Science for Saving Species

Research findings factsheet

Project 4.2.2.1

Threatened Species Recovery Hub

National Environmental Science Programme

Using population models for tackling invasive species: The case of the red fox in Australia

In brief

Decision-makers and local communities are increasingly considering eradication plans for invasive species on inhabited islands including red foxes. The aim of our study was to provide guidance to decision-makers to inform fox control on Minjerribah (North Stradbroke Island), which is an inhabited island close to Brisbane, Queensland of high environmental, cultural, and economic importance.

We identified and assessed three feasible costed management strategies co-developed with local practitioners when considering management aims that included the ability to achieve a 95% reduction in the fox population within three years.

We modelled three scenarios and found that the "high-intensity and high-investment" scenario was not only the most cost-effective, but also delivered results over a three-year implementation period that could lead to eradication.

While our framework was developed for fox control on Minjerribah, it can be applied to other locations and other invasive species. It can assist decision-makers to identify how much effort, time and financial investment is needed to achieve invasive species management objectives.

Our model was effective at predicting changes to the fox population in response to the proposed scenarios, yet it does not predict secondary changes on other invasive species populations, such as feral cats and rats. These may occur as a response to fox population reduction. Where multiple invasive species are present, any such large-scale feral animal control or eradication program should be accompanied by detailed pre-implementation assessments, monitoring programs – before, during and after implementation – and population and ecological response modelling.

A red fox on Stradbroke Island. Image:Dan Carter, Sibelco Ltd

Background

Invasive species are not only one of the main threats to biodiversity, they also can have negative impacts on local economies and social values. Introduced red foxes (*Vulpes vulpes*) are a significant threat to native culturally valued and threatened species in Australia, to communities' values, and economic activities such as tourism. Red foxes have been found to impact at least 95 threatened native species in Australia, and cause an estimated AUD$227.5m in damage annually. In 2000, red foxes were recognised as a "Key Threatening Process" to native fauna under the national conservation legislation.

In this project, we set out to assess possible management strategies for red foxes on Minjerribah (North Stradbroke Island, colloquially known as Straddie). Minjerribah is an inhabited island approximately 40 km off the coast of south-east Queensland, and is the second largest sand island in the world. Its unique ecological community coupled with its cultural heritage make it one of 50 priority islands for protection in Australia. Foxes on Minjerribah have direct impacts on threatened and culturally valued species such as the green turtle (by consuming and destroying eggs in nests), agile wallaby, koala and beach stone curlew.

On 31 December 2019, after 60 years of sand mining on the island, the last mine (operated by Belgian company Sibelco) closed. It is expected that tourism will replace sand mining as the main economic activity on the Island, with many tourists drawn to the island's natural landscapes, including its native wildlife.

The network of Protected Areas on Minjerribah is also expected to expand. Managers on the island are aiming to eradicate red foxes to improve the conservation status of the threatened and culturally valued species that they prey on.

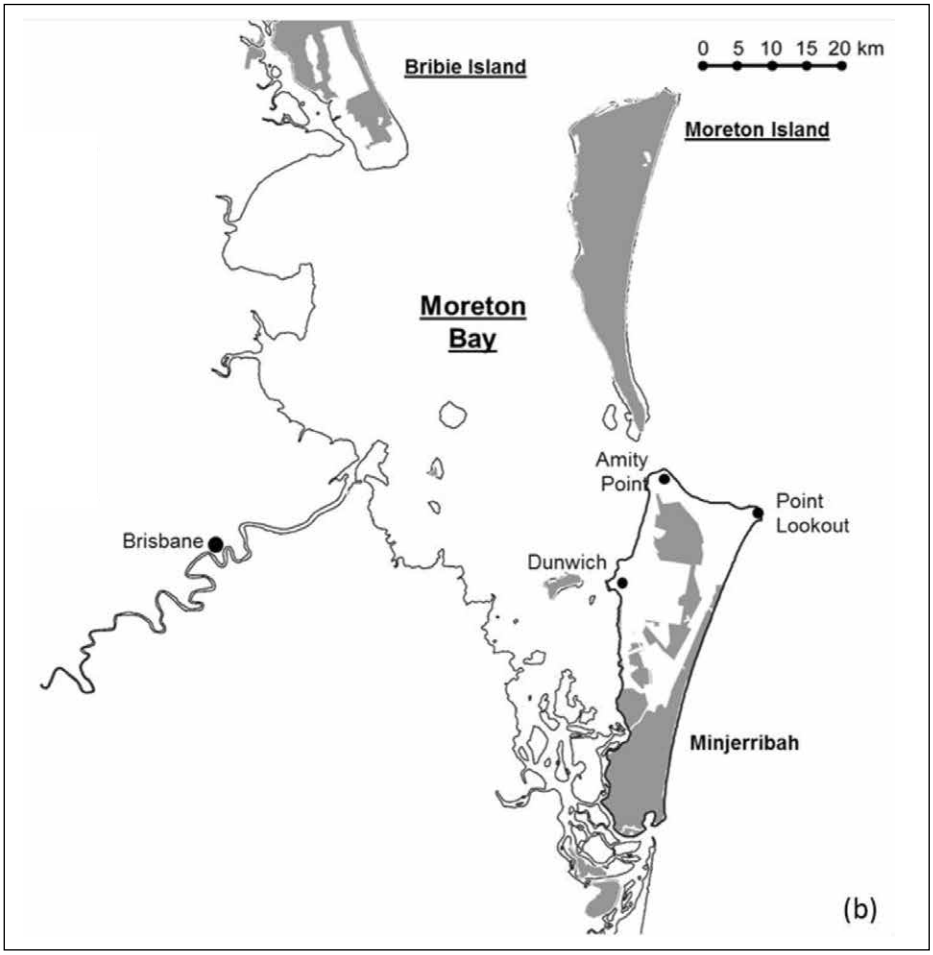

Figure 1. Minjerribah and surrounding islands in Moreton Bay, east of Brisbane. Conservation areas are shown in grey.

Research aims

Effectively managing red foxes on Minjerribah, as elsewhere, requires a strategic approach. The aim of this study was to provide guidance to decision-makers to inform fox control on Minjerribah (North Stradbroke Island), by identifying, costing and assessing feasible management strategies.

Local managers set management objectives for the program of 1) protecting the native fauna; and 2) ensuring the local community remains engaged with the environmental values of the Island; and a goal of reducing the initial red fox population by 95% over a period of three years.

To test the effectiveness of strategies to meet this goal we developed a mathematical model to predict changes to fox populations under specified management scenarios.

What we did

Our framework was developed to assist red fox control on Minjerribah but could be applied to other islands or invasive species. We identified three feasible management scenarios through a combination of literature review, consultation with members of the Straddie Pest Management Group (a partnership of federal, state and local government agencies, Indigenous groups, private businesses and local NGOs), community members and other environmental managers from local government agencies.

The scenarios describe three levels of management intensity (low, medium, high) at three investment levels.

Management intensity is a score defined by local practitioners that indicates the number of hours spent implementing four core actions: (1) trapping; (2) hunting; (3) baiting; and (4) den search.

We modelled fox populations to explore different seasonal combinations of the four actions; and allow for population growth once the implementation period ends, with a yearly birth pulse during spring.

We determined an initial population size of 2280 female foxes, based on assumptions that foxes occupied the entire 285 km^2 island with a density of 16 foxes per km^2, the highest density described in Australia. (not including local data, we assumed the "worst case scenario", especially as foxes on Minjerribah have access to water, food, and no predators.) We considered a management scenario to be successful if it reduced the initial fox population by 95% (to fewer than 114 foxes) by the end of the implementation window of three years.

Costings are based over a period of 25 years, which includes planning, three years of implementation, post-implementation monitoring, and long-term monitoring.

The three proposed management scenarios, with their three-year and total costs are given in Table 1.

Table 1. Summary of proposed management strategies for red fox management.

Proposed European red fox (*Vulpes vulpes*) management strategies			
Actions	Scenario 1	Scenario 2	Scenario 3
Target species	European red fox (*Vulpes vulpes*)		
Level of investment	Low	Medium	High
Total cost (AU$m)[1]	$3.48	$4.08	$5.33
Cost of implementation (3 years) (AU$)	$274,302	$556,102	$1,021,044
Intensity	Low	Medium	High
Baiting campaigns[2]	1 p.a. (152 person-hours/yr)	2 p.a. (304 person-hours/yr)	3 p.a. (456 person-hours/yr)
Bait density (baits/km^2)	2	5	10
Inter-station distance)	1 station every 500 metres of tracks (or 1 station/km^2)		
Den search	114 person-hours/yr	171 person-hours/yr	228 person-hours/yr
Spotlighting and hunting	684 person-hours/yr	1026 person-hours/yr	1368 person-hours/yr
Trapping	684 person-hours/yr	1026 person-hours/yr	1368 person-hours/yr
Management objective	Improve the status of threatened and culturally valued species by controlling red fox impacts		

[1] Over a period of 25 years. This includes planning, implementation, post-implementation monitoring, and long-term monitoring.
[2] A baiting campaign covers a period of four weeks.

Key findings

While all three proposed scenarios achieved some level of population reduction, and would therefore benefit native fauna, our key finding was that that the "high-intensity and high-investment" scenario was the most cost-effective strategy for red fox control on Minjerribah. This scenario can also bring about the knockdown of Minjerribah's fox population after three years of implementation, with a mean reduction in population size of 86.32%. If fox control were to stop after three years, from this point the fox population would take seven years to recover to pre-control levels.

The "medium-intensity and medium-investment" scenario could also result in a knockdown of the fox population, with a mean reduction in population size of 70.61%, but with faster recovery to the initial population size if fox control then stopped – recovery after four years. This was the second-most cost-effective scenario.

The "low-intensity and low-investment" scenario could initially reduce the fox population with a mean reduction of 39.04%, but this type of strategy would require

Further Information

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Acknowledgement

We thank the support of everyone who gave their time to participate in the study, especially to the members of the Straddie Pest Management Group.

Key findings (continued)

continuous investment, as the fox population would bounce back to the initial population size every year. As such, it was found to be the least cost-effective of the scenarios. Furthermore, continuous low levels of management intensity can reduce the effectiveness and efficacy of baiting programs, by leading to bait aversion, and increase the risk of by-catch, therefore negatively impacting non-target species.

If the management goal is to remove red foxes from Minjerribah within a three-year implementation window, only the "high-intensity and high-investment" scenario is likely to meet the requirements, resulting in a long-lasting lower abundance of foxes. We note that none of the three scenarios achieved the target reduction of 95% (relative to the initial population size) over the three-year implementation period; and once it has ended, the red fox population was able to recover to its initial population size under all three scenarios. However, the "high-intensity and high-investment" scenario achieved knockdown levels comparable to those that have reduced red fox populations in other programs in Australia.

We also found in our modelling of population growth rates that targeting foxes in early life stages seems to be most effective in reducing the population. However, targeting specific life stages can be challenging, as actions like trapping, baiting and hunting are not stage-specific, and their efficacy can also be affected by fox behaviour.

Implications and recommendations

Minjerribah is rich in socio-cultural and environmental values which are being threatened by foxes. Fox eradication programs can only be considered successful if native and culturally valued species respond positively and the condition of the local habitat improves. Our modelling has shown that native species are predicted to benefit most from a fox control program that is high-intensity and investment, and next from a program that is medium-intensity and investment. The least benefit would come from a program that is low intensity and investment.

However, on Minjerribah there are eight other invasive species that are very likely to be interacting with red foxes, including feral cats and invasive rats. Previous studies have shown that controlling only red fox populations can lead to "mesopredator release", meaning that the reduction in the top predator, can result in populations of smaller predators increasing. On Minjerribah, a reduction in foxes could lead to an increase in feral cats, mice, and/or rats. It is important to consider the implementation of an integrated island-wide management program that targets multiple invasive species. This approach will likely reduce the possibility of unintended negative effects on native species.

Overall, ecological systems are complex, and do not always respond as expected. The possibility of unpredicted effects of implementing management strategies supports the need for detailed pre-implementation assessments, monitoring programs – before, during and after implementation – and modelling approaches that can shed light on the possible ecosystem responses of any large-scale management initiative.

Nevertheless, the framework we propose can identify the effort, time, and financial investment needed to achieve invasive species management objectives. It can also be readily adapted to other species and management projects. Such participatory and mathematical models can help decision-makers reduce uncertainty, and provide a transparent method to assess, rank, and select proposed management strategies, especially when they are incorporated into an adaptive management framework. The framework can allow conservation planners and decision-makers to assess possible outcomes of planned or optional strategies and scenarios before making long-term economic and social commitments to them.

Cited material

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This project is supported through funding from the Australian Government's National Environmental Science Program.