Using local stakeholder knowledge to inform best practice for invasive predator management

In brief

Islands are known to be hotspots of biodiversity. However, their native species can also be particularly vulnerable to the impacts of invasive species, and especially invasive predators. Eradicating invasive species on inhabited islands can be especially problematic due to conflicting views regarding various management alternatives, the presence of other non-native species and livestock and/or or technical difficulties. As local communities push for the implementation of eradication programs to protect native and culturally valued species from invasive predators, natural resource managers often face great uncertainty regarding possible ecosystem responses resulting

from the implementation of control strategies. Hence, it is important for Natural Resource Management to engage with local stakeholders early in the planning process.

We integrated local stakeholders knowledge with a fuzzy cognitive map to reconstruct a terrestrial animal network for Minjerribah (North Stradbroke Island). We simulated the terrestrial community dynamics for two management strategies co-developed with the local NRM aimed at controlling the impacts of introduced predators by: (1) the eradication of non-native European red foxes; or (2) the simultaneous eradication of European red foxes and feral cats.

The key benefits of the approach include: (1) maximising local participation; (2) providing an opportunity for local stakeholders to collaborate in the development of conservation management strategies; (3) improving the assessment of management strategies; and therefore (4) increasing their potential ecological benefits.

We found that the most effective strategy to protect local threatened and culturally valued species is a simultaneous eradication strategy. Our simulation also showed the risk of increased numbers of small invasive mammals (i.e., rats and mice) following the simultaneous eradication of red foxes and feral cats.

Eastern grey kangaroos (Macropus giganteus), *one of the culturally valued species of Minjerribah in Point Lookout, a must-see spot for visitors to the Island. Image: Hernan Cáceres-Escobar*

Background

Invasive species have led to the decline and extinction of native species around the world. They are especially damaging on islands, where approximately 75% of recorded terrestrial extinctions have taken place globally. European red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) have been identified as two of the world's most damaging invasive species. Both of these invasive predators have been directly linked to the decline and extinction of dozens of native Australian fauna species. Due to their ecological, economic and social impacts, red foxes and feral cats have each been listed as a "Key Threatening Process" under Australian national environmental law.

More than 1000 eradication programs have been implemented on islands around the world, and while most have benefited native species, they have also mostly been undertaken on uninhabited islands. A global challenge is to expand the focus of invasive species control to include inhabited islands.

Inhabited islands can pose especially difficult challenges to invasive species control due to the presence of pets and livestock and the need to restrict implementation around populated areas. All eradication programs need to consider environmental, biological and technical factors; however, on inhabited islands, local social and economic conditions must also be considered.

To achieve the best possible results on inhabited islands, natural resource managers must use techniques to engage local stakeholders when undertaking eradications. Failure to incorporate local knowledge and local perspectives can compromise the ability of decision-makers to achieve long-lasting conservation outcomes.

Case study island: Minjerriba

Minjerribah, also known as North Stradbroke Island, or colloquially as "Straddie", has unique ecological, economic and cultural values for the local and Australian Indigenous population. Located approximately 40 km east of Brisbane, it is one of the top 50 offshore islands prioritised for protection in Australia.

Minjerribah is the second largest sand island in the world (approximately 285 km2), and the largest of the Moreton Bay islands (see Figure 1). It hosts a wide variety of habitats that support many species. The island is a stepping stone along the East Asian–Australasian Flyway and is a wetland of international importance under the Ramsar Convention, as it an important site for resident Australian bird species as well as for intercontinental migrants.

For at least the past 21,000 years, the island has been inhabited by the Quandamooka people, who are the historical custodians of Moreton Bay. In 2011, this was recognised by the Federal Court of Australia, highlighting the cultural significance of the area. The island was also the site of extensive sand mining operations from the 1940s until they ceased on 31 December 2019, ushering in the prospect of major change and potential economic growth for the local tourism sector and the local community more generally.

Fifteen invasive animal species have been recorded on the island, including red foxes and feral cats, which are two of the main drivers of native species declines on Australian islands. These two invasive predators not only have direct and indirect impacts on the threatened and culturally relevant species of the island, but they also affect its cultural heritage, and increasingly economically valuable local industries like tourism.

In response to this threat, the local NRM formed the Straddie Pest Management Group (SPMG). The aim of this group is to manage the impacts of invasive species on the island. The diversity of local stakeholders, including Indigenous and non-Indigenous residents along with the island's biological uniqueness make Minjerribah a perfect location to assess optimal invasive species management approaches, especially now that mining has ended on the island.
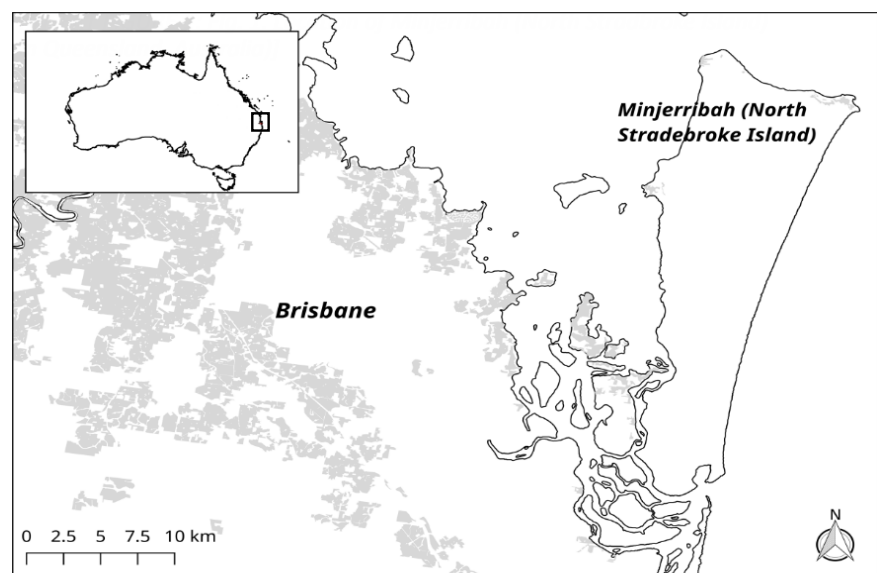

Figure 1. Location of Minjerribah (North Stradbroke Island) in Queensland. Light grey areas indicate urban development.

A red fox is caught on a remote camera digging up a bait on Minjerribah.
Image: Dan Carter/Sibelco Australia Limited

Research aims

We aimed to evaluate the possible responses from the terrestrial community for two management strategies co-developed with local NRM. These responses were aimed at controlling the impacts of introduced predators by: (1) the eradication of European red foxes; or (2) the simultaneous eradication of European red foxes and feral cats. Of particular concern was the possibility of undesired effects on threatened and culturally valued species of Minjerribah.

Overlooking the interactions with the target species may lead to undesired management outcomes, as previous management targeting foxes and cats has shown the potential for "mesopredator release", where cats, rats, mice and other species, have increased their populations, leading to negative consequences.

We were also interested in gathering local ecological information about these interactions among species, as such information is often difficult to obtain due to limited time and/ or economic resources. Hence, we sought to integrate local stakeholders' knowledge about species. We incorporated this knowledge into a "fuzzy cognitive map" of the terrestrial animal network on the island.

What we did

Over a period of two years (2015 – 2017), we met with members of the Straddie Pest Management Group, local NGOs, and community members to discuss management alternatives for controlling the impacts of red foxes and feral cats on threatened and culturally valued species on Minjerribah.

The development, assessment and selection process we developed for invasive species management strategies included five stages, starting with stakeholder engagement at Stage I and implementation and assessment at Stage V (see Figure 2).

Following the consultation process, we identified two goals: (1) the eradication of European red foxes; or (2) the simultaneous eradication of European red foxes and feral cats. We did not develop a management goal targeting only feral cats as this action was thought to be infeasible in the absence of long-term commitments from residents to control local pet cat populations.

We organised a workshop with local practitioners and community members who had an ecological background to develop a system model. This model is designed to identify and characterise the species of importance (whether threatened and/or culturally significant) and to assess potential undesired effects of the two management strategies. Community engagement was critical because although the impacts of feral animals on native species are relatively well documented, less well understood is how the implementation of management strategies can affect interactions among the multiple local species.
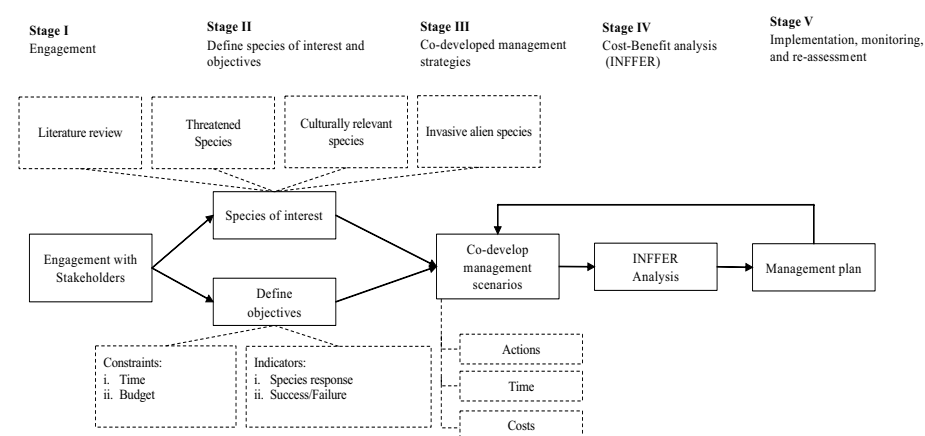

Figure 2. Stages of the framework to develop, assess and select invasive species management strategies. Boxes with broken outlines represent complementary actions that need to be undertaken to complete the main goal in every stage, which is represented by boxes with solid outlines. (Caceres-Escobar et al., 2019)

What we did (continued)

Resulting networks following from the workshop "Maximising long-term outcomes for threatened species through non-native species management"

The functional groups and species are represented by nodes (see Figure 3 below). Red nodes represent invasive species, and green nodes represent native and culturally valued species. The connections between the nodes (edges) are represented by solid lines; the colour of the edge represents the source node (green for native species and red for invasive species). The end of the arrow represents the species that benefits from the interaction.

During the workshop, we used the book *A Nature Guide to North Stradbroke Island-Minjerribah* by Barram et al. (2016) as a guide to ensure we were accounting the occurring species on the Island. The participants constructed three terrestrial networks: (1) Bushland network; (2) Mangrove and coastal network; and (3) General network – which were then merged to run our analysis.

The participants also identified the direction, certainty and strength of the species interactions, and suggested groupings of species according to behaviour and impacts from the existing invasive species. After the workshop, there were follow-up meetings with external reviewers, who checked for conflicting information and grouped the species according to existing literature and personal expertise.

| Invasive/Native	Nodes	Label	Name
Invasive species	1	Cat	Cats
	2	Fox	Foxes
	3	Dog	Dogs
	4	SmInMam	Small Invasive Mammals
Native and Culturally-valued species	5	BoP	Birds of Prey
	6	LTerMam	Large Terrestrial Mammals
	7	Frog	Frogs
	8	SmTRep	Small Terrestrial Reptiles
	9	GrBir	Ground Birds
	10	ArBir	Arboreal Birds
	11	Snake	Snakes
	12	MegaBat	Megabats
	13	CrWRMam	Critical Weight Range Mammals
	14	Monitor	Monitors
	15	Turtle	Turtles
	16	FSmMam	Flying Small Mammals
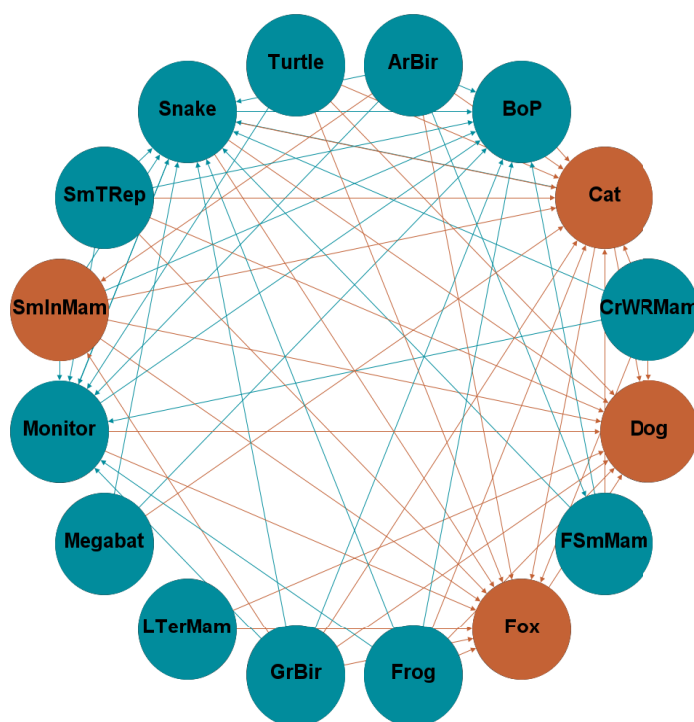
Figure 3. Fauna terrestrial network of Minjerribah-North Stradbroke Island. Red nodes (circles) are invasive species, green nodes represent native and culturally valued species. The arrows (edges) are directed from source (prey) to target (predator). The edges are coloured according the target species' origin (native or invasive).

Key findings

The safest strategy to minimise the probability of undesired effects to local threatened and culturally valued species was to simultaneously eradicate red foxes and feral cats. This approach did not show significantly negative effects on native populations.

Fox-control only carries some risk of meso-predator release.

Pet cats are likely to provide an ongoing source for feral cat populations, reversing the gains of feral cat control unless definitive actions (i.e., mandatory desexing, cat curfews or prohibition) that regulate pet cats are implemented. Local NRM expected that any change to companion animal and tourism policies would incur significant resistance from parts of the community, with it likely that measures would not be consistently adopted.
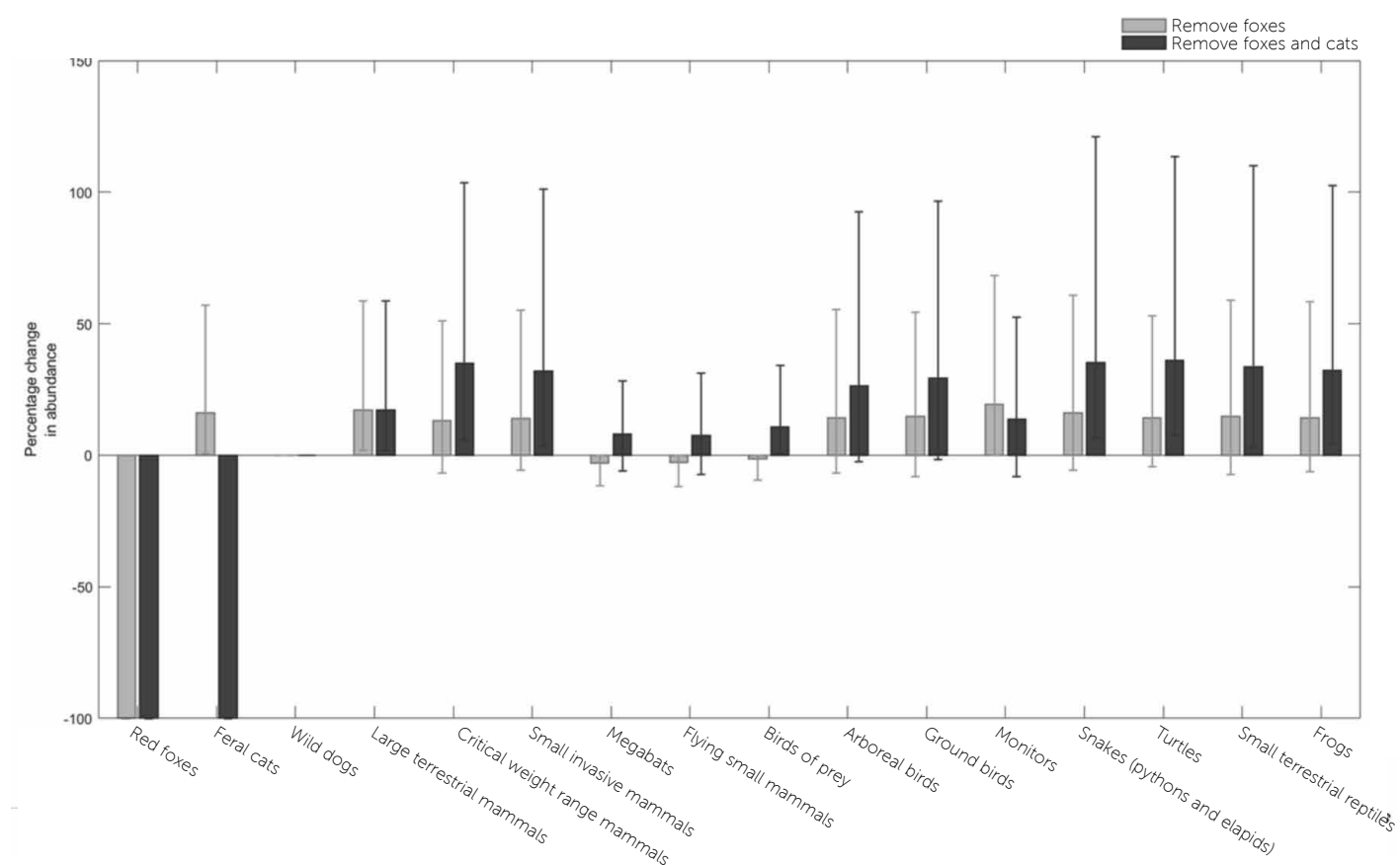

Figure 4. Percentage median change in abundance of the modelled terrestrial vertebrate ecosystem network of Minjerribah. This figure shows the percentage median change in abundance for each node after the modelled implementation of Strategy 1 (red fox removal) in grey and Strategy 2 (joint removal of red foxes and feral cats) in black. The error bars represent the 5th and 95th percentiles across the 100,000-parameter sets.
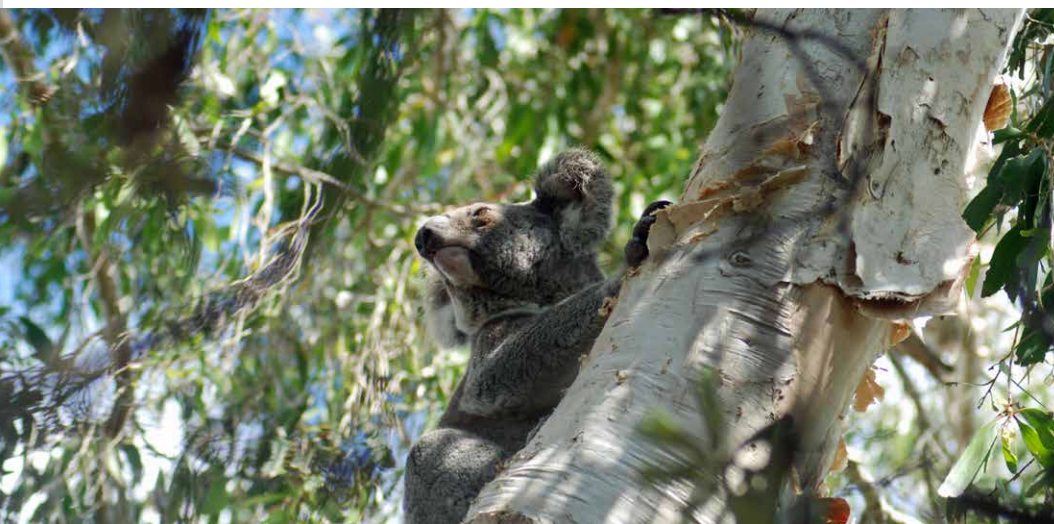
*LEFT: A koala on Minjerribah.
Image: B. Martin*

Implications and recommendations

The implementation of an island-wide management strategy, such as invasive species eradication, comes with great uncertainty. The goal of local natural resource managers and decision-makers is to avoid any possible undesired outcomes and assess which strategy will be the most beneficial for the native and culturally relevant species on the Island. Our analysis showed that Strategy (1), the simultaneous eradication of red foxes and feral cats, is more likely to have a positive effect on the terrestrial vertebrate ecosystem than a single-species approach targeting only red foxes.

Using expert judgement to make forecasts along with informed decision-making is a well-established practice in conservation, helping to make decisions under uncertainty conditions. Nevertheless, the information provided by local experts can vary, and a structured framework to elicit and review local details needs to be implemented. Models, such as the one presented here, can help decision-makers to avoid making decisions based only on intuition or previous experience.

Involving stakeholders in invasive species management is a critical but difficult aspect of management. The implementation of participatory approaches can provide a social benefit by increasing the commitment of the local community, and by developing trust and overall social acceptance of actions that can sometimes be problematic in inhabited islands. We overcame barriers to incorporating local stakeholder knowledge into invasive species management by following a multi-stakeholder engagement process based on adaptive management principles.

Invaded ecosystems are complex management challenges, especially those of inhabited islands, as we not only need to include ecological parameter, but also account for social preferences, and economic objectives. Despite the underlying uncertainty, in many cases delaying the implementation of conservation actions is not an option. Qualitative modelling approaches, such as the one implemented here, can help practitioners to account for the underlying uncertainty of the system, by providing insights on the possible outcomes from planned actions before the actions are implemented

How to undertake invasive management activities, such as baiting and banning companion animals on islands, without incurring significant community resistance is not well understood. Existing management actions (i.e., hunting, trapping and baiting) that target feral cats are unlikely to be effective on inhabited islands in the long term, as pet cats can be a source for re-establishment of feral cat populations.

The implementation of eradication plans has benefited native species worldwide. By implementing models, such as the one applied here for Minjerribah, decision-makers can develop a better understanding of possible population responses, thus helping to adopt a timely response plan in the case of undesired population responses. Our approach can be readily applied to other species management projects. Conservation planners and decision-makers can use it to assess possible outcomes before making long-term economic and social commitments to eradication programs.

Further reading

Caceres-Escobar, H. 2019. *Invasive species management under uncertainty: a participatory and modelling approach.* PhD thesis, School of Biological Sciences, The University of Queensland. https://doi.org/10.14264/uql.2019.620

Caceres-Escobar, H., Kark, S., Atkinson, S. C., Possingham, H. P., Davis, K. J. 2019. Integrating local knowledge to prioritise invasive species management. *People and Nature*, 00, 1–14.

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