

The impact of cats in Australia

Cat origins

Domestic cats are descended from the African wildcat *Felis lybica*. They were domesticated in Egypt and the Middle East around 4000 years ago, and have since been extensively moved around the world by people. They now occur on all continents except Antarctica, and on many of the world's islands.

The domestic cat's scientific name is *Felis catus*. There have been many categorisations for domestic

cats, relating to their lifestyle, or the extent to which they are socialised, owned and cared for. However, the simplest categorisation is 'pet cat' for cats that live in a household and are owned and cared for by people and 'feral cat' for everything else. Feral cats can live in our towns and cities as well as in remote areas of the Australian bush. Feral cats and pet cats are exactly the same species.

Photo: Joanne Heathcote



Quick Facts

National cat population:

- Pet cats – 3.8 million pet cats
- Feral cats in urban areas – 0.7 million
- Feral cats in the bush – 1.4 million in dry conditions, and 5.6 after widespread rain

Cat occurrence in Australia:

- 99.9% of total land area
- 92% of total island area
- Average density of feral cats in the bush, on the mainland, is 1 cat per 3–4 km² but cats reach appreciably higher densities in arid areas and on small islands
- Densities (of feral cats and pet cats) are much higher in urban areas

In Australia every day cats kill:

- Mammals – 3.2 million (mostly native species in the bush; mostly introduced species in towns)
- Birds – 1.2 million (almost all native species)
- Reptiles – 1.9 million (almost all native species)
- Frogs – 0.25 million (all native species)
- Invertebrates – 3 million

Annual toll of cats

- A feral cat in the bush – 791 mammals, birds, reptiles and frogs/year and 371 invertebrates/year
- A feral cat in urban area – 449 mammals, reptiles and birds/year
- A pet cat that can roam and hunt – 186 mammals, reptiles and birds/year

Cats in Australia

Domestic cats were introduced to Australia with the First Fleet in 1788, with many subsequent introductions around the mainland and to many Australian islands. Cats spread rapidly across Australia: historical records and genetic analyses show that cats colonised the entire continent (7.7 million km²) within 70 years.

Cats now occur in all habitats, from alpine areas in south-eastern Australia to the arid deserts of central Australia. They cover more of Australia and occupy more habitats than all other introduced mammals, such as foxes and rabbits. Cats also occur on nearly 100 Australian islands, including most of the largest islands. They are present on over 92% of Australia's combined island area.

We estimate that the cat-free area in Australia comprises only around 8000 km² – about 0.1% of the Australian land mass. These cat-free areas are (small) havens for the many threatened species for which cats (and foxes) are the main cause of decline and endangerment. These havens are either islands or

purposefully designed and established fenced areas on the mainland.

Islands

Cats never made it to some Australian islands, and cat populations that managed to establish on 25 islands were later eradicated. Over 590 islands (covering 5,539 km²) are known to be cat-free; the real number is probably much higher but most of these potentially cat-free islands are small, and would not add much in terms of total island area.

Fenced enclosures

Over recent decades, cats have also been eliminated from 28 fenced enclosures (covering 594 km²) on the Australian mainland, established for the protection of predator-susceptible threatened mammal species.

How many cats are there in Australia?

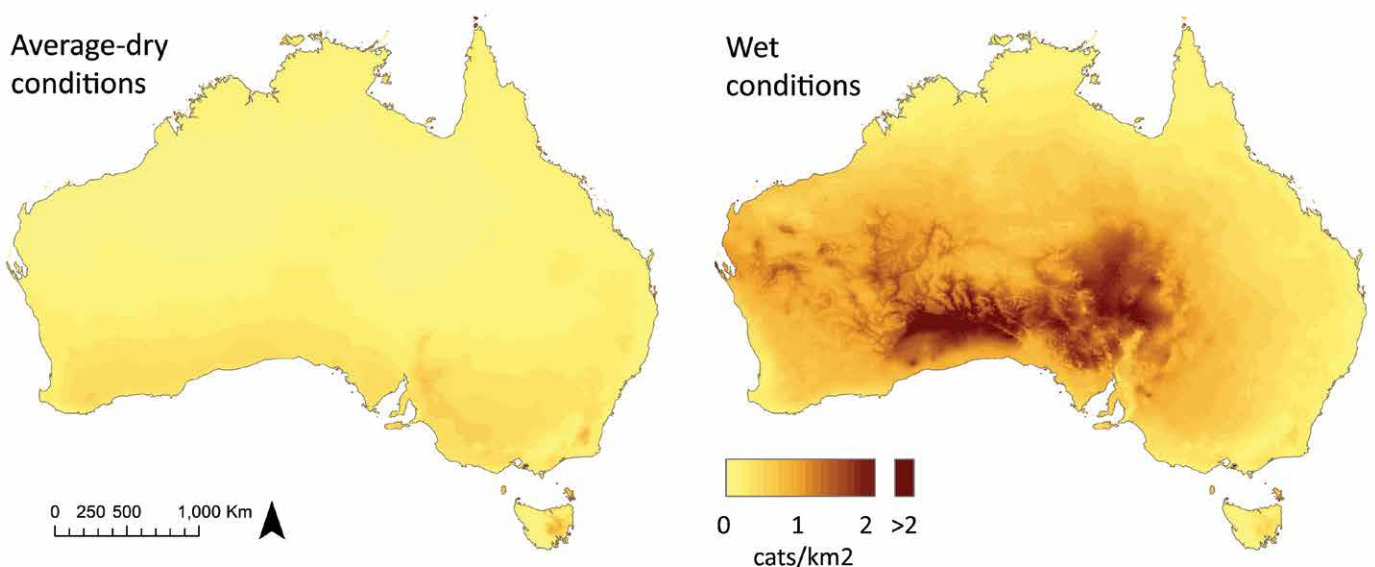
There are 3.8 million pet cats in Australia.

The feral cat population in our towns and cities is estimated at 0.7 million,

but it could be as high as 2.5 million. Towns and cities support a high density of feral cats, including cat 'colonies' at sites such as rubbish tips and skips, or intensive farms that offer abundant food sources.

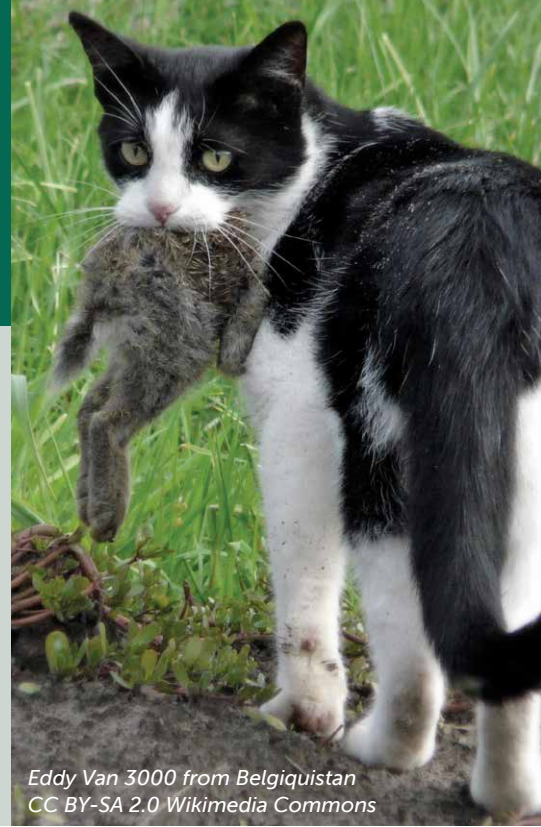
Based on extrapolation and modelling from studies which have estimated cat densities at about 100 locations spaced across Australia, the feral cat population in the bush is estimated at 2.1 million, but fluctuates between 1.4 million in dry-average years to 5.6 million after widespread and extensive rainfall events across arid Australia. These rainfall events cause rapid increases in prey populations (including native rodents), and the cat population increases quickly in response to the resource boom. The average density of feral cats in the bush across the mainland is 0.27 cats/km², with that average fluctuating between 0.2 and 0.7 cats/km² depending on patterns of widespread rainfall.

The density of feral cats is higher on islands, especially smaller islands, which often have abundant food resources for cats, including seabird colonies.



The density of feral cats in the bush fluctuates depending on weather conditions, increasing strongly after widespread rain across inland Australia. Credit: Legge, et al 2017. Enumerating a continental-scale threat: how many feral cats are in Australia? Biological Conservation 206, 293–303.

Reducing populations of introduced prey can also reduce cat populations.



*Eddy Van 3000 from Belgiquistan
CC BY-SA 2.0 Wikimedia Commons*

What do cats eat?

Cats are carnivores, only eating meat, and mostly of animals they have killed themselves. They take a very wide range of prey, including invertebrates, frogs, reptiles, birds and mammals. Cats eat a range of prey from small beetles to mammals almost as large as themselves (up to about 4 kg which is the size of small wallabies).

Some individual cats specialise on particular prey species. Worldwide, and in Australia, mammals make up the bulk of cats' prey, but this varies widely between sites and is influenced by the availability of prey.

Virtually all cats, even well-fed pet cats, will hunt and kill wildlife if given the opportunity.

Impact of cats

Domestic cats are considered one of the most damaging invasive species worldwide, causing impacts from predation, disease transmission, hybridisation (with native wildcats, in Europe and Africa), and competition.

Globally, cats are considered to have contributed to the extinction of at least two reptile, 40 bird and 21 mammal species – over one quarter (26%) of the total extinctions of these groups since the year 1600. Currently, cats are contributing to the

imperilment of at least 360 threatened reptile, bird and mammal species worldwide, about half of which are species restricted to islands.

In Australia, at least 34 mammal species have become extinct since European settlement – a rate of mammal extinctions far greater than anywhere else in the world. Cats have been primary contributors to over two-thirds of these extinctions. Examples include native marsupials like two species of pig-footed

bandicoots, the lesser bilby, the Nullarbor dwarf bettong, the desert rat-kangaroo and the broad-faced potaroo; and native rodents including at least four species of hopping-mice, two species of rabbit-rat, and the lesser stick-nest rat.

Cats have also been primary agents in the extinction of some Australian birds that were restricted to islands, such as the Macquarie Island parakeet and Macquarie Island buff-banded rail.



*ABOVE: Pig-footed bandicoot, white-footed rabbit-rat.
Credit: By John Gould - The Mammals of Australia,
Public Domain*



*Line drawings T. Maggiocomo:
long-tailed hopping-mouse,
crescent nailtail wallaby,
desert bandicoot.*

The five animals above, left and right, are examples of extinct mammals for which cat predation was a major contributor.

Evidence of the impact of cats

There is extensive evidence of the impact of cats on Australian native species.

Many historical mammal extinctions corresponded to the spatial and temporal spread of cats across the continent.

Many native species (for example, the greater stick-nest rat and banded hare-wallaby) now persist only in areas that have remained cat-free (such as some islands, and more recently, fenced exclosures), and are unable to persist if cats are present.

There are also examples where species disappeared from islands after cats were introduced, but after the cats were eradicated, the same native mammal species have been successfully reintroduced to the islands (such as the western barred bandicoot and Shark Bay mouse to Faure Island in Shark Bay).

There have been many reintroduction attempts for threatened mammals on the mainland, and a key factor that determines whether an attempt is successful is whether cats are present or not.

Species that have become extinct, or whose populations have been most severely reduced, are (or were) mostly of the favoured prey size for cats, live (or lived) on the ground (rather than in trees), and that live (or lived) in areas of sparser vegetation (where it is harder to escape predators).

Many studies of the biology of Australian wildlife species have documented high rates of mortality from cats.

Many studies of the diet of cats have shown that they take large numbers of many wildlife species, including highly threatened birds, mammals and reptiles.

The historic and ongoing impacts of cats on Australian wildlife are far more severe than for wildlife on any other continent. This is probably because Australian animals have evolved without cat-like predators, many Australian animals have low rates of reproduction so their viability is readily compromised by an efficient predator (especially one with much higher reproductive rates), and because cats are so pervasive and such adaptable hunters.

How many Australian animals do cats kill?

How estimates are calculated

We have estimated the toll of cats on native (and introduced) animal species by: (i) collating all the local and regional cat diet studies carried out in Australia (about 100 studies, which examined about 10,000 cat diet samples, and with studies collected across a wide range of Australian environments); (ii) modelling and extrapolating from these to derive a spatial layer of the variation in

numbers (and types) of animals killed per cat; and (iii) multiplying this by the (spatially variable) number of feral cats in Australia. From these analyses, we can determine the numbers of different types of animals killed by cats in different parts of Australia, and then sum these to derive national tallies.

This approach relies on some assumptions: for example, that the fraction of carrion (i.e. pre-killed animals) in the cat diet is small (which is reasonable, as cats much prefer to eat freshly-killed prey); and also that the numbers of animals killed by feral cats but not eaten is also small. Information on the diets of pet cats, and feral cats living in towns, is patchier than for feral cats in the bush.

Findings

Overall, feral cats in Australia eat about 2 billion reptiles, birds, frogs and mammals each year, and over a billion invertebrates. Mammals are the most commonly eaten of these prey items, for all types of cat (pets and ferals), with more than one billion mammals killed by cats in Australia every year. Pet cats that roam and hunt kill an additional 390 million mammals, birds and reptiles annually.

Most of the animals killed are native species. The percentage of native animals in the diet depends on whether the cat lives in the bush or in towns, and the type of animal prey. For example, nearly all of the reptiles and birds killed by feral cats in the bush are native species, whilst most mammals killed by pet cats in towns are introduced species.

This annual toll translates to 1.9 million reptiles, 1.2 million birds, 3.2 million mammals, 3 million invertebrates and at least 0.25 million frogs killed every day in Australia by cats.

Most of this toll is caused by feral cats living in the bush (68%), but feral cats in towns, and pet cats, also kill large numbers of animals.

Fencing has been used successfully to exclude cats and foxes from small areas on the mainland, into which threatened mammals can be translocated. Photo: Wandiyali Restoration Trust



*Cats prey on greater bilbies.
Photo: Alexandra Ross*



The number of vertebrate animals killed per cat is highest for feral cats in the bush, at 791 animals every year. Feral cats in towns kill fewer vertebrate animals per capita (449 animals per cat per year) because intentionally or otherwise humans also provide them with some food. Individual pet cats kill fewer still, at 186 animals per cat per year. However, because feral cats in towns and pet cats live at

higher densities than feral cats in the bush, their kill rates per square km are actually much higher.

Cats also kill introduced birds and mammals, especially rabbits and house mice (in southern Australia), however cats rarely control populations of these introduced pests. High densities of rabbits and introduced rodents also allow cats to reach high densities,

which means that even if those cats take only a small proportion of native animal species in their diet, the toll on native species will still be high. Cats will also switch prey types, so if management or weather conditions lead to rapid decline in numbers of rabbits and introduced rodents, large numbers of cats will then switch to consume mostly native animal species.

Summary of the population sizes of cats and their average predation rates on invertebrates, reptiles, frogs, birds and mammals, across Australia.

	Feral cats in bush	Feral cats in towns (heavily modified environments)	Pet cats that roam and hunt
Overall population size	2.1 million	0.7 million	2.1 million
Area in which this type of cat lives	7.63 million km ²	57,000 km ²	29,683 to 54,201 km ²
Overall take of invertebrates per year	769 million	317.3 million	No estimate available
Average number of invertebrates killed <i>per cat</i> per year	371	453	No estimate available
Average number of invertebrates killed per km ² per year	101 invertebrates/km ² /year	5567 invertebrates (rounding up)	No estimate available
Overall take of reptiles per year	466 million (>99% native species)	130 million	83 million (100% native)
Average number of reptiles killed <i>per cat</i> per year	225	180	40
Average number of reptiles killed per km ² per year	61 reptiles/km ² /yr	2280 reptiles/km ² /yr	1530–2790 reptiles/km ² /yr
Overall take of frogs per year	92 million	No estimate available	At least 1.01 million
Average number of frogs killed <i>per cat</i> per year	44	No estimate available	0.5
Average number of frogs killed per km ² per year	12 frogs/km ² /year	No estimate available	19–34 frogs/km ² /year
Overall take of birds per year	272 million (99% native species)	44 million	118 million, (68% native)
Average number of birds killed <i>per cat</i> per year	129	62	56
Average number of birds killed per km ² per year	36 birds/km ² /year	772 birds/km ² /year	2170–3960 birds/km ² /yr
Overall take of mammals per year	815 million (56% native species, but highly variable)	149 million	189 million, (35% native)
Average number of mammals eaten <i>per cat</i> per year	393	207	90
Average number of mammals per km ² per year	107 mammals/km ² /yr	2610 mammals/km ² /yr	3490–6370 mammals/km ² /yr
Overall take of all vertebrate animals	1645 million (78% native species)	323 million	391 million, (62% native)
Average number of vertebrate animals killed <i>per cat</i> per year	791	449	186

The patterns of cat tolls on native wildlife varies between groups and habitat types.

Invertebrates

- Cats eat a large number of invertebrates, although these form a relatively small proportion of their diet by mass. Cats may pose a threat to some large-bodied, range-restricted invertebrate species.
- The favoured invertebrate groups of feral cats in Australia are grasshoppers, beetles and butterflies

Reptiles

- There are records of cats eating about one quarter of all Australian reptile species, including 11 species listed as nationally threatened.
- The toll of reptiles is greatest in arid areas of Australia.

Frogs

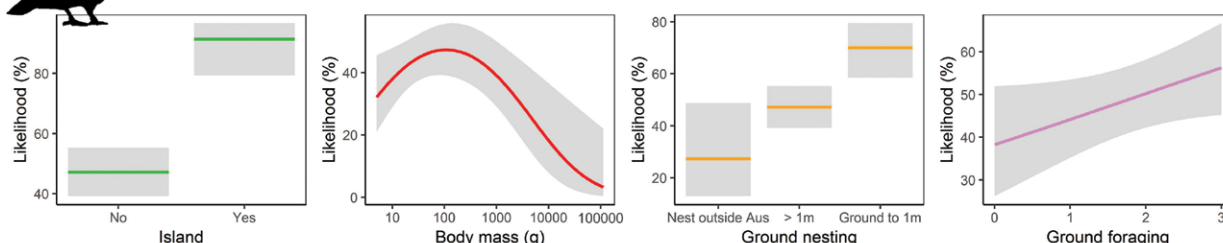
- There are records of cats eating 30 native frog species in Australia.
- Further research is required to clarify the conservation significance of cat predation on frog populations in Australia.

Birds

- There are records of cats eating almost half of all Australian bird species, including 71 species listed as threatened at national or global scale.
- The toll of birds is greatest on islands, and in arid areas of Australia.
- For birds, the likelihood of being killed by a cat is highest if it lives on an island, if it is in the size range 60-300g, and if it nests and/or forages on the ground.

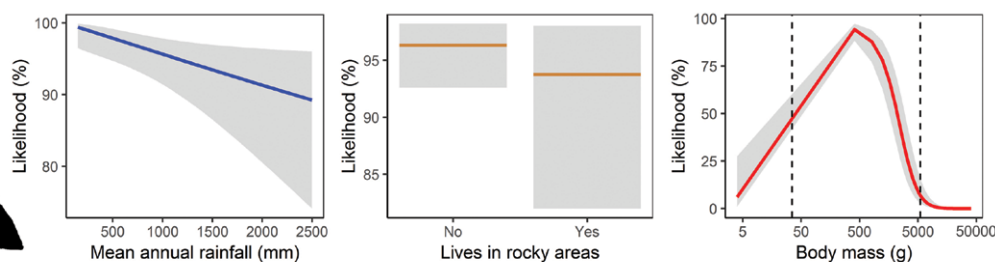


Birds are more likely to be eaten by cats if they live on islands, are medium-sized, and/or if they nest or forage on the ground.



Mammals

- There are records of cats eating over half of Australian mammal species, including 50 species listed as threatened at national or global scale.
- The overall toll of mammals is greatest in areas with lower temperatures, in non-rocky habitats, and on the mainland and large islands (rather than small islands).
- However, the toll of native mammals is highest in northern Australia and wetter parts of eastern Australia, and lowest in southern and dry parts of Australia; the toll of introduced species (e.g. rabbits, house mice) is geographically opposite.
- The likelihood of being killed by a cat is highest for native mammals that aren't bats, live in low rainfall areas, non-rocky areas, and/or are of intermediate size (35-5500 g, peaking around 400 g), such as mulgaras, stick-nest rats, and barred bandicoots.



Mammals are more likely to be eaten by cats if they live in drier areas that are not rocky, and are medium-sized.

The number of species preyed on by cats will be much greater than the available diet studies suggest. For example, some species have not been reported as eaten by cats because these species have small distributions and it is less likely that a cat diet study has taken place within that distribution.

Eradicat baits contain 1080 poison within a moist sausage, and are more appealing to cats than dried meat baits.
Photo: Department of Biodiversity, Conservation and Attractions



Management options

Management options for cats vary depending on whether they are feral cats living in the bush or in towns, or whether they are pets.

Feral cats in the bush

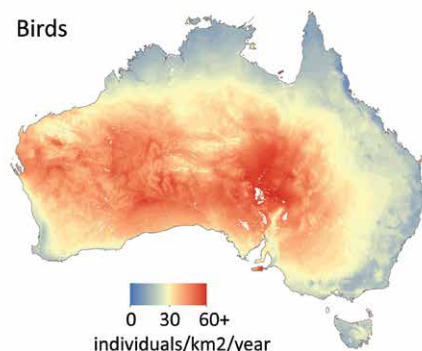
Cats are difficult to control; their wariness makes them hard to trap and shoot at large scales. They prefer to hunt live prey, so the traditional poison-baiting used on dogs and foxes is often ineffective. However, Australian scientists and pest managers have made substantial headway in recent years at understanding when some control options are most effective, and also at developing new control options, which reduce risks of accidental poisoning for other animals.

There is no one cat management approach that is easy and effective across large landscape areas, but there are many options to control cats and their impacts, and the best combination to use will depend on local conditions. Key management approaches include:

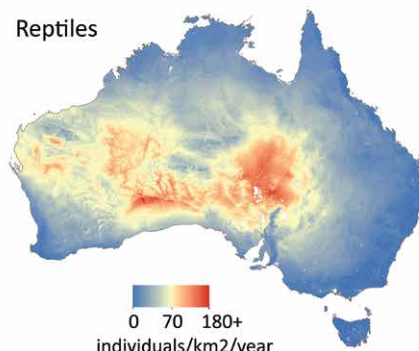
Poison baits: Strategically using new cat landscape-scale poison-bait options, such as the existing Eradicat baits (which have been used successfully especially in the southwest of WA) and developing new formulations including Hisstory and Curiosity baits.

Manage introduced prey species: Implementing landscape-scale control for introduced prey (e.g. rabbits), to try to reduce cat density. Many native mammal species increased rapidly in distribution and/or abundance after the release of calicivirus, which reduced rabbit populations and therefore also cat populations. Reducing introduced prey needs to be carried out carefully, if there is a risk that cats could 'prey-switch' and increase predation on native species for a short period after the introduced prey are removed.

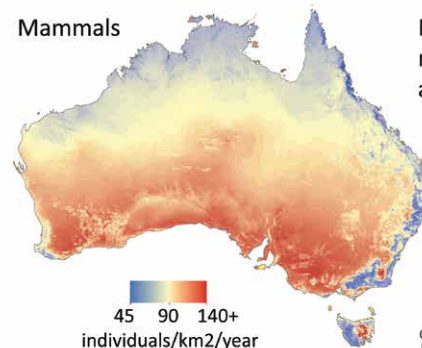
Birds



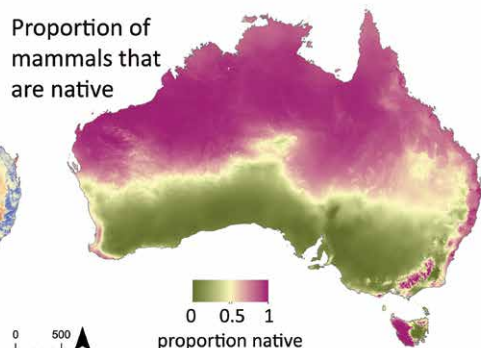
Reptiles



Mammals



Proportion of mammals that are native



Maps showing the spatial variation in the numbers of birds, reptiles and mammals killed by cats per square km each year. In the case of mammals, introduced species can be a substantial proportion of the toll in some places; the fourth map shows the spatial variation in the proportion of native versus introduced mammals eaten by cats.

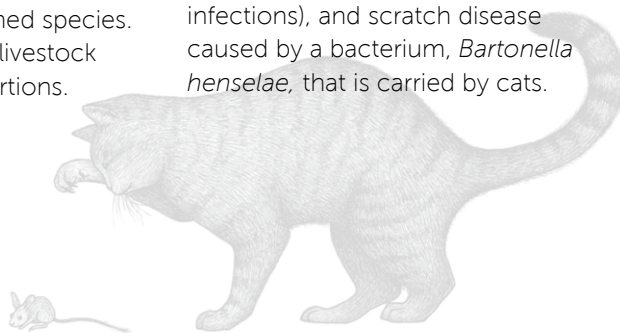
Cat-dependent diseases

As well as preying on wildlife, cats carry diseases that can affect native animals, livestock, and people.

In Australia, cats are the only primary host of the protozoan parasite *Toxoplasma gondii*, which causes the disease toxoplasmosis. This parasite (and the disease it causes) was not present in Australia prior to the introduction of cats. Toxoplasmosis can cause death, debilitation or altered behaviour (that increases predation risk) of infected wildlife species (mostly mammals and birds), with its occurrence now reported in many threatened species. Toxoplasma infections in livestock can cause illness and abortions.

Humans are also susceptible to toxoplasmosis. The responses in infected people are highly variable, ranging from no symptoms, to mild flu-like symptoms, through to miscarriages or foetal abnormalities in pregnant women. Toxoplasma infections may also increase the risk of a range of mental illnesses.

Other cat-borne diseases with impacts on livestock production and/or human health include sarcocystosis (caused by protozoan parasite, *Sarcocystis* spp.), toxocariasis (from cat roundworm infections), and scratch disease caused by a bacterium, *Bartonella henselae*, that is carried by cats.





LEFT: Guardian dogs repel other carnivores from their own ranging area, and may be able to protect populations of threatened species from cats and foxes. Photo: L. van Bommel

Contacts

Professor John Woinarski, Charles Darwin University - John.Woinarski@cdu.edu.au;
Associate Professor Brett Murphy, Charles Darwin University - Brett.P.Murphy@cdu.edu.au;
Professor Sarah Legge, Australian National University - SarahMariaLegge@gmail.com

Management options (continued)

Maintain cover for native animals:

Managing fire and grazing to maintain or increase ground cover, as dense ground-layer vegetation offers more shelter for native wildlife and this reduces the hunting efficiency of cats.

Support ranger programs:

Supporting Indigenous ranger groups to control cats directly (by hunting), and indirectly (through fire and introduced herbivore management).

Retain dingoes: Having dingoes active in an area may reduce cat impacts, either by reducing their density or changing their activity patterns. Retain dingoes in landscapes where possible (e.g. where there is no conflict with pastoral activities).

Trapping and shooting: Although labour-intensive, trapping and shooting may be feasible for protecting native species at key sites.

Guardian dogs: Developing novel ways of repelling cats and other introduced predators from sites that are important for the conservation of cat-susceptible threatened species, such as by using guardian dogs.

New technologies: Using new poison-delivery technology for use in specific situations, such as the Felix traps, or Toxic Trojans.

Biotechnologies: Exploring the potential for biotechnologies, such as gene drives, immunocontraception and disease to deliver effective cat management tools for the future.

Some native mammal species are so cat-sensitive, that we need immediate actions to prevent further species' extinctions. This could include intensively controlling cats at key sites that support cat-sensitive species, for example by using an appropriate mix of shooting, trapping, and poison-baiting.

In addition, the network of cat-free islands and fenced enclosures has been critical for preventing extinctions of many Australian mammal species. It needs to be maintained and expanded so that all cat-susceptible species have adequate levels of protection. Island havens have been particularly successful at preventing extinctions, as they are less expensive to establish and because cats are unlikely to recolonise. However, predator-proof fencing is particularly valuable for protecting species that live in habitats that are not represented on islands.

All management options aiming to reduce the impacts of cats need to be undertaken as strategically and humanely as possible, be carefully targeted, and comply with relevant legislation and by-laws.

Work with engaged members

of the public: While strategic feral cat control is best undertaken by targeted pest management programs, emerging evidence suggests that members of the public make a significant contribution to feral cat control. Engaging with, educating and supporting key groups, such as sporting shooters, may help control cats at key areas.

Feral cats in towns

- Remove sites with abundant food for cats: fence off dumps, intensive animal farms and any other sites that might support cat colonies.
- Remove populations of feral cats from towns with trapping programs.
- Discourage the community from feeding 'stray' cats.

Pet cats

Even well-fed cats can and will kill wildlife. Bells do little to limit this predation, and keeping cats indoors at night is a start but shifts their predation into the daytime.

- Keep pet cats indoors or in contained areas outdoors at all times (many options are commercially available) – it's safer for your cat as well as for wildlife, as it won't be hit by a car, get into fights, pick up a disease or get lost. Contained cats tend to be healthier, live longer and incur fewer vet bills.
- Desex your cat.
- If you choose to own a cat, offset its environmental cost by donating to conservation groups or contributing to local conservation actions.
- Local governments could expand the use of bylaws to make cat containment or cat prohibition mandatory, especially in areas with cat-sensitive wildlife species nearby.

See the "further reading" list on our website: <http://www.nespthreatenedspecies.edu.au/projects/developing-evidence-based-management-tools-and-protocols-to-reduce-impacts-of-introduced-predators-o>