

Science for saving species

ISSN 2652-1334

Spring 2020
Issue 17

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Hayley Geyle



**Threatened
Species
Recovery
Hub**

National Environmental Science Programme

Editorial...

The importance of community for threatened species



IMAGE: DOMINIC CHAPLIN

Threatened Species Recovery Hub Deputy Director **Professor Stephen Garnett** from Charles Darwin University reflects on the importance of the community in threatened species conservation, from passionate volunteers to vast numbers of people making small changes that collectively add up to big wins for Australian nature.

ABOVE: Birdwatchers like Dominic Chaplin have collected vast amounts of valuable survey data across Australia. This photo was taken during a tough walk up Mount Elliot to survey display courts of tooth-billed bowerbirds (below).

The mosquitoes were dreadful, the route steep and unmarked, and the rainforest uncomfortably dense – but there was triumph in this morning’s message about a recent trip to the top of Mount Elliot, a high, isolated peak south of Townsville. The trio of birdwatchers had found display courts of tooth-billed bowerbirds, an upland species at risk from rising temperatures. The expedition also completed the first comprehensive survey of the species, documenting the location of 650 active courts.

Dom Chaplin and his friends are not professional scientists or conservation managers. Rather, they are part of the multilayered community commitment to nature that makes all threatened species conservation possible.

Valuable volunteers

Such support takes many forms. Dom and his friends may have more energy and endurance than most, but they are not alone. Many enthusiastic volunteers contribute

to surveys and monitoring. Birdwatchers are probably the best organised group, with BirdLife Australia and other platforms providing a ready means of assembling observations. However, knowledge of the rarest fish and reptiles described in this issue (page 6 and page 16) would be far less complete but for the contributions of volunteer naturalists. In a similar exercise on butterflies, nearly every expert was an amateur naturalist with a passion for their subject and an extraordinary level of expertise in butterfly natural history.

In a sense, the paid professionals also provide a form of community support that is often overlooked. Few conservation managers see their work as just a job. On the contrary, their chosen career is a vocation, with the salary forming just a part of their deep personal commitment to retaining our biological inheritance.

Many people in government conservation agencies dedicate their careers to threatened



IMAGE: DOMINIC CHAPLIN

species conservation, sometimes putting aside opportunities for professional advancement to remain close to species they have come to love.

Community support is often provided in partnership with professionals for the active management of many species.

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National Environmental Science Programme

TOP: Pittsworth District Landcare Association are important champions for the Condamine and Roma (shown) grassland earless dragons, which are among Australia's most threatened reptiles (see page 16).

IMAGE: STEPHEN ZOZAYA



MIDDLE: The Association has coordinated community surveys of paddocks and road verges for the species, raised awareness and promoted sustainable farming practices to support the survival of the lizards.

BOTTOM: Mt Tyson Landcarer Paula Halford (right) with representatives of Ergon Energy which co-sponsored the production of chocolate Condamine dragons by local confectioner White Mischief as part of an awareness and fundraising campaign. Funds raised supported essential research for the Condamine dragon by Museums Victoria.

Such partnerships were a common thread in the hub's book on conservation success (*Recovering Australian threatened species: A book of hope*). Nest boxes are built and erected for hollow-dependent species, forests planted, weeds pulled, habitat fenced. Outside funding often contributes to the costs of materials but the labour is entirely voluntary, and worth far more because money cannot buy passion for a cause. Involvement in such activities further deepens the bond between the human community and the threatened species with which they live. People can return years later to a replanted forest and witness with pride the grown trees that they first knew as tender seedlings.



IMAGE: PITTSWORTH DISTRICT LANDCARE ASSOCIATION

The power of numbers

Community support can also be more passive. In this issue is an article on the destruction wrought by domestic cats (see page 12). Many people need no persuasion to keep their cat at home. They love Tabitha, but they love wildlife too. Drivers slow down for the sake of cassowaries. Farmers leave forest fragments for the sake of threatened plants. An awareness of threatened species nudges people towards empathetic behaviour. Not everyone can become actively involved, but surveys have shown that the vast majority of Australians do not want more extinctions.

Similarly, for Indigenous people, threatened species conservation is often not an end in itself but rather an emergent property of culturally driven caring for Country. Well-nurtured Country will keep its full quota of species and, as sometimes new threats have arisen, new skills need to be learnt. As with the story of Mankarr in this issue (page 14), threatened species can also act as conduits for old knowledge from a time when the animals were not threatened at all.

Meaningful engagement between Western scientists and Indigenous communities leads to better outcomes for threatened species; as a hub we are working to support researchers and institutions to work with Indigenous people in a culturally respectful way (page 9).

Tangible support

The ultimate form of community support is political. Once naturalists wrote wistfully about the inevitable loss of species in the



IMAGE: PITTSWORTH DISTRICT LANDCARE ASSOCIATION

face of "progress". However, over the past 50 years, more and more Australians have recoiled from the idea of losing nature, particularly threatened species. Of course, as is proper in a democracy, ideas are contested – but legislation to protect threatened species, and investment into research and management, would never have happened without a broad shift in community attitudes.

In some ways the effectiveness of a country in retaining its full complement of species can be seen as a measure of its overall success – a proxy measure of its wealth, its governance and its commitment to a long-term future – in short, a measure of the quality of its society.

Overall, threatened species conservation provides a tangible expression of the community's love of nature, and fear of its loss. Alex Kusmanoff and colleagues talk in their article (page 10) about the role emotional connection plays in messaging. Many abstract notions in conservation – landscapes, biodiversity, threatening processes – have little resonance in the

hearts of the broader community. A personal bond with threatened species is far more powerful, and the product of a long history of communication about species scarcity, the intrinsic value people place on rarity and the finality of extinction.

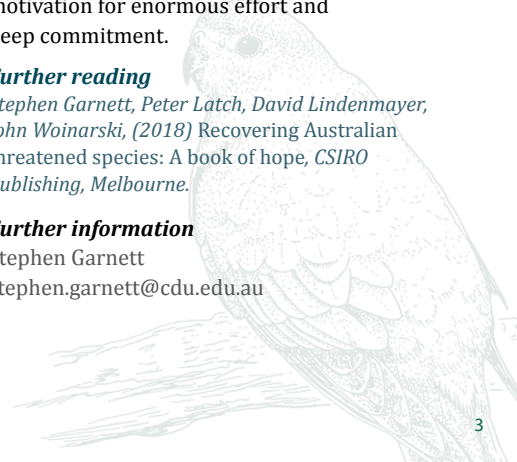
Back on Mount Elliot, long-term climate scientist/biologist Stephen Williams has described climbing the 1218 m mountain as among "the hardest walks I have done on any mountain here or elsewhere in the world". Threatened species continue to provide motivation for enormous effort and deep commitment.

Further reading

Stephen Garnett, Peter Latch, David Lindenmayer, John Woinarski, (2018) *Recovering Australian threatened species: A book of hope*, CSIRO Publishing, Melbourne.

Further information

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Moving mountains for the antechinus:

The importance of food availability and high-elevation habitat

IMAGE: GARY CRANITCH, OLD MUSEUM

Queensland has several species of antechinus, tiny insect-eating mammals. A few species need cool, moist, habitat found at high elevation. But as climate change advances, these rare and often threatened species are forced into ever smaller and higher areas on mountain-tops. **Rachael Collett's** University of Queensland research shows that, without concerted action, the already-fragmented ranges of these cloud forest antechinus species may disappear to nothing. She takes up this story of ancient species with specialist habits.

Antechinuses are insectivorous marsupials found mainly on Australia's east coast. The mountain ranges of eastern Queensland have the greatest diversity of antechinus species, with nine found between the New South Wales border and Cape York, weighing between 15g and 75g. They are agile and nocturnal, and insectivorous – they hunt arthropods (insects and spiders) in moist leaf litter and on tree bark at night.

Male antechinuses go out with a bang. At 11.5 months old, during their first (and only) breeding season, they become active day and night while searching for females and mating repeatedly for up to 14 hours at a time.

This frantic mating period is over after two to three weeks in winter or early spring, and all males die soon after. Females usually survive until after their litter of eight young are weaned the next summer.

Cool climes, small ranges

Since 2012, three new species of antechinus have been discovered in Queensland. In 2018, two of these new species, the silver-headed antechinus (*Antechinus argentus*) and the black-tailed dusky antechinus (*Antechinus arktos*), were federally listed as Endangered. Both occur on isolated mountain-tops and are among the most geographically limited mammals in Australia.

Based on historical records from the 1970s and 80s and more recent survey efforts, the black-tailed dusky antechinus appears to have retreated to high elevations on the Tweed Volcano caldera. Similarly, the silver-headed antechinus is now only found at three small sites in central Queensland: the peak of Kroombit Tops near Gladstone, and the highest sections of Bulburin National Park near Miriam Vale and of Blackdown National Park near Emerald.

The poorly known Atherton antechinus (*A. godmani*) from Queensland's wet tropics only occurs in a 30 km-wide band of rainforest above 650 m elevation in the Atherton uplands. The distribution and habitat of the Atherton antechinus is highly fragmented, and it is expected to lose much of its current range to climate change over the next 30 years.

The persistence of Australian insectivorous marsupials is thought to be tightly linked to the availability of their prey. Climate change has been implicated in reduced insect abundance in the northern hemisphere. Understanding the relationship between these insectivorous marsupials and their prey has become particularly important, as local populations of antechinuses disappear in drought, and they appear to be declining across Australia.

To understand why threatened antechinuses are so rare, and how climate change is affecting them, we collaborated with Andrew Baker at Queensland University of Technology and members of his mammal ecology lab, PhD students Eugene Mason, Emma Gray and Thomas Mutton, to examine antechinus population density

IMAGE: ANDREW BAKER

LEFT: *Antechinus argentus* female with 6–8 week-old pouch young.

across mountains in Queensland. We then looked at how population density was related to rainfall and seasonal food abundance.

Ancient species, modern problems

Historical data, combined with intensive live trapping and prey sampling has shown that the lowest population densities for antechinuses are in the tropics and at low elevations. Low population density is caused by limited food in winter, due to lower winter rainfall. High-elevation sites maintain high food abundance throughout the year because they receive ongoing “orographic” rainfall. This is rainfall produced as moist air lifts over a mountain range. Australian mountain-tops are therefore vital refuges for threatened and range-restricted antechinuses. As the climate continues to become hotter and drier, suitable climate for cool-adapted species is contracting to higher elevations, and year-round supply of the insects and spiders that these predators rely on is contracting along with it.

Winter (dry season) food is limited in the tropics. The rarity of tropical species has been noticed by past researchers, but the cause has remained elusive. We have shown that the low abundance of insects and spiders in winter helps to explain the rarity of antechinus species in the seasonal subtropics and tropics, including the Endangered silver-headed antechinus in central Queensland, and the restricted Atherton antechinus and rusty antechinus in far north Queensland.

Genetic research has established that Queensland antechinus species have been evolving for at least six million years, and the most recent species separated from sister species around 1 million years ago.

We also found that while up to three antechinus species could occur on the same mountain, they would have different elevational distributions. The most ancient antechinus species had the smallest ranges and only occurred on mountain-tops. This may be because they are restricted to cool climates and rainforest habitats most similar to those

IMAGE: GARY CRANITCH, QLD MUSEUM



The black-tailed dusky antechinus (*Antechinus arktos*) has retreated to high elevations on the Tweed Volcano caldera.

in which they evolved. These ancient antechinus species restricted to high elevations are at greatest risk from climate change. As the area of suitable climate, habitat and food decreases on mountain-tops, and antechinus distribution shrinks upwards, these rare and threatened animals may eventually have nowhere left to find refuge.

The threat of climate change

A substantial proportion of the world’s vertebrate fauna is insectivorous, and the prey base for these animals appears to be declining globally. Their cryptic and uncharismatic nature means that this loss of invertebrate biodiversity has received relatively little attention.

Our study has shown that the abundance of invertebrates can affect the persistence of threatened mammals that depend on them for food. Maintaining insect abundance should be a high conservation priority, not only because these species are important in their own right, but also because declines are likely to have detrimental flow-on effects on other species that depend on them worldwide.

We conclude that climate change is, and will continue to be, a major threat to the persistence of antechinuses. With changed climatic conditions, insectivorous species will need protected areas with high food abundance. Our study found that many Australian mountain-tops maintain high insect numbers year-round because they receive moisture from cloud-drip and orographic rainfall.

Most montane, high-elevation habitats where antechinus species occur have acted as refugia during past climatic changes, and they are likely to be important refuge areas under scenarios of ongoing climate change. Protecting these habitats is a critical priority. Luckily, many of these areas are currently located in national parks, but montane habitats outside of the reserve system should also be identified and preserved if we are to have the greatest chance of conserving these rare and ancient species.

Further information

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Springbrook National Park, Queensland, provides cool, moist habitat for the black-tailed dusky antechinus (*Antechinus arktos*).

IMAGE: LEANNE WHITE, DES



Big trouble for little fish: The 22 freshwater fishes at risk of extinction

IMAGE: MICHAEL HAMMER

Australian freshwater fish are in dire straits. A team of fish experts took a close look at which species were likely to go extinct in the next 20 years or so and warn that without targeted interventions over 20 species are at risk of extinction in the near future. **Associate Professor Mark Lintermans** of the University of Canberra and **Hayley Geyle** of Charles Darwin University take up this tale of fishes in hot water.

The tragic recent fish kills in the lower Darling River have helped draw attention to the dire plight of Australia's freshwater fishes, but Australian freshwater fish have been in trouble for a long time. Many species have declined sharply in recent decades, and as many as 90 of our approximately 315 freshwater fishes may now meet criteria as threatened.

No Australian fish species is yet listed officially as Extinct but some have almost certainly been lost before scientists ever knew they existed. With so many fishes at risk, understanding which species are in greatest peril is a vital first step in preventing extinctions.

Small freshwater fish are slipping through the conservation cracks

In collaboration with the Australian Society for Fish Biology, our team of leading Australian freshwater fish experts evaluated population sizes and trends, and current and looming threats to identify species at high extinction risk.

We identified 20 species that have a 50% or greater probability of extinction within the next two decades unless there is new targeted conservation action, and a further two with a greater than 40% chance of extinction in that period.

Many small-bodied species like the Daintree rainbowfish, Barrow cave gudgeon, red-finned blue-eye, little pygmy perch and stocky galaxias that have evolved over millions of years look likely to be lost within a single human generation.

Nineteen of the species identified are unlisted under the EPBC Act; 12 have only been formally described in the past decade, and seven are awaiting description.

This highlights the need to act before species are listed under legislation and even before they are formally described. These formal processes can take many years, at which point it may be too late for some species.

Drought, trout and fires

More than half of the species on the list are galaxiids – small-bodied, scaleless fish that live in cooler, upland streams and lakes.

A north Queensland stream that is habitat for the Daintree rainbowfish.



IMAGE: MICHAEL HAMMER-MUSEUM AND ART GALLERY OF THE NT

These habitats are also favoured by trout, much larger predatory species which were introduced to Australia for recreational fishing. Trout have taken a heavy toll on galaxiids and many other small-bodied species in southern Australia.

For example, Victorian Shaw galaxias have been eaten out from much of their former range. Now just 80 individuals survive, protected by a waterfall from the trout below. We estimate that the Shaw galaxias has a greater than 80% probability of extinction within the next 20 years unless we do something soon to save the species.



IMAGE: TARMO A. RAADIK
Victoria's Shaw galaxias is one of 14 species of galaxias identified as being at high risk of extinction. Predation by introduced trout is a major threat to these small-bodied native species.

Many galaxiids do not thrive or readily breed in captivity, so suitable trout-free streams are essential for their survival. Urgent, sustained effort is needed to improve trout management, including collaborations with recreational fishers, increased awareness, and changing values among government and key sectors of society. Without this, trout will almost certainly cause extinctions of native galaxiids.



IMAGE: MARK LINTERMANS
This waterfall in New South Wales is protecting highly threatened fish from downstream trout.

Native fish out of place can also be a problem. For example, sooty and khaki grunters, favoured native fishing species that have been widely translocated in northern Australia, threaten the ancient Bloomfield River cod. Tiny Malanda and Running River rainbowfishes are being displaced or hybridised out of existence by larger eastern rainbowfish that have been released from aquaria.



IMAGE: MICHAEL HAMMER - MUSEUM AND ART GALLERY OF THE NT
The Malanda rainbowfish is at risk from hybridisation with the larger and more common eastern rainbowfish.

All our eggs in one basket

All of the most imperilled species are now highly localised, with ranges of between only 4 and 44 km². These species could now be wiped out by a single catastrophic event, like a large bushfire that fills their streams with ash and robs them of oxygen.

Until 2019, the Yalmy galaxias had survived in the cool creeks of Snowy River National Park. Just two survived the great fires of last summer, one male and one female, in separate areas. Millions of years of evolution could be lost if a planned reunion is too late.

One of the key management steps that can be taken to reduce this risk is carefully considered translocations to safe locations.

Climate change is another threat to all identified species, as it is likely to cause reduced flows and water quality, or increased fires, cyclones and flooding. Many species have been forced to the edge of their range and a prolonged drought could dry their remaining habitat.

The short-tail galaxias existed in two small, separated populations in creeks of the upper Tuross River Catchment: one stream dried, and the other was burnt. Luckily, the species is still hanging on in the burnt catchment, but only a single individual has been found in the drought-affected creek.



IMAGE: MICHAEL HAMMER - MUSEUM AND ART GALLERY OF THE NT
The main threat to the Daintree rainbowfish is loss of stream flow due to drought, climate change and water extraction.

Unlisted, unprotected

Only three of the highly imperilled fish species are currently listed as threatened under national environmental legislation (EPBC Act). Listing species under legislation is important to provide some protection to the last

remaining survivors and can prompt recovery action. Given our assessment of extinction risk, we consider that 19 fish species should be urgently added to the national list of threatened species.

The study is part of a larger project to identify the plants and animals at high risk of extinction. Assessed with the same method, the extinction risk for the top 20 freshwater fishes is much higher than those of the top 20 birds, reptiles or mammals. Most of the fishes have far smaller distributions and have received far less conservation effort.



IMAGE: STEPHEN BEATTY - HARRY BUTLER INSTITUTE, MURDOCH UNIVERSITY
The little pygmy perch in the far south-west corner of Western Australia is one of only three of the imperilled species identified that is formally protected under the EPBC Act.

Preventing extinctions

Understanding which species are at highest risk is a critical first step, but must be followed by targeted action, investment and collaboration among governments and non-government organisations to mitigate threats and support recovery.

Small native freshwater fishes are worth saving; they play a vital role in our aquatic ecosystems (such as preying on pest insect larvae) and are part of our natural heritage. By identifying and drawing attention to the plight of these highly imperilled species we are aiming to change their fates. We cannot continue with business as usual if we want to prevent their extinctions.

Further information

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See next page for the Australian freshwater fish at greatest risk of extinction within 20 years.

The Australian freshwater fish at greatest risk of extinction within 20 years

Species	Region	Likelihood of extinction (%)
Shaw galaxias <i>Galaxias gunaikurnai</i>	Vic.	≥70
West Gippsland galaxias <i>Galaxias longifundus</i>	Vic.	≥70
Tapered galaxias <i>Galaxias lanceolatus</i>	Vic.	≥70
Dargo galaxias <i>Galaxias mungadhan</i>	Vic.	≥70
Morwell galaxias # <i>Galaxias sp.</i>	Vic.	≥70
McDowall's galaxias <i>Galaxias mcdowalli</i>	Vic.	≥70
Malanda rainbowfish # <i>Melanotaenia sp.</i>	Qld	≥70
Stocky galaxias <i>Galaxias tantangara</i>	NSW	50–69
Red-finned blue-eye* <i>Scaturiginichthys vermeilipinnis</i>	Qld	50–69
Kosciuszko galaxias <i>Galaxias supremus</i>	NSW	50–69
Yalmy galaxias # <i>Galaxias sp.</i>	Vic.	50–69
East Gippsland galaxias <i>Galaxias aequipinnis</i>	Vic.	50–69
Hunter galaxias # <i>Galaxias sp.</i>	NSW	50–69
Moroka galaxias # <i>Galaxias sp.</i>	Vic.	50–69
Barrow cave gudgeon <i>Milyeringa justitia</i>	WA	50–69
Swan galaxias* <i>Galaxias fontanus</i>	Tas.	50–69
Short-tail galaxias <i>Galaxias brevissimus</i>	NSW	50–69
Running River rainbowfish # <i>Melanotaenia sp.</i>	Qld	50–69
South-western Victoria river blackfish # <i>Gadopsis sp.</i>	Vic.	50–69
Daintree rainbowfish <i>Cairnsichthys bitaeniatus</i>	Qld	50–69
Little pygmy perch* <i>Nannoperca pygmaea</i>	WA	40–49
Bloomfield River cod <i>Guyu wujalwujalensis</i>	Qld	40–49

*The red-finned blue-eye, Swan galaxias and little pygmy perch are each listed as Endangered under Australia's Environment Protection and Biodiversity Conservation Act 1999. All other species identified in the study as being at high extinction risk are not listed under the Act.

Species recently discovered and not yet formally described.



IMAGE: MARK KENNARD

The Bloomfield cod occurs at only one location. Its main threats are introduced fish species and habitat degradation caused by feral pigs.



IMAGE: TARMO A RAADIK

The stocky galaxias is only found in one 4 km stretch of stream in Kosciuszko National Park, above a waterfall which protects the fish from the trout below.



IMAGE: BUSH HERITAGE AUSTRALIA, ADAM KEREZSY

The red-finned blue-eye is only found in a few shallow marshy spring-fed pools on top of the Lake Eyre basin. It has been seriously threatened by the introduced eastern gambusia.



IMAGE: TARMO A RAADIK

The newly discovered south-western Victoria river blackfish is undergoing decline due to loss and deterioration of habitat as a result of ongoing dry conditions, poor land practices and fishing.

Karajarri Rangers Marissa and Jacko undertaking a fauna survey in the Edgar Ranges as part of a hub project that Karajarri Rangers are leading to investigate how different fire management approaches affect biodiversity on their desert country. The project is answering questions they have and will support them to make more informed land management decisions.

IMAGE: NICOLAS RAKOTOPARE

Indigenous Engagement Protocols: Forging respectful, meaningful partnerships for research impact

Bradley Moggridge, the Threatened Species Recovery Hub's Indigenous Liaison Officer, brought his authoritative Indigenous voice to the creation of a set of protocols for hub researchers seeking to collaborate with Indigenous partners. Drawing on his experience as a research scientist and natural resource practitioner, he has written a practical guide which is designed to complement the hub's Indigenous Engagement and Participation Strategy (2016). He tells us more about this exciting and important new publication.

The success of our hub's research activities is based on meaningful partnerships with many Indigenous Australians. To support meaningful collaboration with Indigenous partners, the hub developed an Indigenous Engagement and Participation Strategy (IEPS, 2016) at its inception. The IEPS sets out high-level aims and vision, and overarching principles for engagement, behaviours expected of hub researchers, and how the hub is to monitor progress against these. The hub also has an Indigenous Reference Group (IRG) to further guide meaningful partnerships between the hub, Indigenous project teams, researchers and research users.

In response to a request from the IRG and the hub early and mid-career researchers' network, we developed a set of protocols: *Indigenous Engagement Protocols for Threatened Species Researchers*. The purpose of these protocols is to guide researchers and institutions to work better with Indigenous people in a culturally respectful way, aiming for a co-developed two-way conversation while recognising that the nature of individual relationships can vary greatly.

Founded on respect and experience

The protocols set out principles for engagement, which start with the importance of respect and go on to outline principles of integrity and authenticity, and accountability. The protocols also underscore the important goal of the hub of providing opportunity for Indigenous-led research and projects, and acknowledge that in the past too many Indigenous people and communities have experienced loss of their knowledge and intellectual property through research engagements. The meaningful engagement that the protocols are designed to support, on the other hand, ensures that Indigenous people have a say in all aspects of a project and will own their intellectual property, while being recognised as the owners of that knowledge.

The protocols emphasise not only reciprocity but also the need for cultural awareness and competence, as well as offering guidance about communicating appropriately with Indigenous people and communities. Engagement needs to be built on deep listening, learning and talking or yarning, with researchers ready to consider the stories and perspectives of Indigenous partners.

Researchers who wish to work alongside Indigenous communities will find the explanations of common cultural practices insightful, such as the consideration of men's and women's business, who can "Speak for Country", and knowing what you are allowed to know.

Meaningful engagement is not only the right thing to do, it also leads to better science and research outcomes for the environment. Engagement that is based on co-benefit can link Traditional Knowledge and Western science in ways that can bring about new science for threatened species recovery.

Further information

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Work cited:

<https://www.nespthreatenedspecies.edu.au/publications-and-tools/indigenous-engagement-protocols-for-threatened-species-researchers>

5 lessons for more effective conservation messaging

Building community support for conservation is crucial for achieving successful outcomes. Communication activities are an important part of building this support and are used to encourage specific behaviour changes, such as getting more people to keep their pet cats inside. How we say stuff can have a big influence on how effective our communications are. **Alex Kusmanoff and colleagues** at RMIT University have five lessons that can help conservation managers and researchers make their messages more effective.

1. How you say something can be as important as what you say

We know that how we talk about or “frame” information can have a big impact on the way people understand it, and how they respond to messages (Figure 1). Therefore, how we say something may be just as important as what we say. Although this has long been understood by advertisers and politicians, it is not something that has often been practised within ecology and conservation.

2: Emphasise the things that matter to your audience (not necessarily what matters to you)

Strategically framing a message requires careful identification of the target audience, and understanding something about them and how best to engage them (Figure 2). Unfortunately, considering audiences in this way is not often done well in conservation, where all too often we pitch our messages primarily to those who already care.

Just because you care about protecting the habitat of a threatened species doesn't mean that your target audience will, but other aspects of the issue may resonate with that audience (e.g., retaining natural areas for human recreation or wellbeing). You should also consider who/what might be the best messenger for that audience, as they will pay far more attention to some communication sources than others.

3: Use social norms

Social norms are the informal rules of “normal” behaviour within a particular social group, and strongly influence behaviour. For example, people are more likely to litter in an environment that is already littered, as the discarded litter indicates this is normal behaviour in that environment.

Ensure, then, that what you emphasise in your messages promotes helpful norms. Specifically, you should emphasise desirable behaviour, and also social approval of the behaviour. By the same token, you should avoid emphasising undesirable behaviour, as this can indicate that such behaviour is “normal” and thus (unintentionally) promote it (Figure 3).

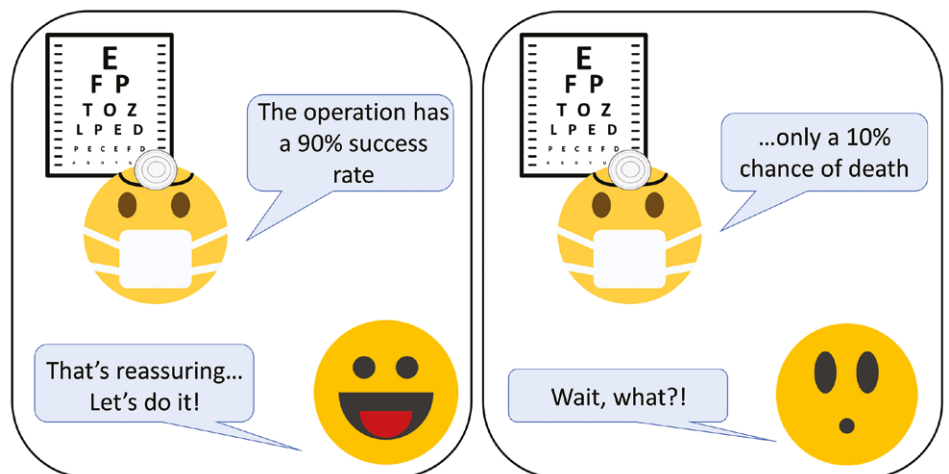


Figure 1. Alternative ways of framing information can influence the ways an audience may respond to it.

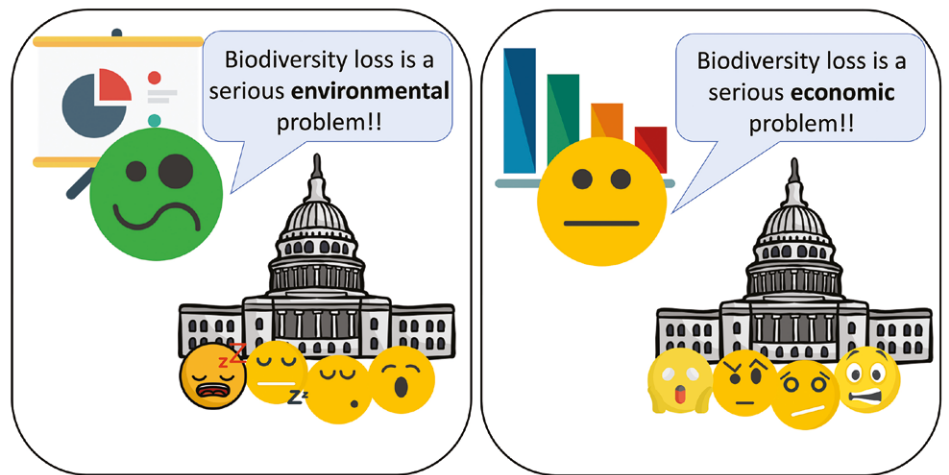


Figure 2. Issues should be framed to suit the audience you want to influence, for example, by focusing on the issues that will be of most importance or interest to them. This figure is based on a cartoon by Felix Schaad.

Deliberately leveraging social norms can be an effective strategy, and has been used to promote many different behaviours ranging from the re-use of hotel towels to pro-health related behaviours and even tax compliance (among many examples).

4: Reduce the psychological distance

Psychological distance is the sense of distance that people feel from themselves to another person, event or issue. When this is larger, people tend to think about the matter in a more abstract fashion, and may be less motivated to take action.

Re-framing a message to reduce psychological distance can help engage the audience about an issue. Psychological distance includes geographic, temporal or social distance, and is also affected by the relative certainty of an event occurring (greater certainty reduces psychological distance).

A message framed to emphasise that a problem will affect people like the audience themselves, occur nearby and is highly likely to occur sometime soon will help reduce this distance (Figure 4).

One approach to increasing the vividness of a message is to evoke emotion. Emotive messages can be effective at motivating an audience, and may often be more influential than rational appeals.

However, when seeking to reduce psychological distance, you must take care not to make the situation seem hopeless. This is a particular challenge for biodiversity conservation, given the complex and diffuse nature of many such problems. Hope-based appeals may be more effective at encouraging individual action.

5: Leverage useful biases

Biases that influence how we think and behave are called cognitive biases. There are many common types and if you are aware of them you can use them to your advantage or at least avoid ones that could unintentionally reduce the effectiveness of your messages.

For example, negative framing is often more effective at influencing people than the same message said in positive language (Figure 5).

Prospect theory results in a tendency for people to weigh losses more heavily than equivalent gains, so for environmental policy options “restored loss” tends to be seen as more favourable than a “new gain”.

Other common biases to be aware of include: the scarcity heuristic, in which items or commodities perceived to be in short supply are considered more desirable and therefore more valuable; the endowment effect, in which people tend to value something more highly when they own it than if they do not; and the status quo bias, which is the preference to avoid change, so that when presented with alternatives, people display a bias for the status quo. (This is one reason why the “default” option is often a popular choice.)

Final note

Framing is no silver bullet and should always be considered for a given audience and context. Nonetheless, these proven general principles will help you begin to strategically frame your messages for greater effect.

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Further information

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Figure 3. These menus are examples of how information can be framed to activate social norms, either helpfully or unhelpfully. Kuzzy's menu communicates that making sustainable choices is normal behaviour for customers. At Sier's this norm is paired with information about social approval of this behaviour, likely enhancing the influence of the message. In contrast, Henry's establishes a norm of eating seafood regardless of how it is sourced, potentially encouraging this undesirable behaviour.



Figure 4. The whale poster on the left communicates the issue as something far away (Antarctica) that has nothing to do with people's lives (a whale in its natural state). In contrast, the poster on the right seeks to reduce psychological distance by: increasing the vividness; making the whale relatable to humans (i.e., the whale is making a plea for help, is crying); avoiding mention that the hunt is occurring far away; and seeks to engender a connection to the reader by referring to “our” whales.

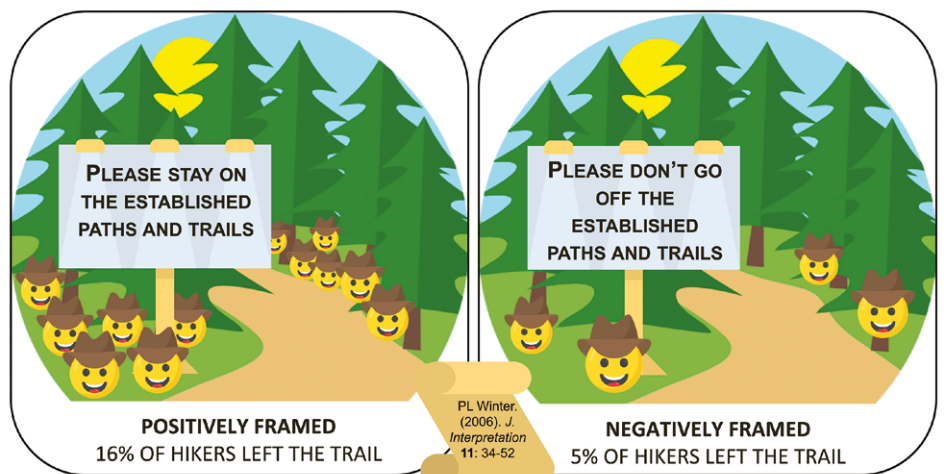


Figure 5. Negative messaging is often more effective than the same message in positive language. In a study by Winter (2006), more than three times as many hikers who encountered the positively framed sign disobeyed the request to stay on the path.

One cat, one year, 110 native animals: Lock up your pet, it's a killing machine



IMAGE: PACTO-VISUAL, UNSPLASH

Our beloved pet cats are having an enormous impact on wildlife. **Jaana Dielenberg** (UQ), **Professor Sarah Legge** (ANU/UQ), **Professor John Woinarski** and **Dr Brett Murphy** (CDU), **Professor Chris Dickman** (USyd), **Professor Mike Calver** (Murdoch) and **Dr Leigh-Ann Woolley** (CDU/WWF) explain why we should expand our focus from feral cats to include cats closer to home.

We know feral cats are an enormous problem for wildlife – across Australia feral cats collectively kill more than three billion animals per year.

Cats have played a leading role in most of Australia's 34 mammal extinctions since 1788, and are a big reason populations of at least 123 other threatened native species are dropping.

But pet cats are wreaking havoc too. Our new analysis compiles the results of 66 different studies on pet cats to gauge the impact of Australia's pet cat population on Australia's wildlife.

The results are staggering. On average, each roaming pet cat kills 186 reptiles, birds and mammals per year, most of them native to Australia. Collectively, that's 4440 to 8100 animals per square kilometre per year for the area inhabited by pet cats.

If you own a cat, and also want to protect wildlife, you should keep it inside. In Australia, 1.1 million pet cats are contained 24 hours a day by responsible pet owners. The remaining 2.7 million pet cats – 71% of all pet cats – are able to roam and hunt.

What's more, your pet cat could be getting out without you knowing. A radio-tracking study in South Australia found that of the 177 cats whom owners believed were inside

at night, 69 cats (39%) were sneaking out for nocturnal adventures.

Surely not my cat

Just over one-quarter of Australian households (27%) have pet cats, and about half of cat-owning households have two or more cats.

Many owners believe their animals don't hunt because they never come across evidence of killed animals. But studies that used cat video tracking collars or scat analysis (checking what's in the cat's poo) have established that many pet cats kill animals without bringing

them home. On average, pet cats bring home only 15% of their prey.

The only way to prevent a pet cat from hunting is to keep it securely contained, indoors or in a cat run.

Collectively, roaming pet cats kill 390 million animals per year in Australia. This huge number may lead some pet owners to think the contribution of their own cat wouldn't make much difference. However, we found even single pet cats have driven declines and complete losses of populations of some native animal species in their area.

Keeping pet cats securely contained 24 hours per day is the only way to prevent them from killing wildlife.



IMAGE: JAANA DIELENBERG

Documented cases have included: a feather-tailed glider population in south-eastern New South Wales; a skink population in a Perth suburb; and an olive legless lizard population in Canberra.

Feral cats vs pet cats

On average, an individual feral cat in the bush kills 748 reptiles, birds and mammals a year – four times the toll of a hunting pet cat. But feral cats and pet cats roam over very different areas.

Pet cats occur mostly in cities and towns, where you'll find 40 to 70 roaming cats per square kilometre. In the bush there's only one feral cat for every three to four square kilometres.

So, while each pet cat kills fewer animals than a feral cat, their high urban density means the toll is still very high. Per square kilometre per year, pet cats kill 30–50 times more animals than feral cats in the bush.

Most of us want to see native wildlife around towns and cities. But such a vision is being compromised by this extraordinary level of predation, especially as the human population grows and our cities expand.

Many native animals don't have high reproductive rates so they cannot persist with this level of predation. The stakes are especially high for threatened wildlife that occur in urban areas.

Pet cats living near areas with nature also hunt more, reducing the value of places that should be safe havens for wildlife.

The 186 animals each pet cat kills per year on average includes 110 native animals (40 reptiles, 38 birds and 32 mammals).

For example, the Critically Endangered western ringtail possum is found in suburban areas of Mandurah, Bunbury, Busselton and Albany in Western Australia. The possum did not move into these areas, rather we moved into their habitat. And to add to their habitat loss we also brought our cats.



IMAGE: L KNIGHT

The Critically Endangered western ringtail possum is found in suburban areas of Mandurah, Bunbury, Busselton and Albany in Western Australia. Cats are one of its major threats.

What can pet owners do?

Keeping your cat securely contained 24 hours per day is the only way to prevent it from killing wildlife.

It's a myth that a good diet or feeding a cat more meat will prevent hunting: even cats that aren't hungry will hunt.

Various devices, such as bells on collars, are commercially marketed with the promise of preventing hunting. While some of these items may reduce the rate of successful kills, they don't prevent hunting altogether.

And they don't prevent cats from disturbing wildlife. When cats prowl and hunt in an area, wildlife have to spend more time hiding or escaping. This reduces the time spent feeding themselves or their young, or resting.

In Mandurah, the disturbance and hunting of just one pet cat and one stray cat caused the total breeding failure of a colony of more than 100 pairs of fairy terns.

Benefits of a life indoors

Keeping cats indoors protects pet cats from injury, avoids nuisance behaviour and prevents unwanted breeding. Cats allowed outside often get into fights with other cats, even when they're not the fighting type (they can be attacked by other cats when running away).

Roaming cats are also very prone to getting hit by a vehicle. According to the Humane Society of the United States, indoor cats live up to four times longer than those allowed to roam freely.

Indoor cats have lower rates of cat-borne diseases, some of which can infect humans. For example, in humans the cat-borne disease toxoplasmosis can cause illness, mental health issues, miscarriages and birth defects.

But Australia is in a very good position to make change. Compared to many other countries, the Australian public are more aware of how cats threaten native wildlife and more supportive of actions to reduce those impacts.

It won't be easy, but since more than one million pet cats are already being contained, changing behaviour is possible if we take responsibility for our cats.

Further information

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Kids learning to track Mankarr on Martu Country

On the Martu Determination in the Western Deserts, Kanyirninpa Jukurrpa's (KJ) Punmu Ranger and Families Programs are working together to teach important Traditional Ecological Knowledge about Mankarr (the greater bilby) to Martu children and their families. Kanyirninpa Jukurrpa Culture, Country and Communities Coordinator **Tracy Carboon** shares the fun of a recent outing.

The KJ Punmu Ranger and Families teams have been working together to teach the jijikaja (children) all about Mankarr (the greater bilby). The rangers have been demonstrating the "Mankarr search method" that was developed in conjunction with Martu rangers and elders and Threatened Species Recovery Hub ecologist Anja Skroblin from The University of Melbourne.

The Punmu Ranger and Families Program took a short drive from the community to an important Mankarr monitoring zone. The rangers shared their knowledge and taught the women and children who participate in the Families Program how to look for Mankarr mirrka (food), jina (tracks), jawana (diggings), ngurra (burrow) and kuna (scats). The women and children also learnt how to recognise if the Mankarr tracks were old or new and if the burrows were still occupied.

The children loved to follow the Mankarr tracks. They were excellent at finding diggings, travelling from one to another, as well as finding other signs of Mankarr. In addition to the Mankarr tracking, the children pointed out the termite mounds, a food source for Mankarr. The rangers

guided discussions exploring what Mankarr could be eating, as there were not many food sources, such as lunki trees (witchetty grubs), minyarra (bush onions) or wurmurla (bush tomatoes) available at the survey site.

The rangers taught the women and the children how to use the survey field resources and complete the survey form. In the future, the Families Program team can conduct their own surveys when they are out on country.

As the teams were driving to go back to Punmu community, Marissa Rogers, a participant in the Families Program, spotted a fresh burrow from the vehicle. Everyone decided it belonged to the Mankarr they had been tracking! The women also noticed an important Mankarr food source, yuwinji (grass seed, *Eragrostis eriopoda*), growing nearby.

It was a fantastic trip with rangers sharing their knowledge and expertise with women and children from the Families Program and children increasing their English and Martu environmental vocabulary and learning how to track for Mankarr. Everyone involved was very proud and happy being out on Country teaching and sharing their knowledge with their children.



IMAGE: KANYIRNINPA JUKURRPA

The women find a fresh Mankarr ngurra (burrow) alongside yuwinji, a grass that provides seed for food for Mankarr.

A Threatened Species Recovery Hub project supported the collaboration of Kanyirninpa Jukurrpa (KJ), Martu Elders and The University of Melbourne to co-develop a Mankarr monitoring program that is based on Martu priorities, Traditional Ecological Knowledge and tracking skills. The project is now complete, but KJ Ranger teams are continuing to use the survey method and to teach it to other Martu people. By detecting trends in Mankarr populations, the method will support Martu land managers in their management decisions, such as where and when to carry out burning or feral animal control.

Further information

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Business– Biodiversity webinar series: Putting biodiversity into business decisions

Intact ecosystems and biodiversity resilience are key to a sustainable future society and economy, but human activity has degraded our biodiversity and ecosystems. These losses are being exacerbated by changing climate and weather extremes, drought, altered fire seasons and an increased risk of natural disasters. Integrating biodiversity in business decisions has never been more critical. The Threatened Species Recovery Hub’s **Dr Holly Vuong**, **Heather Christensen** and **Dr Rachel Morgain** report on how our recent webinars have been exploring these issues with the Australian business community and other interested groups.

Getting down to business

To showcase ways to help business systems work for ecosystems, the Threatened Species Recovery Hub teamed up with the Business Council for Sustainable Development Australia for a series of four Business–Biodiversity webinars. Running from 14 July to 4 August 2020, they examined climate risk, biodiversity loss and ecosystem risk, and highlighted how disparate sectors like finance, consulting and agriculture can address environmental challenges. Between them, the four webinars sought to open avenues for better integrating biodiversity research and business decision-making.



IMAGE: DAVE SMITH

Growing numbers of farmers are improving farm productivity by restoring biodiversity assets.

The first, “Biodiversity and ecosystem risk to businesses”, saw hub director Brendan Wintle and MinterEllison’s Head of Climate Risk Governance Sarah Barker introduce the environmental and financial risks for business of biodiversity loss and ecosystem degradation, globally and in Australia. The theme of business decisions was reprised in the final webinar, “Mitigating impact and assessing performance: Tools for business decisions”, which also touched on carbon offsetting.

Urban and agricultural landscapes

The second and third webinars looked at case studies in productive landscapes. “Nature based opportunities for resilient cities” highlighted the importance of nature for human health, and looked at how to make cities resilient to climate shocks, urban heat island effects and changed ways of working and living. Clarence Slokkee of Jiwah and Chris Nunn of AMP Capital gave examples of their companies’ commitment to natural capital, Indigenous values and heritage. Professor Sarah Bekessy from the NESP Clean Air and Urban Landscapes Hub talked about biodiversity sensitive urban design and everyday nature in cities.

In “Valuing nature in agricultural landscapes: Tools from science and economics”, presented in partnership with ANU Sustainable Farms, speakers from the agriculture and banking sectors as well as researchers discussed the transformation of our farming landscapes. With agricultural landscapes likely to be under increasing pressures in coming decades to feed a growing population, tools to improve biodiversity on agricultural lands will be key to supporting resilient farmlands and ecosystems.

In total, over 1650 individuals from four continents and a wide range of sectors and backgrounds registered for the webinars. All of the webinars and their related resources are available at the events page of the NESP Threatened Species Recovery Hub website.

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Unique yet neglected: The Australian snakes and lizards on a path to extinction

IMAGE: A. O'GRADY MUSEUMS VICTORIA

Many Australian reptile species are in trouble. Without a stepping up of conservation action Australia's extinction rate is set to increase in coming decades. **Hayley Geyle** from Charles Darwin University and **Associate Professor David Chapple** from Monash University have been working with reptile experts from across the country to identify the species at greatest risk of extinction in order to provide time to act before it is too late.

Australia is a hotspot for reptile diversity; we have the largest number of species of any country in the world, and about 10% of all known species globally. From tiny skinks to charismatic dragons, our reptile fauna are very distinctive. More than 90% of our species occur nowhere else in the world, but many of these uniquely Australian fauna are at risk of extinction.

Reptiles are undergoing widespread declines on a global scale, which is likely to be further exacerbated by climate change. There has been little conservation action for most Australian species at risk, partly because reptiles are poorly known. New species are being described at an average rate of 15 per year, many of which are already vulnerable to extinction at the time of discovery.

This lack of action has also been compounded by few reptiles in Australia being well monitored. Without adequate monitoring, we have a poor understanding of population trends and the impacts of threats, meaning that species could slip into extinction unnoticed.

Reptiles also lack the public and political profile that helps generate recovery support for other Australian threatened animals

(such as the arguably more charismatic mammals, birds or frogs), leading to little resourcing for conservation.

Only one Australian reptile is officially listed as extinct, but we have most probably lost others before knowing of their existence. In the wake of continued decline and increasing pressures associated with ongoing threatening processes, we will only prevent extinction by recognising risks in time to do something about them.

Six species more likely than not to go extinct by 2040

Our research team – including 27 reptile experts from universities, zoos, museums and government organisations across the country – identified the terrestrial snakes and lizards (collectively known as squamates) at greatest risk of extinction within the next two decades, assuming no changes to current management.

Our research predicts that up to 11 species could be lost within 20 years unless there is a stepping up of conservation action.

The Cape Melville leaf-tailed gecko, pictured here with researcher Conrad Hoskin, is restricted to the top of a small mountain range on Cape York and is threatened by climate change.

IMAGE: TIM LAMMAN



This would represent a marked increase in the extinction rate for Australian reptiles relative to historic levels. The species in greatest peril include two dragons, one blind snake and three skinks, but many others could also be lost.

A recent assessment found that all 20 species at greatest risk meet internationally recognised criteria for listing as threatened (IUCN Red List), but only half are currently protected under Australian environmental legislation. This suggests that the EPBC Act list of threatened species needs urgent review.



The Arnhem Land gorges skink is one of six species considered more likely than not to become extinct within the next two decades. Threats to this species include changes to food resources and habitat quality caused by altered fire regimes, feral cats and, possibly, poisoning by cane toads.

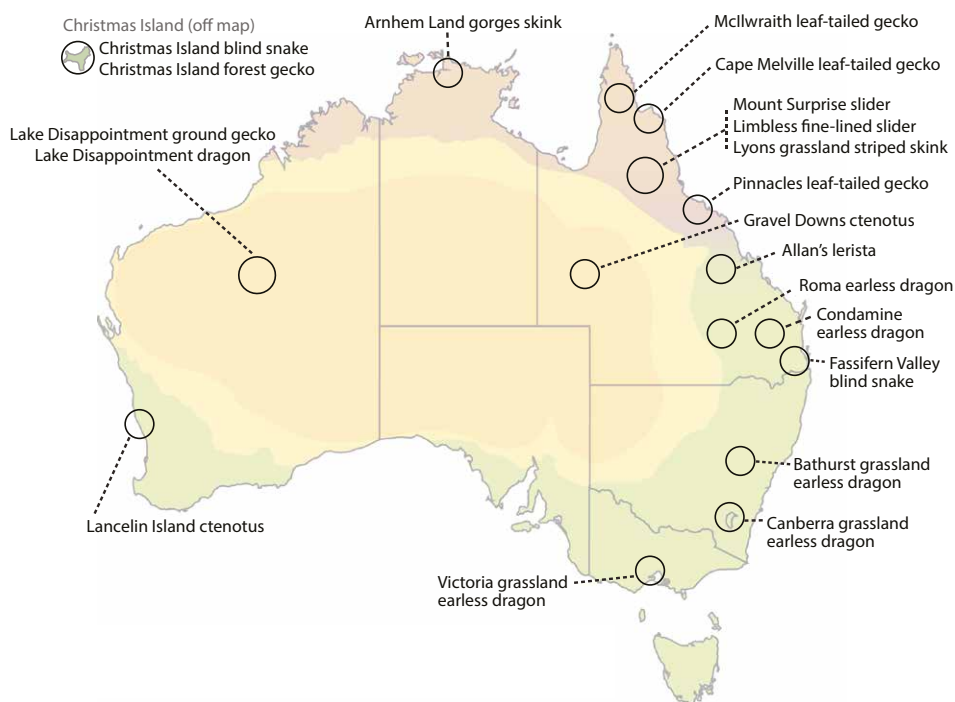
Queensland species especially vulnerable

More than half (55%) of the 20 species at greatest risk occur in Queensland. Three are known from islands: two on Christmas Island, and one on Lancelin Island – a tiny low-lying sand island off the coast of Western Australia. Two more species are found in Western Australia, while the Northern Territory, the Australian Capital Territory, Victoria and New South Wales each have one species.

Each of the 20 species occurs in a relatively small area, which probably explains the Queensland cluster – many species in that state naturally have very small distributions. Most of the 20 at greatest risk occupy 16 km² or less, so could be lost to a single catastrophic event, such as a large bushfire.

The threats facing our terrestrial snakes and lizards

Invasive species were the most common threat, including weeds (and their interaction with fire), feral cats, red foxes, black rats, pigs, deer, horses, introduced invertebrates, oriental wolf snakes and cane toads (through predation, poisoning or direct habitat destruction). Habitat loss or modification (through agriculture, urbanisation, altered fire regimes and mining) and climate change were also important threats.



The approximate locations of the 20 terrestrial snakes and lizards at greatest risk of extinction.

Many threatened reptiles are associated with habitats that historically have been, and still are being, rapidly transformed into farmland, such as the temperate grasslands of south-eastern Australia and the brigalow woodlands of central Queensland. For many of the species currently persisting in highly modified landscapes, changing land use is ongoing, and highly likely to be contributing to further declines.

For example, a shift from mixed-crop farms to broadacre monocultures (often irrigated cotton) in the Condamine River floodplains has led to the destruction of critical habitat for the Condamine earless dragon.



The Mount Surprise slider is threatened by multiple invasive plant species and compaction of sandy soils by cattle.

Lessons from the past

Despite early warnings of significant declines, the Christmas Island forest skink holds the unenviable title of the first Australian reptile to be officially listed as extinct. Action came too late for this species; it was lost from the wild before it was listed as threatened, and the few individuals brought into captivity died soon

after it was listed as Critically Endangered under Australian environmental legislation.

Without increased resourcing and management intervention, many more Australian reptiles could follow the same trajectory as the Christmas Island forest skink.

But it's not all bad news – the pygmy bluetongue skink was once thought to be extinct, until a chance discovery kickstarted a long conservation and research program. Translocations are now being undertaken to establish new populations, signifying that positive outcomes are possible when informed by good science.

By identifying the species at greatest risk, we hope to forewarn governments, conservation groups and the community, giving them time to act to prevent further extinctions before it is too late.

Further information

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See next page for the 20 Australian snakes and lizards at greatest risk of extinction.

The 20 Australian terrestrial snakes and lizards at greatest risk of extinction, their estimated probabilities of extinction in the wild by 2040, state of occurrence, IUCN Red List conservation status and *Environment Protection and Biodiversity Conservation Act 1999* status – Critically Endangered (CR), Endangered (EN), Vulnerable (VU), unassessed due to recent taxonomic revision or description (N/A).

Species	Probability of extinction	State	IUCN status	EPBC Act status
Victoria grassland earless dragon <i>Tympanocryptis pinguicollis</i>	93%	Vic.	N/A	EN
Fassifern blind snake <i>Anilius inoperatus</i>	75%	Qld	CR	Not listed
Lyons grassland striped skink <i>Austroblepharus barrylyoni</i>	71%	Qld	CR	Not listed
Arnhem Land gorges skink <i>Bellatorias obiri</i>	69%	NT	CR	EN
Bathurst grassland earless dragon <i>Tympanocryptis mccartneyi</i>	62%	NSW	N/A	EN (as part <i>T. pinguicollis</i>)
Gravel Downs ctenotus <i>Ctenotus serotinus</i>	52%	Qld	CR	Not listed
Allan's lerista <i>Lerista allanae</i>	46%	Qld	CR	EN
Christmas Island blind snake <i>Ramphotyphlops exocoeti</i>	41%	CI	EN	VU
Cape Melville leaf-tailed gecko <i>Saltuarius eximius</i>	39%	Qld	EN	Not listed
Mount Surprise slider <i>Lerista storri</i>	37%	Qld	N/A	Not listed
McIlwraith leaf-tailed gecko <i>Orraya occultus</i>	31%	Qld	VU	Not listed
Pinnacles leaf-tailed gecko <i>Phyllurus pinnacensis</i>	28%	Qld	CR	Not listed
Condamine earless dragon <i>Tympanocryptis condaminensis</i>	25%	Qld	EN	EN
Lake Disappointment dragon <i>Ctenophorus nguyarna</i>	21%	WA	VU	Not listed
Roma earless dragon <i>Tympanocryptis wilsoni</i>	19%	Qld	EN	Not listed
Lake Disappointment ground gecko <i>Diplodactylus fulleri</i>	18%	WA	VU	Not listed
Canberra grassland earless dragon <i>Tympanocryptis lineata</i>	18%	ACT	N/A	EN (as part <i>T. pinguicollis</i>)
Christmas Island forest gecko <i>Cyrtodactylus sadleiri</i>	17%	CI	EN	EN
Lancelin Island ctenotus <i>Ctenotus lanceolini</i>	17%	WA (LI)	CR	VU
Limbless fine-lined slider <i>Lerista ameles</i>	15%	Qld	EN	Not listed



IMAGE: BRAD MARYAN

The tiny Lancelin Island ctenotus is found only on Lancelin Island, 100 km north of Perth. Its threats include habitat changes caused by weeds, declining shrubs and human disturbance.



IMAGE: JON-PAUL EMERY

The Endangered Christmas Island forest gecko is threatened by Asian wolf snakes, giant centipedes and rats, which have been introduced to Christmas Island.



IMAGE: BRAD MARYAN

The Lake Disappointment ground gecko is known only from a single location, greatly increasing the risk that a single event could cause its extinction.



The large and prickly Pinnacles leaf-tailed gecko is only found in the Pinnacles range near Townsville, where the population is estimated to number only 250. Wildfire, invasive species and poaching are all significant threats to this rare species.

IMAGE: CONRAD HOSKIN

Protecting threatened Christmas Island reptiles from a new disease



IMAGE: DAVID PHALEN

Discovering a new species can be a very cool thing, unless that species is a bacterial disease which threatens other species that you are striving to save. University of Sydney researcher **Jessica Agius** takes a look at a new disease threatening Christmas Island reptiles and her work to combat it.

Recent decades have seen major declines in many of Christmas Island's native reptiles. Although once abundant and widespread, the Lister's gecko (*Lepidodactylus listeri*) and the blue-tailed skink (*Cryptoblepharus egeriae*) have disappeared from the wild. A key cause of the declines is believed to be predation by invasive species, like the Asian wolf snake and giant centipede.

The skink and gecko have been thriving in captive breeding programs where they are protected from these threats, but in 2014 some captive animals started getting sick. The cause was discovered to be a new strain of bacteria (*Enterococcus lacertideformus*), which grows in the tissues of the head then the internal organs, before eventually causing death.

Taking a gecko at translocation

Island-wide surveys revealed that the disease is also present among two invasive non-native gecko species on Christmas Island: Asian house geckos (*Hemidactylus frenatus*) and mute geckos (*Gehyra mutilata*). It is likely that contact with infected invasive geckos has been the cause of outbreaks of the disease in captive blue-tailed skink populations housed in outdoor pens since 2014.

Given the persistence of the disease in wild invasive gecko populations, introducing the two native species to locations other than

Christmas Island is an important "insurance" strategy. Blue-tailed skinks were recently introduced to the nearby Cocos (Keeling) Islands in a successful translocation; and, to safeguard both native species, the possibility of further introductions to Cocos Islands, or other locations with comparable environments to Christmas Island, is also being explored.

How is infection caused?

To learn about the disease, we collected invasive Asian house geckos from the wild on Christmas Island and undertook experimental trials on them. The disease appears to need direct contact to cause infection. Infection generally follows if an animal eats infected tissue or gets infected tissue in contact with its mouth or broken skin – things that commonly occur when geckos fight, particularly during mating.

This means that healthy captive animals need to be kept apart from infected geckos and should also be kept away from areas where infected animals have been.

We found that progression of the disease is slow and highly variable, with the visible signs first showing six to 14 weeks after infection. This complicates the management of the disease, as infected animals may appear to be healthy for many weeks. It also has implications for quarantine; if captive animals

are to be translocated, a minimum quarantine period of 16 weeks will be necessary to prevent spread of the disease.

The future

Antibiotics are one potential way to control this disease, although a treatment trial we conducted was not successful. We could not cure geckos infected with the disease, even after three weeks of intense treatment. Geckos with minimal lesions responded better to antibiotics, but were still infected at the end of the treatment course. But until a universally effective antibiotic treatment is found, control of this deadly disease and long-term conservation of the captive species will depend heavily on strict quarantine and biosecurity practices, and the establishment of threatened populations to locations other than Christmas Island.

Further information

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Rose, K., Agius, J., Hall, J., Thompson, P., Eden, J. S., et al. 2017. Emergent multisystemic *Enterococcus* infection threatens endangered Christmas Island reptile populations. PLOS ONE 12(7): e0181240. <https://doi.org/10.1371/journal.pone.0181240>

Hayley Geyle

Fighting extinction

Hayley Geyle is a Research Assistant at Charles Darwin University who has been instrumental in Threatened Species Recovery Hub research to identify the Australian species at greatest risk of extinction.

I spent much of my childhood in nature – family camping trips were always our go-to holiday. I have fond memories of feeding the kookaburras with my dad at Roses Gap, and exploring the Grampians with my cousins. Naturally this led to a close affinity with nature and wildlife, but it wasn't until my later years at high school that I decided I wanted to pursue a career in conservation.

When I started my VCE, I signed up for environmental science. It was the first year the unit had run at my school, after an enthusiastic teacher managed to scrape a measly 12 students together. We figured it'd involve lots of fieldtrips – and we weren't disappointed. I was inspired by my teacher's passion for the natural world. He was an exceptional educator, who opened my eyes up to many conservation issues. But, ultimately, it was a school trip to Mount Rothwell, and my first interaction with an eastern quoll and an eastern barred bandicoot that sealed my fate. I was shocked to learn that both of these incredible species now depended on a predator-proof fence for their survival, and I knew then that I wanted to work with wildlife.

Fate sealed

I went on to study environmental science at Deakin University, a course I can't recommend highly enough. All of my lecturers were fantastic, and the course offered some great

hands-on experiences, including a study tour to Borneo. I signed up to do an honours project on small mammals in Wilson's Promontory National Park before an opportunity surfaced to work on the brush-tailed rabbit-rat on the Tiwi Islands. After finishing my honours degree, and realising just how much I loved working in the tropics, I made the move to Darwin. I had no job lined up, but kept afloat doing some casual research work on introduced predators with Deakin University and Parks Victoria. I was optimistic that something might pop up in Darwin.

My timing couldn't have been better. I was absolutely delighted to secure a part-time zookeeper position at the Territory Wildlife Park looking after northern quolls. Around the same time, I was lucky enough to be offered a casual research position at Charles Darwin University (with much help from one of my former honours supervisors, Brett Murphy), working with the Threatened Species Recovery Hub. These two roles happily complemented each other for the next year or so, but as much as I loved spending time with my spotty family, I soon realised that zookeeping wasn't for me.

Research beckons

When a full-time position became available with the Threatened Species Recovery Hub, I jumped at the opportunity. Research is my true passion, and I was particularly keen on working on projects that would contribute directly to the conservation of threatened species. For the past three years, I've been working on two main projects, identifying the animal species on the brink of extinction and investigating the impacts of introduced predators on native species (while also chasing northern brush-tailed phascogales in my spare time).

LEFT: Checking the pouch of a northern brown bandicoot.



IMAGE: CASSANDRA HOLT

Setting up a remote-sensor camera to target northern brush-tailed phascogales on Melville Island.

So far, we have completed assessments of extinction risk for birds, mammals, freshwater fish and reptiles (you can read more about the latter two projects on pages 6 and 16), which wouldn't have been possible without the input of many amazing ecologists from across the country. Our ultimate goal is to raise awareness of the species at greatest risk of extinction, and to generate more support for their conservation. There are some signs to suggest that it's working. Following the publication of our paper on imperilled birds in 2018, resources were invested into new survey and management effort for the two species identified to be at greatest risk – the King Island brown thornbill and the King Island scrubtit – that resulted in the discovery of new populations. We're hopeful that this work will also lead to positive outcomes for our less furry and feathery critters.

Further information

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IMAGE: CASSANDRA HOLT

The Threatened Species Recovery Hub is supported through funding from the Australian Government's National Environmental Science Program.



www.nespthreatenedspecies.edu.au

COVER IMAGE: CAPE MELVILLE LEAF-TAILED GECKO
(SEE PAGE 16 FOR THE FULL STORY.) IMAGE: CONRAD HOSKIN

Science for saving species

A quarterly publication of the Threatened Species Recovery Hub

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