the recovery of natural ecosystems. Queensland has large areas that have been recently cleared that could be restored with active and sensitive management to allow existing trees and seed-banks to regenerate.

Carbon sequestration is compatible with native ecosystem recovery because the native tree species are best adapted to local site conditions and will be most robust in the face of climate, pest and fire. The value of regrowth vegetation is heightened because it will be cost-effective relative to tree planting in most instances. Furthermore, native ecosystem recovery represents an outstanding opportunity to restore fragmented landscapes and recover biodiversity. Restoration is also critical for building the adaptive capacity of ecosystems to climate change impacts.

International markets will be responsive to the opportunities for sequestration with cost-effective and biodiversity-friendly projects that are secured by adequate regulation. With CATER and a price on carbon, regional economies in Queensland will have the opportunity to diversify their economic base.

The project will deliver web-based information showcasing this outstanding opportunity. The CATER web-site will provide carbon forecasts, management prescriptions and define the biodiversity value of ecosystem restoration projects.

The Federal Government has an existing carbon forecasting facility, the National Carbon Accounting Toolbox (NCAT), which will support the proposed Carbon Pollution Reduction Scheme (or its next incarnation). Carbon forecasts for ecosystem restoration, required for CATER, will be delivered by the NCAT web-site that is currently being upgraded to provide user-friendly (Google Earth style) and spatially explicit forecasts for carbon sequestration on lands suitable for reforestation. Over the next few years, comparisons of modelled predictions and measured biomass across the range of Queensland ecosystems are likely to improve the accuracy of carbon forecasting.

CATER will provide prescriptive advice on fire management, optimal planting strategies (where this activity is necessary), grazing management and weed control for both carbon and biodiversity outcomes. In fire-sensitive ecosystems such as the brigalow forests that extended over 14 M ha, grazing for fuel reduction will be part of an optimal management strategy. Management prescriptions will support the planning and approval phase for carbon offset projects and the regular reporting and compliance required by a regulated carbon market.

An exciting collaboration between the Qld Department of Environment and Resource Management, University of Queensland and CSIRO will evaluate the geography of ecosystem restoration that maximises carbon compared to restoration that maximises biodiversity outcomes. The approach will use information on the biomass potential of ecosystem types, the opportunities of agricultural production that are forgone, the price of carbon, the net management cost of restoration and the biodiversity values of Queenslands' ecosystems. By identifying the spatial trade-offs that exist between carbon and biodiversity goals, we will be able to answer such questions as – is the most cost-effective carbon sequestration in the mulga, the box woodlands, the coastal eucalypt forest or the rainforest?; and if it is in the mulga, how much resources or efforts will it take to deflect restoration to the rainforest where biodiversity gains might be more substantial? This information will be useful for investors, governments, NGO's and regional planning groups, to make decisions about where and how to restore native ecosystems.

Carbon sequestration is compatible with native ecosystem recovery because native tree species are best adapted to local site conditions and will be most robust in the face of climate, pest and fire. This image shows regrowth of native tree species intermixed with exotics in the Wet Tropics of north Queensland. (Photo by Heather Proctor)

Management advice will be founded on the best available science through consultation with land-holders and other management practitioners.

International voluntary carbon markets already pay a premium for projects accredited for their biodiversity benefits (see for example http://www.climate-standards.org/). The outputs from CATER will provide a mechanism for carbon and biodiversity market operators to combine the sequestration of carbon with biodiversity conservation in the design of offset projects. It is hard to imagine a more efficient means of delivering environmental outcomes than by topping-up carbon investments to ensure that ecosystem recovery occurs where it is most needed.

The CATER web system will present and account for biodiversity gains from ecosystem restoration. This will be underpinned by the regional ecosystem mapping and will define the value of restoration in terms of habitat for threatened species and fragmented landscapes. It will deliver photographs and information on relevant species and ecosystems, as well as providing an objective metric for biodiversity.

CATER will engage with ecologists, planners, policy makers, land managers, and land holders, and will foster cogent research activities amongst them. The broad scope of activities delivered by CATER, the great breadth and ecological importance of ecosystems in Queensland, and the urgent need to improve our ecological knowledge ensures plenty of scope for exciting new projects.

CATER presents opportunities for PhD students through the Ecology Centre at the University of Queensland. There are many exciting projects compatible with CATER's broad agenda and top-up funding will be available for students eligible for APA scholarships.

More info: Rod Fensham <r.fensham@uq.edu.au>

Reference

Fensham RJ & GP Guymer (2009). Carbon accumulation through ecosystem recovery. *Environmental Science and Policy* 12: 367-372.

Note: CATER is not connected with AEDA. Decision Point, however, regularly features the work of other groups where that work contributes to improved environmental decision making.

Beyond the science

Collaboration can benefit science and practice

Collaborative projects between researchers and policy makers can be an efficient and rewarding way for science to influence decision making while producing real conservation outcomes. These relationships provide practitioners with the best scientific knowledge and frameworks while scientists learn about the real world of practice. In this article, scientists Liana Joseph, Carissa Klein and Hugh Possingham from the AEDA hub at the University of Queensland, and practitioners Belinda Mellish and Richard Maloney from the Department of Conservation, New Zealand, reflect on the lessons coming out of their collaborative project on prioritisation.

New Zealand's South Island saddleback. It's believed there are only 650 birds left in this population. How do you weigh up the cost of conserving this bird against the needs of the 2,000 other endangered species? (Image by James Watson)

The problem

New Zealand, an island nation with high levels endemism and diversity, has a major conservation challenge. There are more than 2000 species listed as threatened. More than 300 of these are critically endangered (with fewer than 250 individuals and numbers declining). Tragically, the resources available are not sufficient to do all of the management that is required to recover these species. Of the 2000-odd species listed as threatened only 188 species (under 10%) are under some form of active management within the threatened species work area.

The decision making to manage these particular 188 species has been informal and has not been guided at the national level. In the past, most management on threatened species in New Zealand has been pursued by local managers without a clear and supported national strategy. Therefore, priorities have not been consistent across regions. In addition, the selection of priority management actions amongst the unlimited possible choices has not been transparent or declared.

Recovery plans for New Zealand's threatened species have been a useful tool for the guidance of management at a national level. These plans have stimulated cooperation between stakeholders and the collation of information and facilitation of learning about threatened species. However, the recovery plans do not:

(1) offer consistent, transparent or declared out-put driven objectives;

(2) compare management projects among species and identify management priorities that will maximise the conservation outcomes for the nation for a particular budget;

(3) successfully engage and facilitate ownership and acceptance among practitioners or integrate priority actions into existing business plans to allow for transition to new management areas.

Because of this, much of the priority actions outlined in New Zealand's threatened species recovery plans are not nation-level management priorities nor have many of the actions been successfully implemented.

Over the last decade the Department of Conservation has invested resources into developing scientific tools to help address this problem. Many of these tools were technically savvy and included smart scientific thinking. However, for a variety of reasons, they have failed to make any significant difference to on-the-ground conservation actions of the department. Central to these reasons is the difficult nature of changing the culture of an organisation, at all levels, to trust priorities driven by new tools and to support the transition to new work at an operational level.

> "Using a Cost-Effectiveness Analysis to rank management projects it is possible to effectively manage 300 species more than are currently being managed with the same conservation budget."

Richard Maloney, Belinda Mellish and others at the Department of Conservation were looking for a framework to identify management priorities that would help to conserve the greatest number of threatened species in New Zealand with the budget they had available. It was critical that this framework also enabled them to address the cultural change and organisational process issues required for successful implementation.

The scientific solution

Cost-Effectiveness Analysis (CEA) is a framework for ranking management projects by their cost-effectiveness – that is, the projects that are ranked highest are those with the largest conservation outcomes per dollar. The concepts are basic – we all use Cost-Effectiveness Analysis to make purchasing decisions every day. For example, if we want to purchase a bag of sugar we will consider the quantity, the quality and the price of the sugar. We will base our decision about which bag to purchase on some combination of the quality and quantity divided by the price to give as a measure of benefit per dollar.

This is not a new science or a particularly complicated one. Indeed, it's been used by the medical practice for nearly 50 years but has only recently been applied to problems around the allocation of scarce conservation resources. And because it's new to conservation, new methods were required for calculating quantity, quality and costs that are relevant to management. This is where the real scientific developments of our project have been made. We developed an operational protocol for estimating the information that's required to carry out a Cost-Effectiveness Analysis for threatened species management. Defining the management objectives, the benefits and costs of the management and the probability of management success has required an understanding of population dynamics and extinction ecology, biogeography, systematic, economics and probability theory.

The Department of Conservation required a framework for identifying national level management priorities that would help to conserve the greatest number of unique threatened species with the budget they had available. The solution that we developed is called the Project Prioritisation Protocol. It's a recipe for collecting the information required to carry out a Cost-Effectiveness Analysis for threatened species management.

The Protocol consists of nine steps and results in a rank ordered list of management projects that will deliver the greatest conservation outcomes with the available resources. (See the box on the nine steps. Also see *Decision Point #29* for discussion on the science behind PPP). We've demonstrated that by using a Cost-Effectiveness Analysis to rank management projects it is possible to effectively manage 300 species more than are currently being managed with the same conservation budget. Similarly, ranking management projects by their cost-effectiveness resulted in managing considerably more species for any budget than if species were prioritised solely on their value or threat status.

The project-management contribution

Developing a working Cost-Effectiveness Analysis, collecting the data for 680 species and calculating a rank ordered list of management priorities was only one aspect of the solution that we needed for the management problem that existed in New Zealand. The critical part was ensuring that the new, efficient management priorities were accepted by the Department. To do this, we needed to ensure that other needs were taken care of. These can be categorised as cultural change and organisational needs, and consist of work such as getting support from upper management, involving and giving ownership of the process to operational and scientific staff, and ensuring there is confidence in the data that we collect.

In many cases, having strong scientific basis for the methods that we used and support from the scientific community (eg, peer review and a large body of research on which we base our study) strengthened our ability to

"The critical part was ensuring that the new, efficient management priorities were accepted by the Department."

execute these dealings. However, the majority of our job was to ensure that the people that will fund or implement the management priorities understand and are confident and supportive of the new strategy.

The use of 'translators' sitting in a development team within the department was fundamental in enabling engagement within the Department, and with the scientific community. In order to communicate and imbed a scientific solution in our organisation, the translators must understand the science and tools, the organisational structure and culture, and organisational business processes. For this project, the translators spent over three quarters of their time on cultural change and organisational work, and less than a one quarter on technical solutions.

Developing clear and agreed goals for biodiversity work was a key step in the practical solution. It quickly became apparent to the development team that for the Department to support a change to the way threatened species work is prioritised, it needed a clear goal structure across all of the Department's work. This is important because it shows how threatened species work aligns to other biodiversity priorities (nationally important ecosystems, locally important biodiversity and iconic biodiversity), and how these priorities align with the rest of the department's work (recreation, historic sites, engagement with NZders and business opportunities). Building this framework took over

(continued on page 12)

Nine steps to PPP

The Project Prioritisation Protocol consists of nine steps:

Step 1: **Define objectives:** Determine the specific goal(s), and define terms within each goal.

Step 2: **List biodiversity assets:** Identify the assets of interest for each goal; eg, threatened species.

Step 3: **Weight assets:** Calculate the relative value of these assets if required.

Step 4: **List management projects:** Identify the set of feasible projects that achieve the objective.

Step 5: **Estimate cost:** Calculate the costs of each project.

Step 6: **Estimate benefits:** Predict the benefit to species generated by each project.

Step 7: **Estimate likelihood of success:** State the likelihood that each project will succeed.

Step 8: **State constraints:** Identify constraints on the projects and the total budget.

Step 9: **Choose set of projects:** Combine information on costs (C), values (W), benefits (B) and likelihood of success (S) to rank projects according to benefits per unit dollar (E):

$$E = \frac{W \times B \times S}{C}$$

For example, for the NZ Department of Conservation threatened species prioritisation process, experts were asked to design a management project for each species (including intervention actions and outcome monitoring) to meet the objective of securing the species over a 50 year time period. Expert opinion and data from DoC records were then used to estimate values for costs (C), benefits (B) and likelihood of success (S) of these projects. An example of 5 species projects are summarised in the table below.

In this example, the management project for the New Zealand carrot has the largest project efficiency value and therefore is ranked the highest. This management project is extremely cheap, has a large benefit and a high probability of being successful. Compare this with the management project for the long-tailed bat which is 40 times more expensive and has a very low probability of being successful.

Project	Cost *C*	Benefit *B*	Success *S*	Weight *W*	$E = \frac{W \times B \times S}{C}$
New Zealand carrot	$471,547	0.85	1	0.5	900×10^{-9}
Maud Island frog	$2,303,685	0.55	0.80	1	190×10^{-9}
Robust grasshopper	$14,598,136	0.75	0.99	1	51×10^{-9}
Kermadec Petrel	$3,612,270	0.95	0.99	0.1	26×10^{-9}
Long-tailed bat	$19,109,288	0.90	0.2	1	9.4×10^{-9}

Beyond the science

(Continued from p11)

a year to complete and involved conversations across all areas of the Department to ensure it would be supported.

Any successful change in priorities to conservation work on the ground, must be supported by the practitioners who carry it out. This was helped through the use of the Project Prioritisation Protocol, which enabled expert-driven data to be used. Through involving practitioners in the building of the base data set, they gain trust in the process and the outputs it will produce. This data collection was run in two steps: (1) Species experts identified populations for management in order to reach the conservation goal and described the required management intervention (2) Local practitioners determined dollar costs for this work, assessed its feasibility and made changes to the locations and management where appropriate. Many additional meetings and discussions were held to build understanding of the process to ensure it would succeed. In total over 80 meetings were held to build the species data set.

Addressing organisational process changes were just as critical as any other part of the project. New priorities and work-plans may be developed but if they don't fit within funding, planning, monitoring and reporting processes of the organisation they can't be used. In this project the development team spent a significant amount of time ensuring alignment with these processes through engagement with the people who manage those processes and through adapting work-plan structures to ensure they mesh at all points.

The Department of Conservation is also developing priority work plans for New Zealand's ecosystems, and will begin transitioning to new work priorities from 2011.

Reference

Joseph LN, RF Maloney & HP Possingham (2009). Optimal allocation of resources among threatened species: a project prioritization protocol. *Conservation Biology* 23:328-338.

The Benefits Table

Scientists benefit from

- access to data and conservation based publications
- an understanding of the institutional and political processes behind conservation
- support and conversations with smart, knowledgeable and engaged people
- the knowledge that they are part of a solution that is having a positive effect on the conservation

Practitioners benefit from

- strong science to support management decisions
- evidence that the decisions are of a high standard by publications in scientific journals and peer review
- support and conversations with smart, knowledgeable and engaged people

Do you want one of these too?

Do you have a conservation problem that would benefit from a science-practice collaboration like this one?

AEDA and the New Zealand Department of Conservation are keen to develop more collaborative relationships. Contact us to discuss conservation science and practice collaborations.

More info: Hugh Possingham - h.possingham@uq.edu.au
Richard Maloney - rmaloney@doc.govt.nz

Decisions in the supermarket

(and you thought you were making them)

The supermarket might look like a safe place to shop but it's actually a highly sophisticated exercise in marketing psychology.

Did you know that:

- shoppers look at the middle of shelves at eye level, and then 40 degrees up and 10 degrees down. The products that make the largest profit margin can be found within this range;
- in the US, shoppers who travel in anti-clockwise direction will spend, on average, two dollars more per trip then clockwise shoppers (and therefore many supermarkets encourage an anti-clockwise flow);
- the ends of each aisle are the most profitable part of the store;
- the colour blue encourages the release of trust hormones;
- essential items like bread and milk are placed at the back of the store to entice shoppers to buy other items on the way (you probably have noticed this particular trick).

All this and much more is revealed in the April issue of *Choice* magazine http://www.choice.com.au/

Decision Point

Decision Point is the monthly magazine of the Applied Environmental Decision Analysis (AEDA) research hub (see below). It's available free from our website. You can also subscribe to an email alerting you to new issues as they are released at http://www.aeda.edu.au/news

Decision Point is written and produced by David Salt. If you have news or views relating to AEDA or of interest to AEDA members, please send them to David at David.Salt@anu.edu.au

When we print out ***Decision Point*** we use recycled paper. We hope you will too.

αεδα

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Australian Government
Department of the Environment, Water, Heritage and the Arts

The University Of Queensland Australia

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