AEDA News

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Applied **E**nvironmental **D**ecision **A**nalysis
A Commonwealth Environment Research Facility

Smart science for wise decisions

Issue 9 (Monday, 24 September 2007)

AEDA News is a fortnightly newsletter for members and associates of the Applied Environmental Decision Analysis CERF Hub.

In this issue

For more information about AEDA, please visit our website at
www.aeda.edu.au/

What is adaptive management?

Most agencies are not engaged in active adaptive management

Many natural resource management agencies have embraced the principle of 'adaptive management', but what does that phrase really mean. If we rush to *Google*, the source of all knowledge, then near the top we find a quote that represents what most of these organisations mean:

"Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of programs in action. " *Coastal CRC web site http://www.coastal.crc.org.au/amf/amf_index.htm accessed Sept 2007.*

This is agency speak for – if we learn something relevant to how we manage an environmental system then we will review and possibly modify our actions. Arguably, adaptive management in this context is simply 'common sense', who wouldn't change their behaviour if they learnt something new? My pet rat does that on a daily basis.

From an agency perspective, however, this is an important statement that they are not fossilised and ground down by institutional inertia, but they are willing to change as new scientific evidence emerges. Surprisingly this is not adaptive management as it was originally intended, this is passive adaptive management.

If we now turn to the second source of all wisdom, *Wikipedia*, we discover another definition of adaptive management:

"Adaptive management, also known as adaptive resource management, is a structured, iterative process of optimal decision-making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision-making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. Adaptive management is often characterized as "learning by doing."" *Wikipedia: http://en.wikipedia.org/wiki/Adaptive_Management*

"Most agencies do not comprehend this subtle difference and are not engaged in active adaptive management."

I refer to this as active adaptive management because it implies we don't just do what maximises our short-term benefit. Instead we invest in manipulating and

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What is adaptive management
continued

monitoring the system to learn more about it. While this incurs a short term cost, it enables better management in the long term. Most agencies do not comprehend this subtle difference and are not engaged in active adaptive management.

Strangely enough it is also common sense to sacrifice some short-term gain for knowledge that will facilitate better long-term management. My pet rat also knows this – he explores his environment, at some risk to safety and some energetic expense, and will adapt his behaviour if new profitable food sources emerge. People and rats have evolved to be curious – we are, by nature, active adaptive managers.

Despite the logic of active adaptive management, the big question remains: how much effort should we spend on learning and manipulating systems to better parameterise them and understand how they work? AEDA has some of the leading thinkers in this area along with colleagues at The University of British Columbia and US Geological Survey scientists at Patuxent. Our recent paper (McCarthy and Possingham, 2007 – see a description of this paper in the new publications section in this newsletter) is at the cutting edge of building a quantitative theory of active adaptive management.

Unpacking the complexities of active adaptive management is one of the challenges AEDA has set itself. This is essential as active adaptive management will increase the effectiveness and efficiency of natural resource management. We hope to make the general concept, and the computational complexities, more accessible to practitioners throughout the life of our research program.

If you'd like to a bit of background reading on the topic of active adaptive management I'd recommend the following two papers (and the McCarthy and Possingham paper described in new publications, see page 6):

Shea K, Possingham HP, Murdoch WW, and Roush, R. (2002). Active adaptive management in insect pest and weed control: Intervention with a plan for learning. *Ecological Applications* 12:927-936.

Shea K. (1998). Management of populations in conservation, harvesting and control. *Trends in Ecology and Evolution* 13: 371-375.

Hugh Possingham
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Editor's Note: AEDA News *would like to report that the pet rat cited in this editorial was at the time of preparing this issue almost eaten by a four foot carpet python that pried open its cage. The snake was beaten off with a stick by Hugh's teenage daughter. Which just goes to show that even the best active-adaptive-management approach to life can sometimes fail in the face of unexpected events (especially when those events are rare). How you plan for quantifiable random events (like being eaten by a snake), unquantifiable random events or even events that you may never have thought of is another important aspect of decision theory that we'll deal with in a future issue of AEDA News. While the rat was shaken by this experience it's expected it will make a full recovery.*

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Making conservation science relevant

Simon Linke is Riversymposium's Young Water Scientist Award 2007

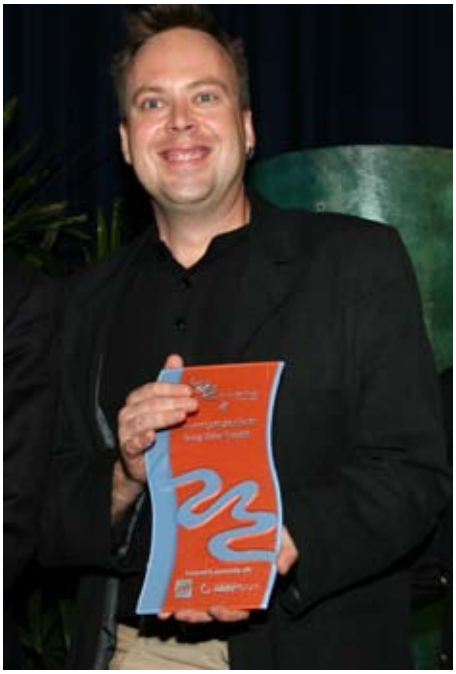
A new way of prioritising freshwater rivers for restoration and conservation has won Simon Linke the Riversymposium Young Water Scientist Award for 2007.

Simon is a member of the Spatial Ecology lab at the University of Queensland, and is part of the eWater CRC research team on landscape analysis. He's also a member of AEDA.

"it's about creating compromises between the conservation of native biodiversity while minimising the impact on other stakeholders such as irrigators or graziers"

He won the award for his research on identifying endangered freshwater systems of high conservation value. This research has been turned into an interactive software package to analyse and help identify freshwater rivers in danger, whilst providing suggestions of ways land owners and managers can manage their land to achieve the best environmental outcomes. Similar systems have been used in the NSW forest agreements and the re-zoning of the Great Barrier Reef Marine Park, but are new in rivers.

"My research is about creating compromises between the conservation of native biodiversity while minimising the impact on other stakeholders such as irrigators or graziers," says Simon. "It's about getting the best bang for your buck in terms of environmental investment.



Simon with the Young Water Scientist Award.

"I am particularly thrilled that I am the first ecologist to ever receive the award. It shows that the discipline of conservation biology is now up there with engineering and hydrology in terms of science and stakeholder relevance."

The Award, worth $3000, is sponsored by GHD and the Water Forum CRCs.

"Simon's research comes at a particularly interesting time, when the water industry is looking for tools to help it provide effective support for the environment," says Professor Gary Jones, eWater CRC Chief Executive.

A prototype for the software is currently being developed and discussions are being held with several state and regional bodies such as Brisbane City Council, the NSW Environmental Protection Authority as well as interest from international institutions from the USA and South Africa.

More info: Simon Linke <simon.linke@gmail.com>

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Beating exotic weeds with natives

Jennifer Firn wins the 2007 Science & Innovation Award for Young People in Agriculture, Fisheries and Forestry

In the war on exotic weeds, Australia's native grasses may prove to be the key.

A range of exotic grass species have been introduced into Australia with the aim of improving pasture productivity. While some of these have been successful, many have failed to live up to expectations or even gone on to become costly weeds (see box on cow feed becomes pest plants). African lovegrass (*Eragrostis curvula*), for example, has proven unpalatable to stock and low in nutritional value. Unfortunately, its extremely vigorous and spreading growth now has it regarded as a noxious weed in many parts of Australia.

Jennifer Firn, a PhD scholar (and AEDA associate) from the University of Queensland, says that native grasses

"If the right species can be found, it could be valuable for building competitive pasture communities that are able to stave off invasion while at the same time ensure sustainable production levels"

may have the potential to help slow the spread of unwanted exotic species. Her research was recognised earlier this month by winning the 2007 Science and Innovation Award for Young People in Agriculture, Fisheries and Forestry. The award (sponsored by the Dept of Agriculture, Fisheries and Forestry) aims to encourage people between the ages of 18 and 35 years to use science, technology and innovation to advance the future of agriculture, fisheries, forestry, food and natural resource management industries

"Native grasses are better adapted to the harsh climate and soil conditions that characterise Australian ecosystems," says Jennifer.

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Cow feed becomes pest plants

A huge number of plants have been introduced to northern Australia in an attempt to improve the productivity of the region's grazing lands. More than 200 exotic grasses (mostly from Africa) and 263 legumes (mostly from Central and South America) were introduced to the region between 1947 and 1985, but these introductions were almost never successful. Only 21 of the 463 introduced species proved useful for domestic livestock grazing, and all but four of those have since become weeds. Amazingly, very few of the introduced plants were subjected to field trials before release – such as testing whether stock would eat them! – with the result that sixty of the introduced species had negative impacts on cropping activities and/or conservation reserves. Thirteen of the introduced species became major environmental weeds, requiring extensive weed control – a serious case of a so-called solution ending up being a massive problem!

This is an extract from

Lindenmayer DB. (2007) *On borrowed time*. Penguin, Australia (see AEDA News #8 for details).

Beating exotic weeds with natives
continued

Fighting grass with grass – Jennifer Firn examines the value of using native grasses to out compete the exotic African lovegrass.

Jennifer is using her Award to investigate whether two native species, pitted bluegrass and kangaroo grass, can out-compete African lovegrass. She'll conduct a series of glasshouse experiments, altering the soil nutrient and water conditions, to measure competitive ability.

"If the right species can be found, it could be valuable for building competitive pasture communities that are able to stave off invasion while at the same time ensure sustainable production levels," says Jennifer. "As current control efforts are not working, it's important to explore solutions outside the boundary of conventional farming practices."

More info: http://www.daff.gov.au/brs/science-awards/winners-2007/jennifer-firn

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The fine art of helping people make decisions

It's all about the dance of reason and emotion, and making sure your numbers come with a story

Earlier this month the Health Report on Radio National ran a fascinating interview on the art and science of decision making. The Health Report's Dr Norman Swan interviewed Dr Joe Arvai, Professor of Judgment and Decision Making at Michigan State University. Joe is the Director of the Skunkworks Lab, a leading centre for risk and decision analysis. Here's an edited excerpt from the interview in which Joe outlines some of their findings. (Links to the full interview and Skunkworks are at the end of this excerpt.)

Joe Arvai: People when they respond to stimuli, for example risk, have two systems that they use to comprehend that information. One of them, which we'll just call system 1, is quick, it's intuitive, it's heavily influenced by our emotional responses. System 2 on the other hand is slower, it requires effort, it requires conscious thought and analysis and for lack of a better word, calculation.

System 1 is so important because if you're out there hunting and gathering as your evolutionary kin, you hear a rustling in the bush, you're not going to stop to make an effort for calculations about what that might be, you're going to take off and run and that's system 1 at work.

Norman Swan: The reality is in many instances, particularly politicians and indeed us when we're patients deciding on operations, we use system 1 when really we should be using system 2.

Joe Arvai: I think in many cases we do rely too heavily on system 1. I think there are a lot of things that are risks that we need to contend with and frankly the ones that get the most attention are the ones that really plug neatly into our emotional response, our system 1 response and therefore we spend a lot of time worrying, and a lot of effort worrying about things that perhaps aren't as risky to us as other things.

Norman Swan: And I also understand that people respond to percentages more than they respond to individual numbers.

Joe Arvai: Yeah, this is also true, so again we're talking here about how people's emotions are engaged when they're evaluating information and you can present people with numbers that tend to be quite meaningless whereas percentage data tends to be quite meaningful.

Norman Swan: At least in people's minds it is?

Joe Arvai: At least in people's minds. A colleague of mine asked people how much effort should be expended to save 150 lives at a hypothetical airport by purchasing some life saving equipment for that airport. And people would indicate a level of support for that and then he would ask another group of people how much effort should be expended to save 98% of 150 lives and there we see much more effort being expended to save 98% of 150 lives even though that's much less in terms of lives saved than the previous example.

Norman Swan: And people respond more to individual stories rather than multiples?

Joe Arvai: Yes, there's also research that's been going on by my colleagues in decision research that says that people will invest a lot of effort when they can help an individual that they can identify with. As soon as you start increasing the number of people that are affected we become numb to the number. So the number becomes much less meaningful to us and we see that happening as early as two people. If you have to choose to give some money to save one person, you'll end up giving much more than when it comes to saving two people or three people and of course we can scale this up to tragedies like genocide where people will largely ignore the plight of hundreds of thousands of people.

Norman Swan: Now you've tried to translate this into

> "we have to be very careful when we present numbers to decision makers... ...to make sure that those numbers come with a story, come with context so people know what they mean instinctively, intuitively and can use them"

how decision makers make decisions because billions of tax payers' dollars could go into the wrong kind of thing, well not necessarily wrong, but things that might not be as productive as other investments.

Joe Arvai: Yes, we've been working with decision makers both in government and in the private and public sectors trying to help them to do a better job of balancing their emotional responses with these more effortful, analytic, calculative responses to risk, helping them to set priorities, helping them to really try and figure out which problems are going to be more significant and really helping them to make trade offs where investing in one area means obviously that you can't invest in another. Money spent on terrorism can't be spent on health care and what we're finding is that just the mere mention to them that they need to start thinking about this, that they need to start making trade-offs, that they need to start setting priorities forces them into system 2 kinds of thinking which tends to help quite a bit.

Norman Swan: You've also changed the way you measure risk and present it to people.

Joe Arvai: What we see happening a lot is that billions upon billions of dollars are spent by scientists to collect data for a number of environmental or human health risks and the assumption is that that data will be helpful to decision makers. And often times there's a disconnect between that information and what decision makers actually want or need, or can use. So rather than going to the scientists first we go to the decision makers and the stake holders for instance and ask them what they care about, how they would like to see their concerns expressed numerically, or narratively, or whatever. And then we go back to the scientists and say look, these people are concerned about the environment, they're concerned about the environment in this respect and therefore can you provide us with data that addresses very specifically what these people care about.

We did some work on contaminated site clean-ups that was funded by the Department of Energy here in the United States and there was a lot of data that was being provided by scientists working in an area about the level of contamination in the soil and that level of radioactive contamination was expressed in very sort of detailed scientific terms like the levels of gamma rays and beta rays and alpha particles and so on. And when we presented that information to decision makers they found it completely useless, they didn't know what a gamma ray was, they didn't know what the levels meant, they didn't know what they meant relative to a background level. And what they wanted was just a simple intuitive 1 to 10 type scale that would be the same kind of information to them and their constituents. So we just went back to the scientific team and asked them if they could reframe their science in those terms which of course they could and were quite happy to do. And the minute we did that those numbers became much more meaningful to the decision makers and they could use that to set some priorities about how to spend money to clean up sites.

Norman Swan: This was things like how dangerous was it on a scale of 1 to 10 to human health, that sort of simple answer?

Joe Arvai: Exactly and quite frankly I think that you know once again when people are looking at numbers, what they are trying to do is to try to put those numbers into context and I think that science tends to obfuscate the context with the meaning of those numbers so we have to be very careful when we present numbers to decision makers, certainly the public, to make sure that those numbers come with a story, come with context so people know what they mean instinctively, intuitively and can use them.

Another example of how this is a problem is when we look at climate change, often times we'll hear that there's going to be a 3, or 4 or 8 centimetre rise in sea level in coastal areas. Well 8 centimetres isn't a whole lot, you know it's the distance between a couple of fingers so of course that's not going to convey a lot of meaning to people when they hear that. They are not going to be afraid of 8 centimetres - if you tell them that that's going to mean the loss of hundreds of square kilometres of coast line that tends to convey more meaning. So it's just a simple reframing of the information so that people can actually make sense of it.

Norman Swan: The paradox here is that you're trying to get people to think system 2 but you're constantly reframing it into system 1. And the classic story of course is the number of premature deaths from tobacco related disease, in the Australian context it's 18,000 or 19,000 a year, people just don't understand the 18,000 or 19,000 even when you say it's a football stadium. But if you say it's two jumbo jet crashes a week at Tullamarine airport people sit up because that's the language of system 1.

Joe Arvai: Yes, that's exactly right and in fact a lot of my colleagues have called this the dance of affect and reason, we really need to balance these. Affect meaning emotion and yes, I mean to some extent we are trying to engage system 1 to provide meaning to the numbers while at the same time engaging system 2 so they can make these trade offs. I think the thing to remember here is that I'm not advocating the elimination of system 1 and relying solely on system 2. Instead I think these two systems need to be brought into balance and often times the balance is out of whack because we rely

> "billions upon billions of dollars are spent by scientists to collect data for a number of environmental or human health risks and the assumption is that that data will be helpful to decision makers. And often times there's a disconnect between that information and what decision makers actually want or need, or can use"

The fine art of making decisions
continued

too heavily on system 1 and not at all on system 2. So just by engaging system 1 in some way, by reframing some of these numbers we can thereby re-engage system 2 and provide that balance.

Norman Swan: But you've also looked at these decision makers after they've made the decision about cleaning up the toxic waste, you followed them through to see whether or not their system 2 retraining lasts.

Joe Arvai: Yes we've done some work like this and the sad news is that you can do a lot of work with an individual or a group of decision makers in a particular context and they'll perform marvellously, they'll be able to sort of come to this balance of system 1 and system 2. If you watch them leave the room and start to make other decisions they kind of reboot and go back to relying heavily on system 1 so it seems to be very context and time specific. We've made arguments that perhaps what you need in agencies for example is dedicated staff devoted to decision support, they are always going to be there to remind these people how to go about making these choices and perhaps at the extreme to start educating children in schools on decision making techniques alongside traditional science and mathematics curriculum.

Norman Swan: What you're describing does not sound like an off the shelf tool, you've got to adapt it to every circumstance.

Joe Arvai: There are certain rules that you need to follow, for example identifying problems, figuring out what we care about, coming up with different alternatives to address those, measuring or predicting how effective those alternatives are going to be. But when it comes to a particular decision problem, there are sort of different dosages of those rules that are needed. For example the problem might be very well defined and therefore we don't need to spend a lot of

"perhaps what you need in agencies for example is dedicated staff devoted to decision support"

time with that. However we might need to spend much more time in thinking about alternatives and how to quantify those. So you do have to adapt these rules to the decision context and therefore some decision support within agencies for example would be helpful because these would almost be like decision making coaches.

For the full transcript of this interview see:

http://abc.net.au/rn/healthreport/stories/2007/2029794.htm#transcript

For more info on Skunkworks, go to

http://www.msu.edu/~sknkwrks/

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Where two CERFS meet

AEDA and Landscape Logic work together on better NRM decision making

AEDA's Brendan Wintle is collaborating with David Duncan, a postdoctoral researcher with the Landscape Logic CERF, to improve NRM decision making.

David works at the Arthur Rylah Institute for Environmental Research (the Victorian Department for Sustainability and Environment) where a major retrospective study of native vegetation change is underway to inform future regional decision making and reporting. Over the next three years he'll spend time at the University of Melbourne with Brendan (with AEDA providing in-kind support).

The collaboration will marry Landscape Logic's interest in improved NRM decision making and resource allocation with AEDA's expertise on adaptive management, decisions theory and optimal monitoring. Native vegetation management and restoration is a major area of investment at all levels of government. It is characterised by great institutional and ecological complexity making it an important area of research for AEDA and Landscape Logic.


David Duncan

(David and Brendan are currently working on a chapter for a forthcoming book on Landscape Analysis and Visualisation.)

More info: brendanw@unimelb.edu.au

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Scientists is Schools is a new program helping scientists to share their enthusiasm with students.

Resources & Opportunities

Scientists in schools & Flagship PhDs

Scientists in schools

Link up and learn

Scientists in Schools is a new learning experience that allows scientists and schools to work together across Australia. The program aims to engage and motivate students in their learning of science, and broaden awareness of the types and variety of exciting careers available in the sciences.

Scientists are able to nominate their preferences for age groups and subject areas, then once a scientist is matched with a teacher they have complete flexibility to set up the partnership in a way that suits them both (style of partnership, frequency of visits, amount of interaction with students etc). Support material is also provided to both the teacher and the scientist to help them get the most from their partnership. If a scientist would like to work with a particular school (such as their children's school), they're only too happy to help arrange this.

Scientists in Schools is being run by CSIRO and the Australian Government Department of Education, Science and Training. Teachers and scientists who register will form partnerships and work together in a way that suits both partners, with the aim of providing inspiration, fun and learning for students, teachers and scientists alike.

If you are already involved in a student or teacher programme, we'd love to hear about it. Please register online so that we can promote your ideas and provide you both with free support material and teaching resources.

If not, you can register to be matched with a teacher so that you can work with a school in a way that suits you both – speaking about careers, helping students with science investigations or taking the class on a tour of your workplace.

More info: www.scientistsinschools.edu.au

Or email scientistsinschools@csiro.au or call 02 6276 6397 for more information.

PhD scholarships in the CSIRO climate adaptation and healthy country flagships

The CSIRO Climate Adaptation Flagship has nominated the following priority areas for postgraduate scholarships commencing in early 2008:

1. Responding to climate change effects on geo-infrastructure.

2. Analysing the contribution of adaptive capacity to offsetting vulnerability to climate change.

3. Effects of climate change on forest fuel dynamics and fire risk.

4. Limits to predictability in seasonal climate forecasts.

5. How will climate change effect landscape scale ecological processes?

Applications close on Wednesday 31 October 2007

More info: http://www.csiro.au/partnerships/ps3hn.html

In **the Water for a Healthy Country Flagship**, priority research areas are:

1. Rapid quantification of microbial pathogens in recycled water

2. Software engineering for large and evolvable software systems in water monitoring and modelling

3. Evaluating adaptive management processes for water dependent ecosystems

4. Ensuring social equity and fairness in water reallocation decisions

5. Environmental water needs across the Murray-Darling Basin.

Applications close on Wednesday 31 October 2007

More info is at: http://www.csiro.au/partnerships/ps3gu.html

Application guidelines: http://www.csiro.au/files/files/pgeu.pdf

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New publications
by AEDA members

McCarthy, MA, Possingham, HP. (2007)
Active Adaptive Management for Conservation
Conservation Biology Volume 21, No. 4, 956–963

Active adaptive management balances the requirements of management with the need to learn about the system being managed, which leads to better decisions. It is difficult to judge the benefit of management actions that accelerate information gain, relative to the benefit of making the best management decision given what is known at the time.

We present a first step in developing methods to optimise management decisions that incorporate both uncertainty and learning via adaptive management. Our approach can be used to determine how best to manage ecological systems in the face of uncertainty. We illustrate the approach with a case study in which a manager is unsure about which of two options for revegetation is best.

(See Hugh's editorial on active adaptive management on page 1 for further discussion on this topic.)

Possingham, HP, Grantham, H, Rondini, C. (2007).
How can you conserve species that haven't been found? *Journal of Biogeography* 34(5):758-759.

By examining studies that attempt to conserve species that haven't been found yet the researchers find that the economic costs of both data acquisition and modelling must be traded off against not just the cost of conservation action but also the progress of time. If we spend time collecting and analysing data we miss opportunities for conservation action because critical areas for an efficient and effective conservation system may be lost through land conversion. This points to an entirely new branch of conservation planning – how much and what kind of research should we do before, and while, we are taking conservation action?

Have you published an article or book recently that other AEDA members might be interested in? If you have, please send us the information so we can list it in the next issue of AEDA news.

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Funny end bit

"An economist is someone lacking the social skills to make it as an accountant."

Professor Robert Reich
(former US Secretary of Labor)

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That ends issue 9 of AEDA News. If you have news or views relating to AEDA or of interest to AEDA members, please send it to the Editor, David Salt <dsalt@cres.anu.edu.au>

Why worry about species that haven't even been found yet?

Is the issue outlined in Possingham, Grantham and Rondini (2007) such a big issue? How many species are still out there that haven't been found, anyway? In terms of Australia, you might be surprised.

In terms of reptiles an average of 15 new species are recognized every year in Australia. Just recently, for example, a dwarf taipan was discovered near Alice Springs (one of our largest inland cities).

In terms of frogs there's an enormous amount of work left to describe them. Between 1977 and 1995 scientists increased the number of described species comprising the country's frog fauna by 30 per cent. Some Australian species became extinct before they were formally described or their biology was understood – even in a rudimentary way.

About 86,000 species of Australian insects have been described, but the total number of species in existence could be 100,000 to 300,000 or even far higher.

It's believed that around 70% of vascular plants have been described but only 5% of fungi.

Because so much of our biodiversity remains poorly known or undescribed, many species will be lost before they are known to science. These are known as Centinelan extinctions, named after Centinela, the western Andean foothills of Ecuador. The foothills were cleared for agriculture consigning what's believed to be ninety species of plant to extinction.

The numbers presented here are based on information contained in:

Lindenmayer DB. (2007) *On borrowed time*. Penguin, Australia (see AEDA News #8 for details).

AEDA stands for Applied Environmental Decision Analysis, a research hub of the Commonwealth Environmental Research Facility program. The CERF program is funded by the Australian Government Department of Environment and Water Resources. AEDA's members are primarily based at the University of Queensland, the Australian National University, the University of Melbourne and RMIT.

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Applied **E**nvironmental **D**ecision **A**nalysis
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Smart science for wise decisions