Science
for saving species

Summer 2018
Issue 6

Out of the box

Designing nest boxes for success

Conserving rocky habitat on farms

Public preferences for numbats and woylies

The adequacy of our monitoring effort

Threatened Species Recovery Hub

National Environmental Science Programme

IMAGE: DEJAN STOJANOVIC

On feral cats **AND** clearing

It's no beauty contest

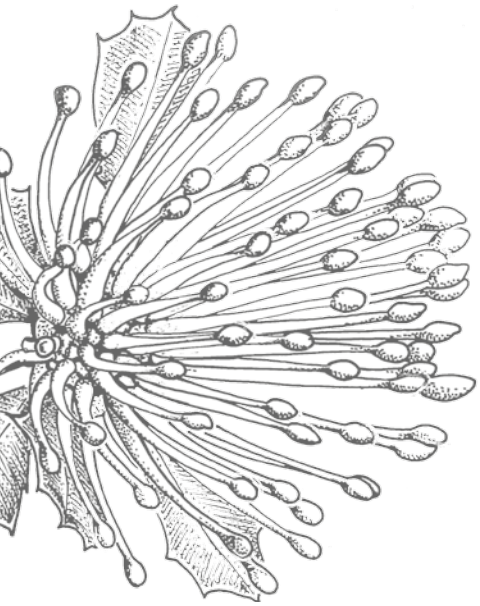
In recent months you may have noticed some energetic public debate about what is the biggest threat to threatened species in Australia. Is it feral cats and foxes or is it the clearing and degradation of native vegetation? (For example, I contributed to one editorial appearing at *The Conversation*.)

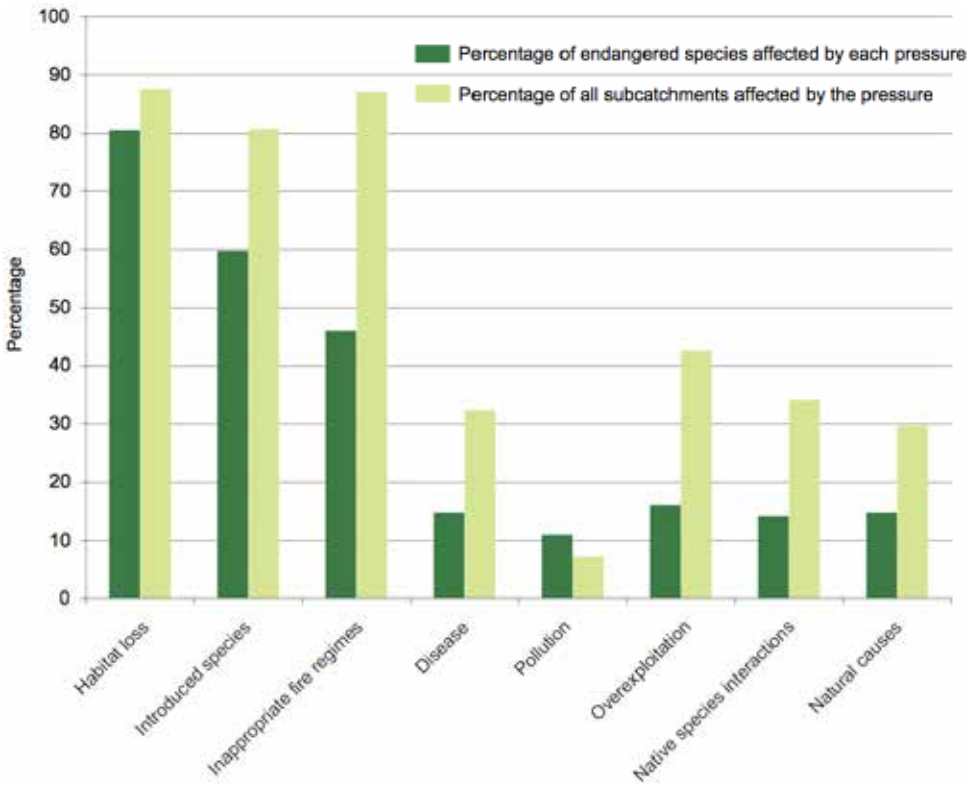
The answer is that Australia's threatened species are under pressure from multiple, interacting threats, and that feral predators and habitat loss are just two that are wreaking a terrible toll on our unique biodiversity. Other invasive species, climate change, changing fire regimes, disease, are some of the other thugs in the gang of extinction, and they all work together very effectively. Researchers in our Hub are working to better understand a multitude of interacting threats to species with the aim of finding effective ways to mitigate them.

While it seems somewhat academic and facile to be sweating on which threat is king (and which are the dark lords) of extinction while species are declining and people are frantically trying to save them, there is a practical side to this question. It relates to how we prioritise spending and develop policy around vegetation management and invasive species programs. If the pervasive narrative is that managing invasive species is paramount in the fight against extinction, then this will influence government spending and policy priorities, which will inevitably trickle down to local, catchment-level programs such as Landcare and Catchment Management Authority budgets. If renewed recognition of the importance of land clearing or climate change hit the headlines, then opportunities for meaningful dialogue and action on these key issues may arise. What we say as a community of scientists and experts does matter. So how we couch our messages really matters too.

A couple of key studies have explored the relative importance of threats to species globally and in Australia. According to a recent analysis of data from the International Union for the Conservation of Nature (IUCN), habitat loss is the number-one threat to biodiversity worldwide. Globally, more species are affected by habitat loss and degradation than by invasive species, disease or other threats. That's the global story. Though, at a finer scale, there is evidence that islands are particularly susceptible to invasive species.

According to the Federal Government's two most recent State of the Environment Reports (in 2011





Pressures affecting species on Australia's list of nationally threatened species (Source: Australia's State of the Environment Report 2011)

Inside the Summer 2018 issue of *Science for Saving Species*

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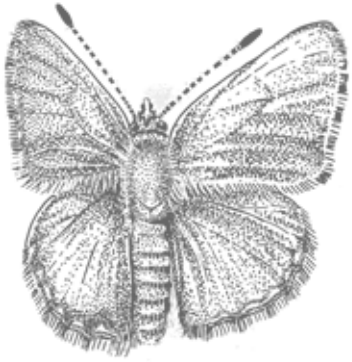

This is not a 'beauty contest' between invasives and clearing; this is two nasty intertwined evils that probably shouldn't be compared side-by-side, but rather thought of as a synergistic snake pit.

and 2016), habitat loss is also a major threat here in Australia too, but invasive species have played a special role in Australia's terrible extinction track record that bucks international trends. Depending on how you categorize and aggregate threats, you can argue that invasive species are as important, or even more important than habitat loss and degradation. The fact is that both habitat loss and degradation and invasive species are recognized as key threats to enough of our species that we won't be taking our eye off either in the near future. A relatively large amount of research effort is allocated by our Hub to addressing the impacts of invasive species, which reflects the fact that we know pretty much what we need to do about habitat loss (stop clearing and degrading habitat!), but we have much to learn about how to effectively nullify the impacts of invasive species.

This is not a 'beauty contest' between invasive and clearing; this is two nasty intertwined evils that probably shouldn't be compared side-by-side, but rather thought of as a synergistic snake pit. After obtaining a broad acknowledgement that both of these threats require much more funding and action than we currently invest, we gain little from arguing the minutiae and handing out gold and silver medals. A much more pressing task is to get on and figure out how we allocate our currently scarce resources to get the best bang for our buck in effectively solving these problems. AND obtaining the social license and greater funding to support conservation and policy improvement efforts.

Right now we are seeing a dramatic return to world-record breaking levels of clearing in Queensland and challenging new habitat management regulations in other states. At the same time, our colleagues are uncovering the horrific magnitude of the impact of feral predators in this country (see the box on 'cats kill birds'). This is no beauty contest, this is a crisis that requires urgent policy reforms on habitat loss and unprecedented investment in managing invasive species if we are to avoid more heart-breaking extinctions.

NESP TSR Hub researchers are closely involved in all aspects of this problem, from fundamental research into which policies and actions work best in what contexts, and in publically advocating for resources and actions that will help prevent extinctions.

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Cats kill birds – millions of them

Cats kill over 1 million birds per day in Australia. That's the finding of new TSR Hub research recently published in *Biological Conservation*. The total is made up of an estimated 316 million birds killed by feral cats each year (and 61 million killed by pet cats). More than 99% of the bird prey are native species.

The estimates are based on results from nearly 100 studies across the country, each sampling cat density, and another set of nearly 100 studies across the country that assessed the diet of feral cats. Lead researcher (and TSR Hub Deputy Director) John Woinarski said that while previous research has looked at the impact cats are having on Australia's mammals, this is the first nation-wide assessment of the impact of cats on Australia's birds.

"Everyone knows that cats kill birds, but this study shows that, at a national level, the amount of predation is staggering, and is likely to be driving the ongoing decline of many species," says John Woinarski.

So, which species are we talking about? A second study found records of cats killing 338 native bird species – almost half of Australia's native bird species. The total included 71 threatened bird species.

"For Australian birds, cats are a long-standing, broad-scale and deeply entrenched problem that needs to be tackled more effectively," says Woinarski.

IMAGE: MARK MARATHON CC BY SA 4.0

Rock on!

Restoring **critical rock habitat for reptiles** on farms

IMAGE: DAMIAN MICHAEL

ABOVE: A pink-tailed worm-lizard sits contentedly atop a lichen encrusted bushrock. For many reptiles, rock outcrops and bushrocks are critical habitat.

Conservation and restoration in production landscapes mostly focusses on native vegetation. Millions of dollars are spent each year on broad-scale revegetation programs. Native vegetation is important but so too are native rocks. Indeed, rocky habitats are critical to many small mammals and reptiles in farming landscapes but they don't get the same attention as native vegetation. Dr **Damian Michael** from The Australian National University hopes to set that right. Here he explains why protecting rocky outcrops and bushrock is important, how this critical resource is being destroyed, and what measures need to be taken to improve habitat for threatened reptiles in agricultural landscapes.

Next time you see a tiny patch of rocks out on a farm, try to envisage it as a possible refuge for native animals; a little island of habitat surrounded by an unfriendly sea of farmland.

Small rocky outcrops have large ecological roles that extend well beyond their boundaries. Island-like protrusions of rock that rise above the surrounding landscape provide refuge for ancient flora and specialised rock-dwelling animals. They also protect threatened plant communities and, in doing so, provide stepping stones that enable nomadic and wide-ranging species to move freely through fragmented and heavily cleared landscapes.

IMAGE: DAMIAN MICHAEL

Bushrock is loose and fragile rock that sits on rock or soil surfaces. It's often removed from agricultural landscapes for a number of reasons but its presence is critical for many threatened species.

Indeed, rocky outcrops are often regarded as biological hotspots. They can be relatively small areas of habitat but often support a disproportionately high number of species, large numbers of endemic species and a high percentage of threatened species.

More than 180 vertebrate species are restricted to rocky outcrops in Australia, and fifty of these rock-dwelling species are threatened with extinction. For some, such as the iconic inland carpet python, well-managed rocky outcrops are key to their survival in agricultural landscapes. Similarly, bushrock provides critical habitat for threatened animals like the pink-tailed worm-lizard, striped legless lizard, little whip snake and the grassland earless dragon (a once widespread lizard that hasn't been seen in Victoria since 1969).

Mind the bushrock

Bushrock is loose and fragile rock that sits on rock or soil surfaces. It takes millions of years to form and plays a vital role in the environment. It naturally provides habitat for plants and animals, many of which are threatened, but it also provides animals with shelter, protection from predators, and places where they can escape from fire and extreme weather conditions.

Key messages

In agricultural landscapes, more than 180 vertebrate species are dependent on rocky outcrops and hundreds of others rely on bushrock for shelter and protection

Main threats to rock-dwelling species are bushrock removal, vandalism, loss of native vegetation, weed invasion, over grazing and inappropriate fire regimes

The ecological roles of small rocky outcrops and bushrock in agricultural landscapes needs better recognition and protection

Damian Michael's passion is the conservation of reptiles in agricultural landscapes. He is pictured here holding a specimen of Burton's snake-lizard.

Bushrock also serves an important ecosystem function by helping to maintain macro and micro environments by preserving soil moisture, stabilising slopes, reducing soil erosion, increasing seed germination rates and reducing the effects of fire.

And, you're not supposed to remove them. The removal of bushrock is listed as a key threatening process under the New South Wales Threatened Species Conservation Act 1995. Though this law does not include the removal of rock from approved quarrying activities, the salvage of rock where the removal of the rock is necessary for carrying out a development or activity (with an existing approval under the Environmental Planning and Assessment Act 1979), or the removal of rock from paddocks when it constitutes a necessary part of the carrying out of a routine agricultural activity.

Or mine the bushrock

In agricultural landscapes in some parts of Australia, massive amounts of rock have been quarried or removed from paddocks over time. This process has been attributed to declines in a range of ground-dwelling native small mammal and reptile species. In Victoria, rocks removed from the paddock were often repositioned to form dry-stone walls. In other parts of Australia, bushrock was legally (and illegally) collected and used in garden landscaping.

Bushrock removal continues to happen in some national parks and on private property, but now new technology is being developed to speed up the rate at which this critical habitat can be removed (and destroyed) on a much broader-scale than ever before. New machines such as the 'reefinator' and 'rock crusher' are towed behind large tractors enabling farmers to rip through rock beds, pulverise surface rocks and convert rocky paddocks into arable cropping land at a rate of 1 ha/hr. Even low rock formations can be turned into gravel within a few hours. Unchecked, this emerging practice of 'renovating' rocky paddocks could push already imperilled small native mammals and reptiles into further decline.

Legislation outlawing bushrock removal is urgently required.

The restoration experiment

Re-creating and re-establishing rocky habitat will be necessary to reverse the decline of some species. Over the next few years, researchers from The Australian National University in partnership with the Central Tablelands Local Land Services will trial different methods to restore bushrock on grazing farms in parts of southern New South Wales. In this study, researchers and landholders will work in collaboration towards finding optimal solutions to managing threatened species without compromising farm productivity.

The pink-tailed worm-lizard will be one of the target species we hope to assist by improving and restoring rocky habitat on working farms.

We have support from the Local Land Services and a number of interested landholders in the region. This is extremely encouraging as reptiles don't often get a lot of good media attention. However, if we want to maintain the natural values that can be found in our agricultural landscapes then it's absolutely essential that we look beyond native vegetation and start caring for our under appreciated rocky outcrops.

For further information

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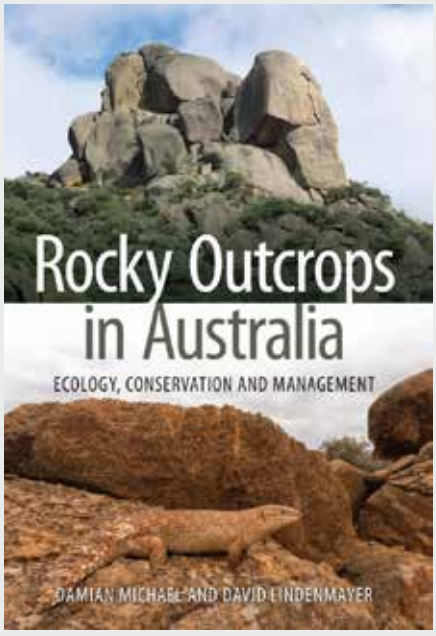
You've seen the outcrop, now read the book

If you are interested in rocky outcrops, farms and biodiversity, then we have a book for you. *Rocky Outcrops in Australia: Ecology, Conservation and Management* (written by Damian Michael and David Lindenmayer, and published by CSIRO Publishing) is due to be released in early 2018. This richly illustrated book contains chapters on why rocky outcrops are important, the animals that live on them, key threatening processes and how this critical habitat can be managed to improve biodiversity conservation in agricultural landscapes, state forests and within Australia's network of protected areas.



Public preferences for threatened species in WA

Fox and cat control in Western Australia

IMAGE: AUSTRALIAN WILDLIFE CONSERVANCY

Foxes and feral cats pose a serious threat to over 100 native Australian mammals, birds and reptiles. Controlling fox and feral-cat populations is therefore crucial to the survival of many native species. Usually, it's the government who undertakes this management which means it's the general public who pays. But has anyone ever bothered to ask the general public what they think about fox and cat control? Actually, **Vandana Subroy** and colleagues at the University of Western Australia have just investigated this very question. Here Vandana discusses what they found.

ABOVE: The numbat (*Myrmecobius fasciatus*) once inhabited southern and central Australia. Its range and abundance shrunk following European settlement of Australia. Today only two naturally occurring populations remain: Dryandra Woodland and Perup Nature Reserve (both in south-west Western Australia).

Numbats and woylies are two much loved mammals in Western Australia. They are also threatened, and the focus of a study I am leading on social preferences for fox and feral-cat management. Working with the Department of Biodiversity, Conservation and Attractions Western Australia (DBCA), our study focussed on social preferences for fox and feral-cat management, using Dryandra Woodland in southwest WA as a case study.

The Dryandra Woodland lies around 160 km south-east of Perth. Not only does this woodland include the largest area of remnant native vegetation in this region, it is also home to several threatened species of flora and fauna, including numbats and woylies. The woodland is highly fragmented and surrounded by farmland making predator management a challenge.

Semi-dried meat baits containing the poison 1080 (sodium monofluoroacetate) are currently the primary means of controlling foxes and feral cats in Dryandra Woodland. Other strategies being implemented by DBCA include trapping, fencing and community engagement (ie, actively involving the local community in feral predator management).

Research shows that people care not only about conservation outcomes but also the means by which those outcomes are achieved. For example, although people may prefer an increase in the population of a threatened species, if the means of achieving that increase was objectionable (say, for example, people being uncomfortable with using poisons) then this might undermine support for the program itself. Therefore, since most conservation programs are funded through public taxes, it is important to consider public support along with biological, geographic and economic aspects.

Our study seeks to quantify the intangible or non-market benefits to society of various fox and feral-cat management strategies that might be deployed in Western Australia. It also seeks to determine the non-market values of the threatened species, like numbats and woylies, being protected. These benefits will be used in a cost-benefit analysis to assess various conservation policy options for fox and feral-cat management in the Dryandra Woodland.

Non-market benefits are the values of goods and services that are not traded in markets. For example, most environmental goods like clean air and water, threatened species and wetlands provide benefits that are not traded in markets. 'Value' is measured in terms of the tradeoffs (typically monetary) that individuals

Key messages

We assessed public preferences for managing foxes and feral cats, and for conserving numbats and woylies in WA

There is a preference for using a combination of strategies such as fencing, trapping and community engagement in addition to 1080 baiting (over using just 1080 baiting alone)

There is strong public support for increased numbat and woylie populations

The woylie or brush-tailed bettong (*Bettongia penicillata*) once inhabited more than 60% of the Australian mainland, but now occurs on less than 1%.

are willing to make to procure a certain change in environmental outcome relative to no conservation. For example, what's the value of a 50% increase in the population of a threatened species relative to doing no conservation. The tradeoff is often termed as the public's 'willingness to pay'.

Our study used an economic approach called choice experiments to survey 500 West Australians about their preferences for feral predator management. The online survey was administered at the end of 2016. In the survey, respondents were shown multiple 'choice sets' that each described four hypothetical scenarios (choice options) of different fox and feral cat management strategies. The outcome of each scenario was captured by the effects management would have on numbat and woylie populations. A management cost was also included for each choice. Respondents selected their most preferred option from the four, implicitly indicating the trade-offs they were willing to make between the management cost, the type of management, and the conservation outcomes. The trade-off between the management cost and other outcomes enables us to calculate willingness to pay for the management strategy, and for improvements in numbat and woylie populations.

Results showed that people strongly support increasing numbat and woylie populations. It also showed that they prefer using strategies with a combination of approaches rather than 1080 baiting alone.

The average willingness to pay (per household) was estimated to be $21.76 for 100 additional numbats and $7.95 for 1,000 addditional woylies (ie, higher for numbats than for woylies). This was possibly because more respondents had prior knowledge about numbats than woylies, likely because the numbat is WA's faunal emblem, and there have been campaigns to educate the public about numbat recovery.

The same is not true for the woylie, even though the species' threat status is Critically Endangered (unlike the numbat whose threat status is Endangered). Species' charisma appears to be an influencing factor in willingness to pay.

This study identifies that it may be advantageous for managers to take into account these public preferences when they design their conservation strategies. Conservation agencies could consider using a charismatic species to obtain support for conservation programs that also target other, less charismatic species.

For further information

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Note: This work was undertaken as part of Vandana's PhD at UWA. She would like to acknowledge the assistance and support of her supervisors Dr Abbie Rogers and Dr Marit Kragt at UWA, and Dr Manda Page at DBCA. She would also like to thank Brett Beecham, Peter Lacey, Marissah Kruger and other staff at DBCA's Narrogin office for their expertise and assistance in developing the choice experiment survey.

The Dryandra Woodland (pictured above) is one of the last natural refuges of the numbat and woylie. (Photograph by Gnangarra.commons.wikimedia.org, CC BY 2.5 au)

Build your profile

The numbat was proclaimed the animal emblem of Western Australia on 25 July 1973 (the official image is on the right). It has been the subject of considerable research and recovery efforts since then, and the focus of fund raising programs such as Project Numbat. It's believed this high public profile has contributed to a greater 'willingness to pay' for its conservation (as compared to the lower profile woylie).

Drawing of a numbat by Belgian street artist ROA in Fremantle near Perth. (Photograph by Gnangarra.commons.wikimedia.org, CC BY 2.5 au)

Out of the **box**

Designing nest boxes **for conservation success**

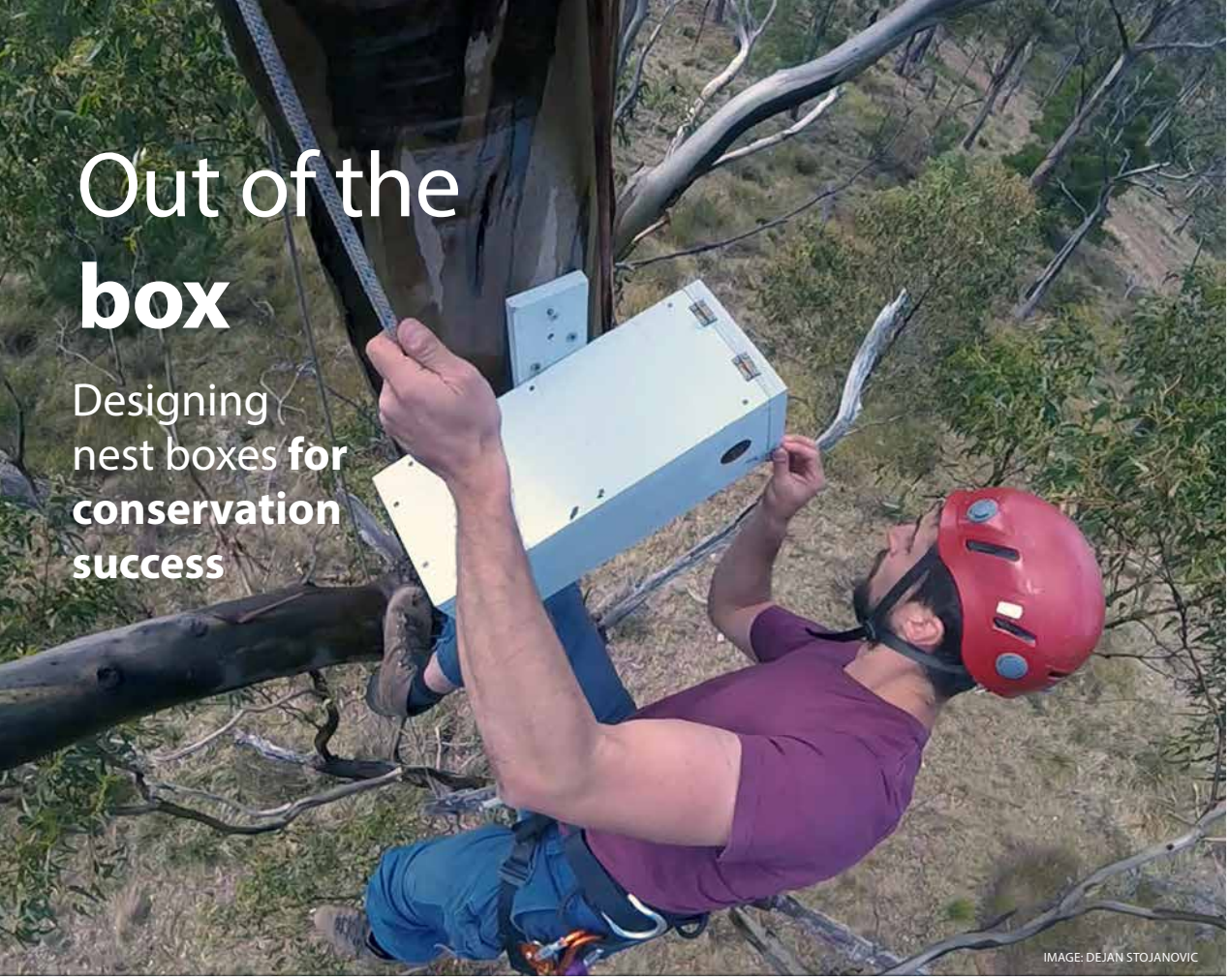

IMAGE: DEJAN STOJANOVIC

ABOVE: Dejan Stojanovic checks a swift parrot nest box mounted 20m up a tree.

Many of our threatened birds and arboreal mammals rely on tree hollows for nesting, but because we've cleared most of our big, old trees, these hollows are in short supply. Nest boxes are commonly proposed as an alternative, but do they actually provide an appropriate housing solution for our threatened species? **Rachel Robbins** from the Australian National University examines four case studies on our successes and failures with nest boxes.

A safe box for swift parrots

It's estimated there are only 2,000 mature swift parrots (*Lathamus discolor*) left in the wild. This Critically Endangered native bird is in desperate need of a little help, especially when it comes to safe nesting hollows.

Each year these slim, medium-sized green-and-red birds migrate from the Australian mainland to Tasmania to breed. Swift parrots need tree hollows to breed, however with the loss of suitable nest hollows due to land management, in particular forestry, the parrots are facing a life-threatening housing shortage. Population modelling by the TSR Hub suggests that without intervention the bird faces extinction by 2031.

To further complicate conservation efforts, Hub researchers Rob Heinsohn and Dejan Stojanovic have discovered that sugar gliders are preying on nesting swift parrots. A much loved native species on the mainland, sugar gliders are not native to Tasmania, and their introduction has had disastrous consequences for swift parrots. The small possums are just the right size to access the high, deep nesting hollows of the parrots. Once inside, the sugar gliders devour both the adult female, her nestlings and eggs.

During his PhD, Stojanovic uncovered the shocking impact that sugar gliders are having on the swift-parrot population. Swift parrots follow floral resources, breeding in different locations each year. Stojanovic's research has shown that when breeding occurred in areas with sugar gliders, 83% of the nesting females were killed during the breeding season, while none were killed when breeding occurred on Bruny Island (which is free of sugar gliders).

IMAGE: DEJAN STOJANOVIC

A clutch of swift parrot nestlings in the bottom of a nest box. In some situations nest boxes can provide critical habitat for threatened species.

"Swifties and gliders actually share a lot of the same habitat requirements," explains Stojanovic. "They both nest in tree hollows, they both feed on nectar, and they both like old-growth habitat."

However, there are glimmers of hope. Heinsohn and the swift-parrot research team have been trialling nest boxes and artificial tree hollows as potential nesting sites for the birds, and have demonstrated they can work.

But how might these nest boxes be configured to protect nesting swift parrots from the nocturnal raids of sugar gliders? With the help of an electrician, Stojanovic thinks he may have found the solution.

"We've designed "possum-keeper-outer" (PKO) nest boxes," he says. "In this version, a door closes behind the parrot once darkness falls.

"Effectively, it's just a little motor and a light sensor. As soon as it's daytime the sensor automatically detects that there's ambient light and it will open the door to release the parrot to go about their business.

A good night's rest was had by all swift parrots sleeping within – the sugar glider is blocked from entering a nest box by the PKO (Possum Keeper Outer).

"Then, as the light fades at the end of the day and the swift parrots are back in the box, the sensor triggers the door to close for the night."

The new PKO boxes need to be sturdy says Stojanovic because the possums really want to get into them after dark. But he is confident the new design is a potential winner.

"We trialled PKOs on swift parrots last year to check if the birds are disturbed by the light-triggered door," says Stojanovic. "We we were thrilled to find they didn't mind the machinery at all."

At $400 a nest box, the price on protecting the swift parrot remains a significant barrier. At the end of October last year the swift-parrot team launched a crowd-funding campaign (titled 'Operation Possum Keeper Outer') to raise $40,000 to cover the costs of installing 100 nest boxes to protect the parrots this season. Community support was critical to enabling fast action to protect this irreplaceable species during this year's breeding season.

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Offset fails to tick the box

Biodiversity offsetting aims to mitigate (or offset) the adverse impacts of human activities on biodiversity in one area by improving biodiversity value in another area. In theory gains should equal losses so there is no net loss. Despite being widely applied across Australia, the impacts of biodiversity offsetting are rarely evaluated.

TSR Hub researcher David Lindenmayer and colleagues embarked on a four-year case study examining the impacts of a biodiversity offset which established nest boxes to compensate for the losses of natural tree hollows caused by the widening of sections of the Hume Highway (the road linking Sydney and Melbourne).

The expansion of the Hume Highway resulted in the clearing of nationally endangered temperate box gum grassy woodland which provides habitat for three (NSW listed as vulnerable) threatened species: the squirrel glider (*Petaurus norfolcensis*), brown treecreeper (*Climacteris picumnus*) and superb parrot (*Polytelis swainsonii*). The biodiversity offset was targeted to provide habitat specifically for these three threatened species.

Over four years of monitoring, the researchers found the nest boxes weren't used much by the target species. For example, of the 324 nest boxes which were checked around ten times each over the monitoring period, there were no records of use by superb parrots, and only two by brown treecreepers and seven by squirrel gliders.

The inevitable conclusion from the monitoring was that the offset was clearly not effective in compensating for the loss of hollow-bearing trees and the 1:1 offset ratio (ie, one nest box for each tree hollow lost) was inadequate because it did not account for the risk of the boxes not being used. Improving offset ratios could lead to greater success in future offsetting programs.

Researchers conducted 3,000 checks of the nest boxes along the Hume Highway in southern NSW.

Eight percent of the nest boxes also fell out of trees or were stolen in the four year monitoring period. Given that trees are usually 80 to 120 years old before they form tree hollows, it is fair to assume that most nest boxes would therefore fail before new hollows formed. This highlights the need for any nest box program to include a long-term and adequately resourced program of monitoring and maintenance.

The main takeaway message from this case study is the distinction between offset compliance and offset effectiveness. In Australia, it is not mandatory that offset effectiveness is assessed. As a result, offset programs can be considered compliant at implementation, but there is no expectation that the effectiveness of these offsets will be monitored after implementation.

Nest boxes alone were inadequate in providing habitat equivalent to the tree-bearing hollows which were lost because of the development. Offset programs need to go further than simply ticking compliance check-boxes and provide measurably effective outcomes for biodiversity.

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Putting the heat on nest boxes

Nest boxes are often advocated by people wanting to create a little bit of habitat for wildlife. Some wildlife care groups, for example, recommend installing nest boxes out in the garden so possums use the boxes rather than invading the roof spaces of houses. It's a nice idea but do nest boxes provide the protection that wildlife need? Natalie Briscoe from the TSR Hub was part of a team that looked into whether nest boxes provided thermal protection. Their study measured the temperature suitability of nesting boxes for four different species of possums.

Paired tree hollow and nest-box from the study of den thermal suitability in the Strathbogie Ranges. Tree hollows are generally better insulated.

The researchers compared the temperatures in nest boxes against those in tree hollows during summer and winter to see which ones provided the best living conditions across the seasons.

Temperatures inside the nest boxes fluctuated greatly compared to tree hollows. This is because the nest boxes responded strongly to changes in solar radiation and outside temperature whereas the tree hollows were generally better insulated. On average, nest boxes were 8°C warmer than tree hollows in summer (with a maximum temperature of 52°C recorded in nest boxes, compared to 38°C in tree hollows) and 3°C warmer in winter.

In summer, possums seek shelter so they can cool their bodies down, avoiding heat-stress and dehydration which can lead to death. Briscoe and colleagues found that large species like common brush tails and common ringtails needed to lose up to 2.4 times more heat to remain cool in nest boxes than tree hollows. In winter, nest boxes were beneficial because their warmer temperatures reduced the amount of energy possums needed to expend to keep warm.

They concluded that nest boxes do not match the performance of tree hollows in summer, but they can be valuable over the winter months. While nest boxes can in some cases provide a habitat solution for our native species, it's clear that we need to start thinking outside the box when designing nest boxes.

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Judging a box by its cover

Natalie Briscoe and colleagues were part of a team that has been investigating whether we can improve the functional performance of nest boxes. They wondered what difference surface reflectance would have on the temperature inside nest boxes if the outsides of the boxes were painted in different colours.

The team tested three different coloured nest boxes (white, light-green, and dark-green) to see if the colour of the nest boxes had an effect on the internal temperature they maintain.

Their study found that light coloured boxes were the best at reflecting heat during summer and dark coloured boxes asborbed heat well in winter. Other factors including box design, placement, and the amount of shade boxes received also influenced the internal temperature of the nest boxes.

These conclusions have important implications for the use of nest boxes as a conservation tool. Conservation managers considering the implementation of nest boxes programs need to give careful consideration to design, colour, placement and shade profile of nest boxes.

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Whose house is cooler? Turns out it's the light green nest boxes on the tree on the right (in this case, boxes for bats). Which probably means light green is better in the summer but the warmer dark green boxes might be more suitable in winter. (IMAGES: STEVE GRIFFITHS)

Key messages

Achieving a conservation outcome is not as easy as simply putting up a nest box. Different species and situations require tailored solutions

In some cases, nest boxes can assist with threatened species, as with the swift parrot.

In other cases focusing on compliance and ignoring the effectiveness of nest boxes, as in the case of the Hume Highway offset, results in little being achieved.

Nest boxes do not replace tree-hollows, however, creative approaches to designing nest boxes and pairing nest boxes with other conservation strategies could greatly improve their value as a habitat resource.

The turtle, the fox & the **bandicoot**

One problem solved **another created**

What happens when your efforts to save one threatened species creates a new problem involving another species of conservation concern. Suddenly you're faced with some difficult choices. **Helena Bowler** at the University of Western Australia explains here the unexpected complication that arose when fencing was put up to save endangered turtles from foxes.

Key messages

Fences protecting western swamp turtles from foxes are also benefitting bandicoots (and the bandicoots may be feeding on turtle eggs)

We monitored bandicoot disturbance of artificial turtle nests

The western swamp turtle (*Pseudemydura umbrina*) is the most critically endangered reptile in Australia. It has only one viable population remaining at the Ellenbrook Nature Reserve and three other populations being sustained by translocations of captive-bred individuals (at Twin Swamps, Mogumber and Moore River Nature Reserves).

With a naturally restricted distribution to specific wetlands on the Swan Coastal Plain (near Perth, WA), this species is particularly susceptible to predation by foxes, habitat loss and climate change. As an example of the turtle's vulnerability, in the 1960s the Twin Swamps Nature Reserve held the largest wild population of swamp turtles, with more than 200 mature turtles, but by the late 1980's there were fewer than five adults remaining. Predation by foxes was considered a major cause of decline.

A key management action to save the turtle was the construction of predator-proof fences surrounding the Twin Swamps and Ellenbrook Nature Reserves in the late 1990s. Combined with the active removal of foxes (via 1080 baiting) within the reserves, this strategy effectively protected the swamp turtles from fox predation.

But it wasn't just the turtles that benefitted. Foxes also prey on the southern brown bandicoot or quenda (*Isoodon obesulus fusciventer*). Though not as endangered as the swamp turtle, the quenda's numbers have long been in decline and it is a conservation priority-listed marsupial.

Quenda share the two nature reserves with the swamp turtle, and the removal of foxes has resulted in an increase in quenda populations within the reserves. And here's the problem: anecdotal evidence suggests the bandicoots, opportunistic omnivores, are seeking out turtle nests as a food source and therefore may pose a threat to their persistence.

So, what do we do? First, we need to confirm the quenda is the culprit preying on turtle nests. And this is where I became involved. For my Honours year research (working with Leonie Valentine), I helped monitor artificial turtle nests to see what was digging them up.

We set up 100 artificial nest sites in 2016 and monitored them using remote sensing cameras. Sites included artificial nests containing either quail eggs (as a surrogate for turtle eggs) or artificial (plasticine) turtle eggs, or no eggs, and control sites (with no artificial nest). The different nests were used to determine if quenda actively preyed on nests using olfactory (smell) cues, visual cues or both in combination.

Images captured on camera showed both quenda and rats visiting the nest sites but only quenda were observed actively digging them up. Thirty one artificial nests were disturbed during the trial period (52% with artificial egg nests, 32% with quail eggs). No activity was observed at sites without eggs. Of the "no egg" nests, 27% were also disturbed, indicating that quenda were using a combination of olfactory and visual cues.

Our study provided evidence that quenda could pose a significant risk to swamp-turtle populations by actively seeking out and preying on nests. Through a combination of olfactory and visual cues of the nest, quenda are able to directly locate turtle nests and eat the eggs. It is believed that quenda rely heavily on olfactory cues to determine if there is food in the soil, before they begin digging their foraging pits.

As part of the swamp-turtle conservation management strategy, managers have translocated turtles to reserves in south-west WA. If fox management occurs at these sites (and foxes are removed), there is the potential for quenda numbers to rise and also threaten turtle recruitment. To ensure a successful turtle translocation project, quenda populations at translocation sites should be monitored.

Conservation recovery plans for the swamp turtle (implemented by the WA Department of Biodiversity, Conservation and Attractions), involve the trapping and translocation of quenda away from the Twin Swamps and Ellenbrook Nature Reserves. Long-term monitoring indicates that the juvenile recruitment of turtles has subsequently improved (due to the removal of the quenda).

Our study has highlighted how conservation actions can have unintended (and unforeseen) consequences. However, with adaptive and creative responses, it's possible to save both turtles and bandicoots.

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The western swamp turtle, one of Australia's most endangered vertebrates.

Caught in the act! A motion-sensing camera records a quenda feasting on quail eggs it dug up from an artificial turtle nest.

Lost **with the brigalow**

Rediscovering something lost in order to save what still exists

ABOVE: The brigalow forest of eastern Australia has been extensively cleared and converted to pasture and crops.

The vast brigalow forest that extended from northern New South Wales to southern Queensland has been cleared in the space of 60 years. It seems likely that many species have become threatened with the destruction of the forest. **Rod Fensham** and co-workers have identified the plant species that are likely to have become threatened and many of these species were not previously recognised as imperilled

The brigalow forest occupied about 14 million hectares of the fertile plains between the coast and the semi-arid interior of Queensland and New South Wales and has been extensively cleared and converted to pasture and crops since the 1950s. Today only about 8% of the original forest is still standing and large areas of the remainder are heavily degraded with infestations of exotic grasses. This raises the important question: What has been lost with the brigalow forest? It is entirely probable that formerly common species have become endangered over the relatively brief period of time during which the forest was cleared without anyone having realised. How do we identify the plant species that are likely to have been imperilled with the decimation of the brigalow forest?

The first step in the process was to identify the plant species that occur where the brigalow tree provides habitat. There are about 16 million records of plant collections available online through Australia's Virtual Herbarium, and all of these records include locations of where a specimen was collected. Many also provide habitat descriptions.

The scientific name of brigalow is *Acacia harpophylla*, so we used the search terms 'brigalow' and 'harpophylla' in the habitat field to identify over 1,000 plant species that occur with brigalow.

Next, we reasoned that the stronger the association between a plant species and brigalow the more likely it was to be in trouble (given that the brigalow has largely been removed). This association was represented by a fraction representing the number of records associated with brigalow relative to the total number of records.

We also reasoned that the closer a species was associated with the region where brigalow was cleared (the Brigalow Belt biogeographic region) the more likely it was to be in trouble. Using a Geographic Information System, we mapped the area where records occurred for each species. We then derived another index that was a fraction representing the proportion of a species geographic range within the Brigalow Belt biogeographic region. We multiplied this index with the first fraction and represented the product as a percentage.

Viscum bancroftii is a leafless mistletoe that grows on another mistletoe that grows on the brigalow tree. (Image CC, Australian Parasitic Plants)

Key messages

Where habitat loss is rapid, formerly common species may be at risk of extinction

A method has been developed for using habitat mapping data and herbarium records to identify plant species that are threatened by the rapid conversion of brigalow forest

The method weights species depending on the strength of their association with the brigalow forest habitat and their association with the Brigalow Belt region where the clearance of the forest has been most extensive

This we called the Threat Exposure Index for each species. Our approach weights species depending on the strength of their association with the brigalow forest habitat and their association with the Brigalow Belt region where the clearance of the forest has been most extensive.

The flora of the brigalow forest consists of 1,229 native plant species. Of these, 56 have a Threat Exposure Index score greater than 10 and probably include the species most threatened by the clearing of brigalow forest. Twenty of the 56 also occur in habitats that have not been extensively cleared so are likely to persist into the future. Of the remaining 36, 10 species are almost exclusively associated with brigalow forest.

Importantly, some of the plant species identified by our process had never previously been recognised as threatened. Our analysis brought their parlous prospects amongst the diminishing brigalow forest into sharp focus.

One of the species is a tree in the genus *Denhamia* that is only known from a single specimen. Another is a species in the genus *Aneilema*. It's allied to the weed wandering jew though the white flowered *Aneilema* stands upright and has only rarely been sighted. There is also a mistletoe, *Viscum bancroftii*, with the appearance of orange twigs that parasitises another mistletoe, *Amyema quandang*, that in turn parasitises the brigalow tree itself. Bush tomatoes (*Solanum* spp.) are prominent in our list with four species that had distributions within brigalow habitat that has been extensively cleared.

What we needed beyond the life of this project is to undertake a more detailed assessment of these plant species and then work with the stakeholders and landholders who preside over the last vestiges of the brigalow forest.

The brigalow forest provides a specialised habitat with high tree densities and little grass.

Management may be critical, particularly the control of exotic grasses to prohibit damaging fires, and brigalow regrowth can provide a start for the recovery of the former forest where appropriate incentives can be provided to landholders. Brigalow itself can regrow from root suckers (from roots left after the initial clearing) though subsequent re-clearing of the regrowth can remove the wattle altogether.

While our study has indicated where we should be putting our effort in regards to plants growing in brigalow forests, our approach has a much broader application. We have demonstrated how existing data, in this case herbarium collection records and vegetation mapping, can be used to identify species threatened by rapid habitat loss, something that is being witnessed in many places across Australia and around the world.

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BELOW: A bush tomato (*Solanum dissectum*) only occurs in brigalow forest and should be listed as Critically Endangered because there is very little remnant habitat across its former range.

Monitoring for **threatened species** and **ecological communities**

Monitoring is fundamental to good policy and effective conservation management. Data derived from monitoring underpin the process for listing of species as threatened, which is a precursor to recognition in policy. When monitoring programs are well designed, they provide critical information to diagnose causes of decline, identify priorities for additional research, evaluate management effectiveness and assess the urgency of management. Monitoring can also be a powerful tool for engaging the community.

One of the first projects initiated by the TSR Hub was to gather monitoring experts, and managers who need and use monitoring information, from all over Australia to discuss the value of, and many challenges involved in, monitoring threatened biodiversity. The workshop led to an authoritative edited book *Monitoring Threatened Species and Ecological Communities*, due for release in early 2018.

Sarah Legge at The Australian National University led a team of editors on the book project, which incorporates contributions from over 70 scientists and managers. One of the key outputs from this collated work was an examination of the extent and adequacy of monitoring programs for threatened vertebrates and ecological communities. In this article, Sarah and John Woinarski discuss some of the key findings from these assessments.

ABOVE: Effective monitoring is the foundation of any effort to save threatened species. Pictured above are efforts to radio track southern brown bandicoots (NSW south coast).

Biodiversity monitoring in Australia is known to be limited and often sub-optimal. This is a particularly vexing situation for threatened species and ecological communities because successful conservation management should rest on robust evidence, and because managers may need to respond rapidly and confidently to population trend information about threatened species lest opportunities to save them are lost. Monitoring threatened biodiversity can be particularly challenging, with those challenges varying among individual threatened species and communities, meaning that monitoring designs need to be tailored carefully for every circumstance. General biodiversity monitoring programs, including surveillance monitoring, may be important for picking up unexpected changes in more common species but are usually inadequate for identifying trends in threatened species.

What should we be aiming for?

Effective monitoring usually entails more than simply counting a threatened species. Although such tallying may be useful, or better than no information, poorly designed monitoring may be a waste of limited resources. In general, the value of monitoring depends on its design, by the interpretation of, and access to, the resulting data, and the integration of that data into management decisions. The book presents a monitoring blueprint and set of standards that can be used to maximise the value of monitoring within a broader objective of improving the conservation outcomes for threatened biodiversity. The monitoring framework proposed recognises that, although the challenge and practicality of monitoring varies among different threatened species, good monitoring programs consistently possess certain objectives and characteristics.

The monitoring assessments were based on a framework of nine 'metrics' against which monitoring can be consistently judged. The framework, originally developed by the authors of the *Mammal Action Plan*[1], was adopted for assessing other species groups and (to a looser extent) ecological communities in this TSR Hub project.

National monitoring programs are high quality when they are 1) fit-for-purpose; 2) take place across sites that represent the threatened entity's distributional and environmental range; 3) occur with appropriate periodicity; 4) run for time periods that are long enough to detect trends; 5) are designed with sufficient statistical power for detecting change; 6) are coordinated across jurisdictions/organisations/stakeholders; 7) produce monitoring data that is publicly available and regularly reported. In addition, monitoring should be 8) clearly linked to management, and monitoring may be better interpreted when 9) information on demography/life history is collected as well as abundance/distribution data.

In our book, we use this framework to assess the extent to which current monitoring for threatened species meets these proposed standards. This proved to be challenging because much of the monitoring for threatened species is undertaken by many different organisations in Australia and is not publicly reported.

How are we faring?

For many threatened species, we could find no evidence of any monitoring activity. Depending on the taxonomic group, 21–46% of threatened vertebrates, and 70% of threatened ecological communities, are not monitored at all. This is a disturbing result, for without information from monitoring programs, managers (and our society more generally) will be ignorant of population trends or of where management most needs to be focused. Without monitoring, we may fail to notice that species are declining rapidly, and lose the chance to recover them. Without monitoring, the beneficial outcomes of management investments are hard to demonstrate.

Where monitoring does occur for a threatened species or community, its quality is often suboptimal. Of 24 threatened ecological communities for which there is some evidence of monitoring activity, the monitoring in eight ecological communities is confined to measuring land cover changes with remote sensing (ie, no on-ground assessments). Most of the remaining 16 ecological communities are ineffectually monitored (poor coverage across the ecological community range, poor design, no links to management, little data coordination, data and reporting not easily accessible by conservation managers or scientists). The book identifies the factors contributing to the limited extent and quality of monitoring for threatened ecological communities, and recommends a range of policy, regulatory, management and research actions that would improve the situation.

Key messages

- A framework of key principles for national threatened biodiversity monitoring programs has been developed. It can be used to assess existing programs and guide the development of new programs.
- Assessments of the national extent and adequacy of monitoring for ecological communities, mammals, birds, reptiles, frogs and freshwater fish have been undertaken.
- Species listed as threatened by the EPBC Act, with recovery plans, or that are charismatic, tend to be better-monitored, indicating the value of policy and public support for threatened species monitoring and management.
- However, many species and ecological communities are not monitored at all, and the average quality of existing monitoring programs is poor.
- Monitoring of threatened reptiles and freshwater fish is particularly inadequate.

For threatened animal species, monitoring quality is highly variable: monitoring was most adequate for threatened frogs and birds, followed by mammals, then fish, with reptiles a distant last. The large, enthusiastic and cooperative citizen science workforces, often centrally managed, that are involved in bird monitoring may explain the relatively higher quality for bird monitoring.

Applying the framework consistently across groups allowed us to identify which metrics generally scored highly or poorly (and therefore where the greatest room for improvement lies). For example, the weakest metrics were: the inclusion of demographic parameters (eg, breeding success) in the monitoring, the links of the monitoring to management, and data availability and reporting. The relatively poor performance of the last two indicates that existing monitoring programs are often failing to report, and failing to inform or affect management; these components of monitoring programs require urgent attention.

The assessments also highlighted several factors that are associated with better monitoring quality. Species that are listed as threatened under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999 are generally better-monitored than species included only in non-statutory lists (eg, like the Red List produced by the International Union for Conservation of Nature). For most vertebrate groups, the most highly-threatened taxa tend to have better monitoring than taxa listed with a lower threat category. Animal species with Recovery Plans generally have better quality monitoring programs than taxa without Plans. This suggests that some of the key functions of Recovery Plans are being realised (strategic approach to monitoring, better coordination, improved data management, reporting, and links to management); this finding supports the case for increasing policy and funding support for recovery planning.

Monitoring is often most adequate for threatened species that have a small range (eg, found on a single mountain top), of high public profile (eg, Tasmanian devils, marine turtles, migratory shorebirds, parrots), and for which the management is clearly the responsibility of a single agency.

In contrast, many taxa with large or multi-jurisdictional distributions suffer from lack of coordination in monitoring activity, or have monitoring carried out in only a small and perhaps unrepresentative extent of their range, threat environment and management. These results suggest that logistics and resources are key limitations for monitoring programs, because taxa with few individuals and small ranges (which will tend to be listed at higher threat categories) and high detectability are probably cheaper and simpler to monitor. However, charismatic taxa with high levels of community engagement are exceptions to this pattern.

The monitoring framework and assessments have highlighted differences in the extent and adequacy of monitoring across threatened species and ecological communities, the factors that influence monitoring adequacy, and the specific components of monitoring programs that most need improvement. The assessments revealed that (with some exceptions) national monitoring is generally inadequate across vertebrates and ecological communities, but the assessment framework provides a clear set of metrics that should be considered when developing new programs, as well as a method for consistently evaluating whether the adequacy of national monitoring for threatened biodiversity improves over time.

For further information

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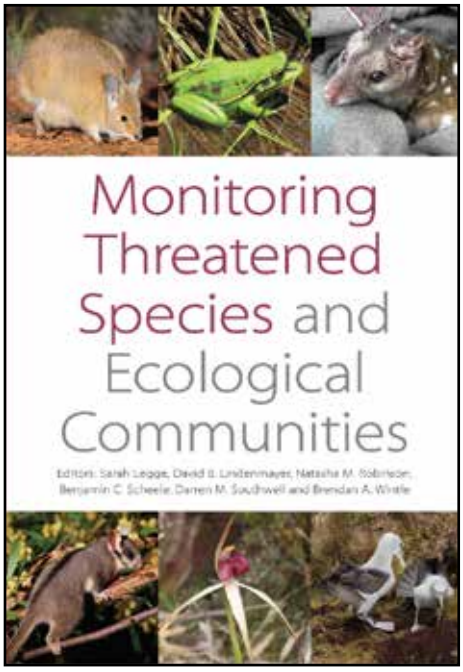
[1] Woinarski JCZ, AA Burbidge & PL Harrison (2014). *The Action Plan for Australian Mammals 2012.* (CSIRO Publishing: Melbourne.)



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Monitoring assessments were led by – *mammals*: John Woinarski, Andrew Burbidge, Peter Harrison; *birds*: Stephen Garnett, Hayley Geyle; *reptiles*: John Woinarski; *frogs*: Ben Scheele, Graeme Gillespie; *freshwater fish*: Mark Lintermans, Wayne Robinson; *ecological communities*: David Keith, Belinda Pellow, Matt Appleby.

Refuge in an uncertain future

Dr Natalie Briscoe's fascination with wildlife goes right back to her early childhood. Living in the foothills of the Dandenong Ranges outside of Melbourne, she was surrounded by bush and inspired by how animals were adapted to different environments, often coping with adverse conditions. And this fascination led to a career in analysing what it takes for a species to persist in a changing climate, and how this understanding helps identify what they need as refuge.

TSR Hub Researcher Profile

I was very fortunate in my early life. I lived in a wonderful bush setting and had a wonderful biology teacher in high school. She channelled my natural curiosity about wildlife into a more scientific way of thinking. I was particularly interested by how different animals managed to make a living in so many different ways, across such diverse environments.

At university, I pursued these interests with a major in zoology, alongside politics. This strange sounding combination proved valuable. Not only did I learn about the ecology of different species' and systems – but I also gained insight into how different societies function, and the drivers of many of the stressors on wildlife. I was particularly struck by the challenge of conserving biodiversity in the face of climate change, in highly modified landscapes. I began to appreciate that to manage species we need to understand their resource needs and what limits their survival.

My research has combined my curiosity for understanding how animals 'make a living' in their environment, with the desire to apply this knowledge to better protect them. I spent my PhD researching how koalas will be affected by climate change. I collected data on their physical traits and physiology, as well as how they behave in different weather. I then used this information to build a model that predicts how much energy and water koalas need to live in a particular place, based on the climate at that location. Using this model, we were able to predict which areas are likely to remain suitable for the koalas in the future – thereby identifying priorities for protection.

Along the way, I also learnt a lot about how koalas cope with the diverse range of environments they live in. In south-eastern Australia, for example, koalas cool down by hugging cool tree trunks during hot weather. It turns out that this behaviour is really effective at helping them cope with temperature extremes, when water is scarce. As a scientist, I love uncovering new information like this. But it can also help us protect koala populations, highlighting the importance of trees that provide cool tree trunks and deep shade, alongside trees they feed on.

Natalie Briscoe has always been fascinated by how animals live where they do. But what does this mean when the conditions where they live change. How do animals like koalas cope with climate change in (already) heavily modified forests and woodlands? What environmental elements would provide them refuge in the future when extreme weather conditions are forecast to be more frequent?

One of the best things about my job is that I work with a broad range of people who have incredible knowledge about the ecology of different species and systems, and a passion for making a difference. As part of my current work for the TSR Hub identifying and managing refuges from threats, I'm working with land managers, field ecologists, hydrologists, as well as experts in modelling and animal physiology. Together we're trying to identify strategies to reduce the impact of disease on threatened frogs, as well as understand what feral predators need to survive in different environments, so that we can better target management.

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Science for saving species

A quarterly publication of the Threatened Species Recovery Hub

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COVER IMAGE: DEJAN STOJANOVIC CHECKS OUT A NEST BOX FOR SWIFT PARROTS HIGH IN THE TREE TOPS. (SEE PAGE 8 FOR THE FULL STORY).
IMAGE: BY DEJAN STOJANOVIC