The *Dudley Peninsula Feral Cat Eradication Plan: Cat control and Monitoring 2019-2023* was received with thanks from Envisage Environmental Services by Natural Resources Kangaroo Island in November 2019.

This plan provides the guiding strategy for development of an annual operational plan for eradication of feral cats from the Dudley Peninsula, Kangaroo Island.

The Operational Plan will be developed based on and in consideration of:

1. Recommendations of the *Dudley Peninsula Feral Cat Eradication Plan: Cat control and Monitoring 2019-2023*;
2. Advice from the Kangaroo Island Feral Cat Eradication Program Steering Committee;
3. Our Program Partner, Kangaroo Island Council and the Council’s domestic cat management activities on the Dudley Peninsula and wider island;
4. Available resourcing; and
5. Adaptive management principles: the recognition that as new tools, technologies and research findings become available, the on-ground delivery of the eradication program will be modified to incorporate the new tools, technology and/or knowledge.
Dudley Peninsula Feral Cat Eradication Plan: Cat Control and Monitoring 2019-2023

ENVISAGE ENVIRONMENTAL SERVICES
PO Box 305 Kingscote 5223.
Citation: Envisage Environmental Services (2019) Dudley Peninsula feral cat eradication plan: cat control and monitoring 2019-2023: Internal report to the Kangaroo Island Natural Resources Management Board.

This report has been prepared by Envisage Environmental Services, on behalf of and for the exclusive use of the Kangaroo Island Natural Resources Management Board and is subject to and is issued in connection with the provisions of the agreement between Envisage Environmental Services the Kangaroo Island Natural Resources Management Board.

Disclaimer

Any representation, statement, opinion or advice expressed or implied in this report is made in good faith. Envisage Environmental Services accepts no liability or responsibility whatsoever for or in respect of any use or reliance upon this report by any third party.

Acknowledgements

We would like to thank Trish Mooney, Karleah Berris, Danny Male, Josh Mulvaney, Venetia Bolwell, Brenton Florance, Grant Flanagan, Kym Lashmar, Damian Miley and Mike Grieg for providing information, maps, suggestions and input into the development of this eradication plan. A range of valuable comments were made by the KI Cat TAG and the KI NRM Board which have been used to improve this document.
Executive summary

The Kangaroo Island Feral Cat Eradication Program aims to eradicate cats from the Dudley Peninsula (371 km\(^2\)) by 2023, as the second stage in a long-term plan to eradicate cats from all of Kangaroo Island (KI). Feral cats pose a threat to native species on Kangaroo Island and predation by feral cats is recognised as a threatening process for a number of threatened species including the KI dunnart, echidna and southern brown bandicoot. Cats are also known as vectors of parasitic diseases of livestock, particularly sarcosporidiosis and toxoplasmosis. These diseases cause substantial economic impact for the Island’s primary producers.

KI has been identified as one of the five islands nominated under Australia’s Threatened Species Strategy to be subject to increased management activity in order to eradicate feral cats. This forms part of a broader Federal Government Safe Havens initiative.

The objectives of this plan are to:

1. review the requirements to achieve eradication and the techniques used in Australia and overseas to identify the control and monitoring tools available and evaluate their applicability for use in the Dudley Peninsula eradication program.

2. identify the gaps in existing knowledge relating to the control and monitoring of the feral cat population on the Dudley Peninsula that may limit progress towards eradication

3. develop a control plan to enable operational staff to move towards eradication of cats from the Dudley Peninsula through a three-stage approach involving a rapid pulldown of cat numbers, mop-up of surviving individuals and a period to assert no individuals remain extant.

The Dudley Peninsula is insular in shape but connected to the larger (4020 km\(^2\)) western portion of the Island at a narrow Isthmus (900 m wide) between Pelican Lagoon and the southern ocean. A barrier fence on the Isthmus will be constructed to prevent movement of cats from the western portion of the Island. Agricultural land covers 59 % of the DP and is used primarily for sheep meat and wool production. Large blocks of native vegetation in conservation parks and privately held properties dominate the southern part of the Peninsula. Three coastal settlements occur on the northern side of the Peninsula: Island Beach, Baudin Beach and Penneshaw. The 2011 census recorded 595 residents. Twenty domestic cats were registered on the DP in September 2019.

Effort required for successful eradication increases with island size, ruggedness, productivity, remoteness and human occupation. The characteristics of species also impacts on the likely success of eradication. Cats are particularly difficult to control because they are solitary, elusive, intelligent, and have a flexible social structure including a strong association with human activity. Ecologically they have a high growth rate, and an ability to adapt to most habitats and food resources. A population will sustain itself even if six out of ten cats are removed from a population each year.

Feral cats have been eradicated from 82 islands around the world. The largest islands to achieve eradication to date are Dirk Hartog Island (620 km\(^2\)) in WA, followed by Marion Island (290 km\(^2\))
in South Africa. Neither of these islands had a resident human population. Ascension (UK) (97 km²) is currently the largest inhabited island where feral cat eradication has been successful.

Of the occupied islands identified for eradication of cats in the Five Islands Safe Havens Program, KI is by far the largest (4,400 km²) and the DP component (371 km²) is larger than the other three: Bruny Island (352 km²), French Island (170 km²) and Christmas Island (135 km²).

There are a number of fundamental requirements that need to be met to achieve eradication. These are:

- the rate of removal exceeds the rate of increase at all population densities
- immigration into the site can be prevented (no reinvasion)
- all reproductive animals must be at risk
- animals can be detected at low population densities
- the benefits and costs of eradication exceed those for control or management of the pest species
- A suitable socio-political environment exists with no unacceptable adverse effects.

A rapid pulldown is necessary to achieve cat eradication on the DP within the designated timeframe of the program and it is also generally considered desirable for island eradications. The target rate for pulldown of a cat population is typically 80-90%. This implies control devices need to remove 8-9 cats from the population over a wide area in a short space of time to limit individuals learning how to avoid control measures and reinvading unoccupied habitat. The use of broadscale baiting is considered necessary to produce a rapid pulldown of cats occupying large islands particularly where access is limited.

The options to control cats on the DP are currently restricted to the use of cage traps, fire arms and the Felixer™. The capacity of each of these tools, used in isolation or combination, to achieve a high rate of pulldown on the cat population has not yet been demonstrated on Kangaroo Island.

No bait to target cats is currently approved for broadscale use on any part of Kangaroo Island. Baiting will be needed to provide control of cats occupying large blocks of bushland where access is limited. The Curiosity™ cat bait containing PAPP inside a hard pellet is the most promising tool for broad scale delivery. It should become available by mid 2020 and will be limited for use in winter to prevent uptake by goannas. The Eradicat® bait is not considered suitable because a large number of non-target species on KI were found to consume the baits and are susceptible to the1080 toxin.

The construction of a barrier fence across the Isthmus is proposed to prevent the movement of cats from west to east. The main road linking communities on western KI to Penneshaw will bisect the barrier fence and other gaps in the fence are proposed to enable the movement of wildlife and people. Considerable uncertainty surrounds the ability of control devices stationed at gaps in the fence or other control measures to halt cat immigration across the Isthmus.

Given the issues outlined above, we consider it unwise to begin the DP-wide pulldown of cats until a bait is available for broadscale distribution (approval should be given in the next 12 months) and until the efficacy of control devices and the fence is better understood and documented.
At least 18 months of preparation will be required before any broad scale pull-down of the cat population could be effectively conducted on DP. This time is needed to:

- ensure permits, approvals, practices and protocols are in place and equipment is fully functional to enable a smooth roll-out of control operations when required
- ensure domestic cat population management is in place with 100% compliance
- begin sustained cat control effort on parts of the DP to realise biodiversity and another agricultural assets
- determine the combination of devices and the effort required to achieve a >80% pulldown in each MU on the DP
- determine the best combination of devices for use in mop-up operations
- determine the efficacy of the barrier fence and the amount of additional effort required to stem the reinvasion of cats from the west.

The activities required to position and prepare for a cat eradication event on the DP in mid-2021 are identified by grouping the activities that need to occur both temporally, by season, and spatially in management units (MUs) and modules. Some activities are time or season critical components, such as bait trials, and others will potentially need to be maintained throughout the program, particularly around the barrier fence. Four MUs are identified: MU1 includes the Isthmus and the cat barrier fence, Island Beach/Strawbridge Point peninsula and numerous lifestyle blocks; MU2 includes large blocks of native bushland and conservation areas; MU3 is predominantly agricultural land, and MU4 incorporates the urban/peri-urban areas of Penneshaw and Baudin Beach.

Smaller areas or modules within the larger MUs are relevant to the first 18 months of trials. They identify where a suite of control and monitoring activities should be trialled and, if found effective, could be extended further across the MU. Two modules, one in farm land (MU3.1) and one in mainly bushland (MU1.1), have also been identified to receive continuous pulldown effort and potentially mop-up effort prior to the DP-wide pulldown. This will enable agriculture and biodiversity benefits time to recover in response to cat control and to become clearly evident by the end the funded program in 2023.

The temporal roll out of the program is summarized in Table 6.1 with more detail on each activity summarized in Table 6.2.
Contents

Acknowledgements .................................................................................................................. 1

Executive summary .................................................................................................................. 2

1. Introduction ......................................................................................................................... 11

2. Background .......................................................................................................................... 11
   2.1 Impacts of cats .................................................................................................................. 11
   2.2 The Five Islands and Safe-haven Projects ........................................................................ 12
   2.3 Justification for the removal of feral cats from Kangaroo Island ...................................... 12
   2.4 Landscape characteristics of the Dudley Peninsula ......................................................... 13
   2.5 Factors affecting successful eradication on islands ......................................................... 14

3. The necessities for eradication ............................................................................................. 15
   3.1 Requirements of a successful eradication ......................................................................... 15
   3.2 Planning for successful eradication .................................................................................. 15
      3.2.1 Community engagement and ownership .................................................................... 16
      3.2.2 Control operations for eradication .......................................................................... 18
      3.2.3 Monitoring for eradication ...................................................................................... 19
      3.2.4 Monitoring biodiversity and agriculture .................................................................. 21

4. Techniques to control feral cats .......................................................................................... 22
   4.1 Baits and toxins ............................................................................................................... 22
   4.2 *Felis*—grooming) traps .................................................................................................... 26
   4.3 Cage traps ........................................................................................................................ 28
   4.4 Soft-jaw (rubber-padded leg-hold) traps ......................................................................... 30
   4.5 Attractants and trap success ............................................................................................ 31
   4.6 Shooting assisted with thermal-image scopes ................................................................... 32
   4.7 Detector dogs to assist hunters ....................................................................................... 32
   4.8 Exclusion fences .............................................................................................................. 33
   4.9 Domestic cat control ....................................................................................................... 34

5. Feasibility for cat eradication on the Dudley Peninsula ..................................................... 35
   5.1 Comparison with other the islands ............................................................................... 35
   5.2 Current technical feasibility for cat eradication on the DP ............................................ 35
      5.2.1 Removing cats faster than they can breed ............................................................... 35
      5.2.2 Putting all cats at risk ............................................................................................. 37
      5.2.3 Preventing reinvansion ............................................................................................ 39
6. Actions to achieve cat eradication on the DP

6.1 Project management

6.1.1 Approvals, procedures and protocols

6.1.2 Practices and protocols

6.1.3 Equipment functionality and data management

6.1.4 Domestic cat control across the DP

6.1.5 Property access and restriction mapping

6.2 Dudley wide annual monitoring

6.2.1 DP Camera grid

6.2.2 Systematic surveys using sign

6.2.3 Citizen cat monitoring

6.3 Isthmus fence activities: MU1

6.3.1 Felixer™ trap improvement trial

6.3.2 Kangaroo use near the fence and collision rate pre and post fence construction

6.3.3 Immigration rate and gap usage

6.3.4 Cat movement and microhabitat use pre and post movement through the fence

6.3.5 Felixer™ efficacy pre- and post-pulldown

6.3.6 Fence efficacy post east-side pulldown

6.3.7 Fence efficacy post west-side pulldown

6.4 Isthmus and Island Beach pull down and mop-up: MU1

6.4.1 Pulldown monitoring

6.4.2 Pulldown in MU1.1, MU1.2 and MU1.3

6.4.3 Mop-up trial in MU1.1

6.5 Bushland Curiosity bait trial: MU2

6.5.1 Persistence of toxin plus shell

6.5.2 Non-toxic trial to determine bait density

6.6 Farmland trial pull down: MU3

6.6.1 Monitoring

6.6.2 Pull down trial in MU3.1 and 3.2
6.7 Urban/peri-urban: MU4........................................................................................................52
6.8 Pulldown DP-wide.............................................................................................................53
6.9 Mop-up and validation........................................................................................................53

7. References ...........................................................................................................................60

8. Appendices ............................................................................................................................71

Appendix 1 Conceptual model describing the current and potential impacts of cats on Kangaroo Island..................................................................................................................71
1.1 Conceptual models used to understand the interactions and complexities of the system .................................................................................................................................71
1.2 Conceptual model describing potential impact following cat eradication.........................74

Appendix 2 Methods to standardize and describe effort and effect........................................76
2.1 Monitoring settings and treatments ...................................................................................76
2.1.1 Trap settings ................................................................................................................76
2.1.2 Active v passive monitoring .......................................................................................76
2.2 Describing control effort, efficacy, impact and outcome ...................................................76
2.2.1 Trap effort ...................................................................................................................76
2.2.2 Catch per unit effort (efficacy)....................................................................................77
2.2.3 Cumulative-catch curve ............................................................................................78
2.2.4 Density-impact functions ...........................................................................................78
2.2.5 Cost-benefit monitoring .............................................................................................79
2.3 Describing characteristics of the cat population ...............................................................80

Appendix 3 Collecting data on movement, immigration, population size and optimising capture effort ..................................................................................................................81
3.1 Cat movement and immigration .......................................................................................81
3.2 Setting camera arrays .......................................................................................................82
3.3 Optimising trap placement and layout .............................................................................82

Appendix 4 Estimating abundance, occupancy, detectability and population growth.. 85
4.1 Absolute abundance and density .......................................................................................85
4.2 Relative abundance and occupancy ..................................................................................86
4.3 Population trend and growth rate ....................................................................................88
4.4 Probability of remaining extant .......................................................................................89

Appendix 5 Management units .................................................................................................91
5.1 Management Unit 1: Island Beach/DP Isthmus .................................................................91
5.2 Management Unit 2: Bushland ..........................................................................................92
5.3 Management Unit 3: Farmland ................................................................. 92
5.4 Management Unit 4: Urban ................................................................. 92

Appendix 6 Additional research needs ......................................................... 94
Project Name: Creating a safe haven for the Kangaroo Island Dunnart and other priority threatened species by eradicating feral cats from the Dudley Peninsula (RLP-MU17-P3)

Federal Government Program Outcomes

This plan will contribute to the delivery of the Kangaroo Island Feral Cat Eradication 2015-2030 which is part of the Five Islands Safe Havens Program. The following Outcomes and Regional Targets from the Plan are relevant to the project:

Long-term outcomes

The trajectory of species targeted under the Threatened Species Strategy and other EPBC Act Priority Species is improved.

Primary Regional Land Partnerships outcome: by 2023, the trajectory of species targeted under the Threatened Species Strategy, and other EPBC Act priority species, is stabilised or improved.

Primary investment priority: Kangaroo Island dunnart *Sminthopsis fuliginosa aitkeni*

Additional benefits: Secondary investment priorities for priority EPBC listed species from the supplied threatened species prioritisation templates:

- *Thinornis rubricollis rubricollis* (hooded plover (eastern))
- *Tachyglossus aculeatus multiaculeatus* (Kangaroo Island echidna)

Short-term outcome statement/s

By 2021, effective feral cat (*Felis catus*) control is being delivered across 15,000 ha of KI dunnart (*Sminthopsis fuliginosa aitkeni*) habitat on the Dudley Peninsula.

By 2021, the trajectories of the KI echidna and hooded plover on the Dudley Peninsula have been stabilised as a result of effective feral cat control.

By 2021, 95% of the KI community supports the Dudley Peninsula feral cat eradication program.

Medium-term outcome statement/s

By 2023, feral cats are eradicated from the Dudley Peninsula, thereby creating a safe haven for the KI dunnart.

By 2023, the trajectories of the KI echidna and hooded plover on the Dudley Peninsula have been stabilised or improved as a result of feral cat eradication.

By 2023, 95% of the KI community supports eradication of feral cats from the whole of Kangaroo Island.
The project brief for Envisage was as follows:

Review of literature, technical reports and data relevant to cat eradication on Ki

Develop a KI Feral Cat Eradication Plan (Dudley Penninsula) 2019-2023.


It was later agreed to combine the two documents to improve flow and continuity for the reader.

Details regarding community engagement considerations were to be developed separately by DEW.

Details regarding monitoring and describing the extent to which better outcomes for biodiversity monitoring and agriculture were to be developed separately by DEW.
1. Introduction

The Kangaroo Island Feral Cat Eradication Program aims to eradicate cats from the Dudley Peninsula (371 km²) by 2023, as the second stage in a long-term plan to eradicate cats from all of Kangaroo Island (KI). Feral cats will be eradicated using a range of methods, including trapping, *Felixer™* grooming traps, baiting, shooting and use of detector dogs.

Feral cats pose a threat to native species on Kangaroo Island and predation by feral cats is recognised as a threatening process for a number of threatened species including the Kangaroo Island dunnart *Sminthopsis fuliginosis aitkeni*, the Kangaroo Island echidna *Tachyglossus aculeatus multiaculeatus*, hooded plover (eastern) *Thinornis rubricollis rubricollis* and southern brown bandicoot *Isoodon obesulus*. Cats are also known to be vectors of parasitic diseases of livestock, particularly sarcosporidiosis and toxoplasmosis (O'Donoghue and Ford 1986; O'Callaghan et al. 2005; Taggart et al. 2019a) and cause substantial economic impact on the Island's primary production.

Kangaroo Island has been identified as one of the five islands nominated under Australia’s Threatened Species Strategy to be subject to increased management activity in order to eradicate feral cats. This forms part of a broader Federal Government Safe Havens initiative (Ringma et al. 2019). The cat eradication initiative for Kangaroo Island builds on the previous success of feral goat and deer eradication on Kangaroo Island (Masters et al. 2018).

To assist planning for Stage 2, NRKI engaged Envisage Environmental Services to develop a cat eradication and monitoring plan for the Dudley Peninsula (DP) and to develop a credible pathway towards the vision of cat free Kangaroo Island within the resources available.

The objectives of this plan are to:

1. review the requirements to achieve eradication and the techniques used in Australia (and overseas) to control and monitor cats, identify the control and monitoring tools available and evaluate their applicability for use in the Dudley Peninsula eradication program
2. identify the gaps in existing knowledge relating to the control and monitoring of the feral cat population on the Dudley Peninsula that may limit progress on eradication
3. develop a control plan to enable operational staff to move towards the eradication of cats from the Dudley Peninsula through a three stage approach involving a trial and planning phase which will move into the rapid pulldown, the mop-up of surviving individuals and a period to assert no individuals remain extant.

2. Background

2.1 Impacts of cats

Feral cats are recognised as a formidable problem for biodiversity and agriculture worldwide. They have contributed to a minimum of 14% of all bird, mammal, and reptile extinctions and the decline of at least 8% of critically endangered birds, mammals, and reptiles world-wide (Medina et al. 2011). Many Australian mammal species are highly susceptible to predation by introduced...
cats (*Felis catus*). At least 34 (10%) Australian endemic mammal species have become extinct since 1788 and predation by introduced cats and foxes is considered a major contributor to most of those extinctions (Ringma et al. 2019). A number of diet studies have been undertaken on Kangaroo Island which have found that cats take a wide variety of native wildlife including water fowl, bandicoots, juvenile echidnas and penguins (Paton 2003; Masters 2007; Rismiller and McKelvey 2003; Doherty et al. 2015).

Cats play a significant role in the transmission of disease that can affect agricultural production and animal health including humans. *Toxoplasma gondii*, is a protozoa that uses the cat as a host and can cause health issues in humans and ground-foraging Australian wildlife species. Clinical toxoplasmosis is recognised as a serious disease in captive Australian mammals, although the true impact of toxoplasmosis on free-ranging populations of Australian marsupials, and other native mammals more broadly, is largely unknown (WHA Fact sheet: Toxoplasmosis of Australian mammals 10, February 2017).

The cat is also the only primary host of the parasite *Sarcocystis gigantea* and sheep act as the only intermediary host. While grazing, sheep consume eggs of the parasite which then turn into cysts that form in the muscle tissue. During meat processing at the abattoirs, the cysts are cut out of the carcass resulting in a reduction of dressed carcass weight. Heavy infestations can result in the entire carcass being condemned. This disease impacts heavily in areas of South Australia, Tasmania, New Zealand and Spain and is particularly prevalent on Kangaroo Island (Munday 1975; O’Donohue 1978; Taggart et al. 2019a).

### 2.2 The Five Islands and Safe-haven Projects

Kangaroo Island has been identified as a component of the Safe Haven Project which aims to focus on islands or mainland fenced areas where the threat of introduced predators is either naturally absent or excluded by management (Ringma et al. 2019). Projects that are either underway or proposed aim to eradicate introduced predators from five large islands totaling 5184 km² (Bruny Is 356 km²; French Is, 174 km²; Christmas Is 137 km²; Phillip Is, 101 km²; and Kangaroo Is, 4416 km²). In addition, several new fenced areas are planned or under construction that would provide a cumulative protection area of over 920 km² (Ringma et al. 2019).

### 2.3 Justification for the removal of feral cats from Kangaroo Island

Due to the absence of foxes and rabbits, and a large proportion of the area covered by native vegetation, Kangaroo Island (KI) still has most its fauna intact, although a number of species potentially impacted by cats are either rarely found, such as the Kangaroo Island Dunnart, or reported to be declining such as the echidna, goanna, and southern brown bandicoot. It is believed that the removal of cats will make these species, and many others that are declining on the mainland, more secure. In addition, KI has one of the highest levels of Sarcosporidiosis and Toxoplasmosis in Australia which impacts heavily on sheep production and profitability for farmers and the KI community more generally. The impacts of Toxoplasmosis on wildlife could also be considerable.
A conceptual model detailing the current situation and expected response of species to cat eradication is outlined in Appendix 1. This helps with the identification of species and interactions among species that should be monitored to determine the benefits and potential problems of cat eradication.

### 2.4 Landscape characteristics of the Dudley Peninsula

The Dudley Peninsula is 371 km² in area and insular in shape but connected to the larger (4020 km²) western portion of the Island at a narrow Isthmus (900 m wide) between Pelican Lagoon and the southern ocean (Fig. 2.1).

**Fig. 2.1** The location of the Dudley Peninsula and proposed eradication as part of Kangaroo Island

The Dudley Peninsula (DP) has a Mediterranean climate and receives 400-600 mm of rainfall which falls predominantly between the months of May and October. Most of the rivers and creeks are ephemeral, often drying out in summer. The environmental characteristics of the DP include land systems of flat or undulating plateaus, limestone hills, coastal cliffs and sand dunes. Agricultural land covers 59% of the DP and is used primarily for sheep meat and wool production with limited cropping, mainly hay. Small pockets of remnant native vegetation are
scattered throughout this landscape and maintained as shelter belts. Larger blocks of native vegetation in State managed conservation reserves and on privately held properties occur predominantly on the southern part of the Peninsula. The area of native vegetation and cleared land covered by each land use type is summarised in Table 2.1.

**Table 2.1** The area of land use, native vegetation within each land use and the percentage cleared land covered by each land use type

<table>
<thead>
<tr>
<th>Land use type</th>
<th>Area (ha)</th>
<th>Native veg. (ha)</th>
<th>Cleared %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>333</td>
<td>227</td>
<td>31.8</td>
</tr>
<tr>
<td>Peri urban/lifestyle</td>
<td>3982</td>
<td>3929</td>
<td>1.3</td>
</tr>
<tr>
<td>Bush Heritage</td>
<td>4930</td>
<td>4918</td>
<td>0.2</td>
</tr>
<tr>
<td>Agriculture</td>
<td>21871</td>
<td>2344</td>
<td>89.2</td>
</tr>
<tr>
<td>Conservation</td>
<td>5995</td>
<td>5961</td>
<td>0.57</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>37111</strong></td>
<td><strong>17379</strong></td>
<td></td>
</tr>
</tbody>
</table>

Three coastal settlements occur on the northern side of the Peninsula: Island Beach, Baudin Beach and Penneshaw. The 2011 census recorded 595 people living on the Dudley Peninsula. The Kangaroo Island Council records indicate that around 40% of rate payers live off island. There is an influx of tourists particularly during the warmer months, most of which arrive at Penneshaw via ferry or cruise ship. Many dwellings are temporarily occupied by tourists and visitors. Residents and visitors must register their cats with the Kangaroo Island Council, although this is not enforced. There are 20 registered domestic cats on the DP (September 2019 figures).

A well-developed road network is present across most of the Peninsula, but there is limited access on some private property land and conservation parks.

### 2.5 Factors affecting successful eradication on islands

Difficulty of eradication depends on both the characteristics of the animal targeted and the socio-economic and environmental features of the island itself. Effort required for eradication increases with island size, ruggedness, productivity and remoteness (Gregory et al. 2014). Human occupation on an island also increases the complexity and expense of eradication because of the diversity of views regarding all aspects of the control program (Braysher 2017; Walsh 2019).

The ability to eradicate varies considerably among species. Goats and black rats have been identified as easier to eradicate than cats, rabbits and pigs. Rodents and cats have been assessed as being 1.7-3.0 times more expensive to eradicate compared to ungulates (Gregory et al. 2014, Helmstedt et al. 2016; Martins et al. 2006).
Cats are particularly difficult because they are elusive, intelligent, and have a flexible social structure including a strong association with human activity. Ecologically they have a high growth rate, an ability to adapt to most habitats, prodigious movement and dispersal capabilities and can switch their diet to whatever prey species are available. When food is abundant cats show high con-specific tolerance and a population can reach very high densities (Denny and Dickman 2010; Bengsen et al. 2015). In the absence of predators and faced with no resource constraints, a feral cat population will double in size every 8.5 months (Short and Turner 2005, Hone et al. 2010); and a population will remain self-sustaining even when six out of every 10 cats are removed annually (Venning, in review; Hone et al. 2015).

Feral cats have been eradicated from 82 islands around the world (2018 figures). The largest islands to achieve eradication to date are Dirk Hartog Island (620 km²) in WA, followed by Marion Island (290 km²) in South Africa (Parkes 2018a; Bloomer and Bester 1992). Neither of these islands had a resident human population. Ascension (UK) (97 km²) is currently the largest inhabited island where feral cat eradication has been successful (Parkes 2018b). There have been few occupied islands greater than 50 km² where an attempted cat eradication has been successful.

3. The necessities for eradication

3.1 Requirements of a successful eradication

There are a number of fundamental requirements that need to be met to achieve eradication (Bomford and O’Brien, 1995; Parkes and Panetta 2009). These are:

- The rate of removal exceeds the rate of increase at all population densities
- Immigration into the site is prevented (no reinvasion)
- All reproductive animals must be at risk
- Animals can be detected at low population densities
- The benefits and costs of eradication exceed those for control or management of the pest species
- Suitable socio-political environment exists with no unacceptable adverse effects.

The first three relate directly to the ability to apply control techniques. In other words, the adequacy of the tools and resources available to reduce the population. The last three relate to the social constraints and ability to determine whether eradication is being achieved and whether tangible social, economic and environmental benefits have resulted from eradication, for example, better biodiversity protection and agricultural production on Kangaroo Island.

3.2 Planning for successful eradication

The relationship between community engagement, control and monitoring operations, and the monitoring of biodiversity and agricultural assets can be summarised (Fig. 3.1). Coordination among the streams is important to ensure the outcomes from each contribute to the overall outcomes required to satisfy the funding bodies and the local community. In each stream,
examples of the type of activities and analyses needed to produce program outputs are identified. The outputs identify the key conditions and indicators used to gauge whether eradication is progressing and the outcomes reflect the requirements necessary to achieve eradication and the main goals of eradication.

### Fig. 3.1

The components for the eradication project (inputs), the activities and analyses that link to agreed outputs required to assess eradication progress and feasibility on the Dudley (Stage 2) and remainder of Kangaroo Island (Stage 3). Adapted from Cape2City Te Matau a Māui Project Management Team (2016).

#### 3.2.1 Community engagement and ownership

Pest management is a people issue. People are part of the problem and also integral to the solution: they greatly influence the way that pests are managed. (Braysher 2017; Algar et al. 2019). The manager of the program needs to understand and take into account the various perceptions, attitudes and values that people hold about the pest status of an animal, and how it might be managed. People’s perceptions affect their willingness to take action or even support the program; this in turn can determine the success or failure of a pest control program. Even on non-populated islands the cost of maintaining the appropriate socio-political environment is an ongoing and time-consuming component of a program (Algar et al. 2019).

Public opposition is the most common obstacle to the implementation and completion of an eradication program due to variation in land tenure and the need for a cohesive approach among many landholders who may have diverse views on conservation and invasive species.
management (Glen et al. 2016; Masters et al. 2018; Oppel et al. 2011; McLeod 2018; Russell and Taylor 2019). Hence, maintaining community support, finding solutions to community concerns and gaining access to property is one of the greatest challenges. Active and open consultation between the parties will help to develop trust and a sense of cooperation. Too often, pest management programs are developed and implemented in a top-down approach by government. This does not encourage those who are affected by the pest to have ownership of the program (Braysher 2017). For example, implementation of a rat eradication program on Lord Howe Island had to be delayed for seven years because the community lost trust in the proponents. Once the project focused on building relationships in the community through one-to-one communication using local officers, and working within the community rather than from the outside, support began to build (Walsh et al. 2019).

Stage 1 of the Kangaroo Island feral cat eradication program identified a number of points of contention including concerns about:

- the types of control devices to be used and particularly the impact of toxic baits
- the impact that a barrier fence would have on human and animal access and movements
- the potential adverse outcomes such as rodent plagues once cats have been removed
- domestic cat management and ownership.

With good project planning and communication and active involvement of stakeholders, support can be improved by ensuring:

- the threats posed by the pest are understood
- the requirements to achieve eradication are clearly and honestly explained
- suitable solutions to contentious issues are identified and agreed on in a collaborative way with the residents
- the benefits expected can be shown to out-way the costs (Gregory et al. 2014).

These factors affect the support provided by landholders to assist control and monitoring operations and the willingness of the community to abide by the By-laws for domestic cat management and biosecurity. Not all stakeholders and pest management projects require the same level of engagement as summarised in Fig. 3.2.
3.2.2 Control operations for eradication

Control operations during an eradication program typically involve two steps:

- **Pulldown:** initial reduction in pest numbers at a pace much faster than they can breed and to limit individuals learning how to avoid control measures (Macdonald et al. 2019). This should happen over months not years (Parkes pers. comm. 2019).

- **Mop-up:** the signal that this stage has been reached is that a target species is difficult to detect and limited to discrete patches. This is usually the most challenging and expensive phase because animals are more difficult to locate, they often occupy remote locations, and some individuals may have learnt to evade detection and capture (Bayne et al. 2000; Courchamp et al. 2003; Masters et al. 2018). At this stage, the focus of operational staff needs to change from targeting the species within habitat types to one of targeting the remaining individuals. This frequently requires a change in tactics (Parkes, pers. com. 2019).
An initial amount of control at a locality is likely to result in some reduction in the target species abundance. To reduce the level of abundance further or to extend the period over which low abundance has been attained, there are four options:

- increase the density of the existing control measures applied within the target area
- introduce other techniques to the existing control measures
- Increase the frequency that control measures are applied (i.e. reduce the interval between applications of control)
- Increase the area effectively controlled (i.e. broaden the area controlled to include neighbouring locations).

The first two options may be necessary to implement in situations when the density of control devices is insufficient to intersect with the movements of every cat or the remaining cats have become wary of the existing control measures. The second two options may be necessary to counter high reinvasion rates or seasonal bursts in recruitment.

A number of control techniques generally need to be applied concurrently or sequentially to achieve pulldown, mop-up or to prevent reinvasion. The efficacy and specificity of each control technique at a range of cat densities needs to be assessed using trials or information from studies conducted elsewhere. This information is critical to have prior to embarking on an eradication using a rapid pulldown.

The range of control techniques used in island cat eradications has been comprehensively outlined in Denny and Dickman (2010). Not all techniques are suitable for all situations. Macquarie Island (127 km²) relied heavily on shooting, cage trapping and leg hold traps; Marion Island (290 km²) introduced *Feline panleucopaenia* to achieve pulldown then mopped up the remaining cats using shooting and leg hold traps; Dirk Hartog Is (630 km²) the world’s largest island to eradicate cats, divided the island into two management units using fencing and relied heavily on *Eradicat®* baits for the pull down; and Ascension Is (97 km²), the largest occupied island to eradicate cats, focused on sterilising domestic cats first, then poisoning using 1080 baits plus cage trapping (Parkes et al. 2014; Parkes 2018b). In summary, there is no one formula that suits all situations and each island has to assess the advantages and disadvantages of the range of tools available and select those that will work for the targeted area. However, nearly all successful eradication campaigns on islands >25 km² have used poisoning with toxic baits as one of the main control options (Algar et al. 2019). There are large parts of the DP where baiting would likely provide the most practical and effective form of cat control once a suitable bait becomes available.

### 3.2.3 Monitoring for eradication

An understanding of the amount of effort required to produce a desired outcome is critical in eradication. Hone et al. (2017) identified the key linkages between effort and outcome (Fig. 3.3). Level 1 includes measures of management effort (E) such as staff hours or funds expended that are required to deploy traps, baits or other control devices. Level 2 describes the response that effort has on altering pest abundance such as the catch from cumulative control effort. Level 3 identifies the ‘outcome’ organism’s response to lowered pest abundance through altered
survival or reproductive rate. Level 4 is a measure of biodiversity abundance or agricultural production resulting from investment of effort in Level 1.

The monitoring component of this report is concerned primarily with describing the relationship between a reduction in cat abundance and trend (level 2) in response to management effort (level 1). It is concerned mainly with the question ‘What is the effect of management on the cat population and is it sufficient to achieve eradication?’

Fig. 3.3  A schematic representation of the cause-and-effect relationships at the population level connecting management efforts (E, Level 1) through to outcome (M, Level 4)

Effective monitoring is widely recognised as vital to the success of invasive species management (Bengsen et al. 2012; Nicholls and Glen 2015) and essential in cat eradication programs (Campbell et al. 2011; Ramsey and Will 2012). Monitoring programs need to be adaptive, question-driven, and make use of appropriate analytical procedures and an interpretive approach (Austin 2007; Field et al. 2007; Lindenmayer and Likens 2010).

Monitoring is often seen to be of secondary importance to control which is one of the major reasons why management can go on for decades with little reduction in the pest impacts or improved strategies to implement control. A well thought out monitoring program is needed to:
• guide control effort in the field to improve management efficiency
• determine the rate of population decline during the pulldown phase
• determine the probability that a population remains extant during the mop-up phase
• determine movement and reinvasion rates within and among habitats
• provide feedback on progress to those involved in the program, including funding agencies and operational staff to maintain their support and engagement

At the end of control operations monitoring is critical to:

• validate that eradication has occurred. Data form a range of monitoring techniques may need to be combined to assert absence (Lee 2014).
• assess the reinvasion risk from importation or immigration from adjacent areas or domestic populations (Parkes 2018a).

Capture rates should not be used as the primary measure to inform the direction and rate of population change. This is because catch per unit effort (CPUE) reflects the weariness of an individual to be captured by a device not the number remaining. An independent and sensitive monitoring technique is needed to track the change in population size and rate of decline. A technique proposed as a primary technique to broadly monitor pulldown needs to have capacity to provide meaningful data on abundance at high and low levels. Low detection should not be confused with low abundance or occupancy.

Camera arrays are now used extensively in monitoring wildlife communities (Shannon et al. 2014, van Hespen et al. 2019) and have been used to assess the effect of management effort including baiting to reduce cat abundance (Robley et al. 2008, 2010; Ramsey and Will 2012; Hohnen et al. 2016; Comer et al. 2018; Palmer and Anderson 2018). Shannon et al. (2014) provide advice on survey design and the trade-off between sample occasion (survey length) and the number of sites (camera locations) for species with different detectability and occupancy. More detail on aspects of effective monitoring is provided in Appendix 2, 3 and 4.

A different approach to monitoring must be used during the mop-up phase of an eradication program (Appendix 4). Combining information from multiple monitoring techniques is often needed to determine population trends and assess the probability the target species remains extant (Lee 2014; Ramsey et al. 2011; Ramsey and Will 2012; Robley et al. 2016). The ability of each technique to detect a target species needs to be assessed while the species is abundant. These ‘expected’ detection estimates derived when a population is abundant are necessary to estimate the probability a species remains extant at very low abundance when repeat surveys produce few detections. When population density is low, it becomes more important to understand where individuals persist and to provide information to improve control tactics.

3.2.4 Monitoring biodiversity and agriculture

Cat removal has been implemented because of the perceived and real impacts that cats are having on native species and agriculture. Hence, monitoring the response of biodiversity and agriculture to the removal of cats is key to the cat eradication program.

While a focus on threatened species is important, the monitoring also needs to include species that will respond rapidly to a decrease in cat density and are relatively easy to monitor. On Dirk
Hartog Is for example, despite it being only a few years since complete removal of cats, cameras monitoring quickly picked up species which were not previously detected in 2014. These included the long-tailed dunnart (Sminthopsis dolichura), painted button quail (Turnix varius) and bush stone curlew (Burhinus grallarius) (Algar et al. 2019).

Monitoring of the unintended ecological consequences of a species removal is also important to understand (Dickman 2007, 2009; Hone et al. 2017). The release of meso-predators such black rat and house mice following cat removal is well documented (Macquarie Is experience). Hence, the extent to which the abundance of rats and mice increase and the effect on native species such as penguins and other nesting birds will be critical to monitor on the DP.

In addition to biodiversity benefits, economic benefits and the decline in Sarcocystis and Toxoplasma will be important to monitor. The quantification of these benefits will provide strong economic and community support for the program gaining more strength in the commitment to move to Stage 3, the eradication of cats from the rest of Kangaroo Island.

This document is concerned primarily with the second and third streams of Fig. 1 (i.e. the control and monitoring of the cat population), but monitoring the effect of cat control on biodiversity and agricultural is also critical to the cat eradication program.

4. Techniques to control feral cats

Overall, devices currently approved and available for cat control on DP include trapping using cage traps, shooting with thermal-scopes, shooting with detector dogs, exclusion fencing and domestic cat control. Devices currently being trialed or assessed for approval for use in South Australia under a research permit include toxin delivery devices such as the Eradicat® and Curiosity™ cat baits, and the Felixer™. The use of soft-jaw traps (rubber-padded leg-hold traps) on cats is currently not approved in SA. Constructing a barrier fence to prevent cat immigration across the DP Isthmus is in the planning phase. The CPUE of most techniques during pulldown and mop-up still need to be assessed in the different habitat types on the DP. Similarly, the existing KI Council By-laws require strict management of domestic cats however, the level of compliance and the need for greater enforcement needs to be assessed.

4.1 Baits and toxins

The two most promising baits to control feral cats are Eradicat® which contains Sodium monofluoroacetate (1080) and Curiosity™ which contains Para-aminopipiophenone (PAPP) imbedded in a capsule. Eradicat® is injected with 4.5 mg of 1080 per bait which is sufficient to kill a feral cat if consumed. The Curiosity™ bait contains 78 mg of PAPP within a HSDV (Hard Shell Delivery Vehicle) pellet designed to dissolve in the cat’s stomach (Johnston et al. 2014). Cats are known to consume large food portions whole. Conversely, most wildlife species process food items more thoroughly in the mouth. Field studies have shown that many Australian species tend to reject the pellet if they consume the bait and therefore avoid exposure to the toxin (Johnston et al. 2014). The sausages used as an attractant and to deliver the toxin are similar. Both weigh around 15 g when dry and commercial production is used to ensure
consistency of ingredients, although the Curiosity™ sausage is slightly more alkaline than the Eradicat® sausage to protect the HSDV pellet from dissolving.

PAPP is considered to be a much more humane toxin than 1080 with cats dying within 0.5-4 hours, compared to 1080 which can take between 2-12 hours after the onset of the first clinical signs (Denny and Dickman 2010). Animals dying of PAPP poisoning not only die faster, but lack the spasms, paddling and convulsions associated with death by 1080 poisoning (Denny and Dickman 2010). Hence, Curiosity™ is considered a more humane and socially acceptable bait. The PAPP toxin is reported to be water soluble, mobile in the soil but readily biodegradable and non-bio-accumulating. Greater than 90% degradation occurred in 28 days (APVMA 2015).

Eradicat® baits have been successfully used to eliminate cats from a number of islands and to control cats on the mainland (Algar et al. 2015). It was the main tool used in the recently successful Dirk Hartog Is cat eradication. This bait is currently only registered for use in WA, but has been trialed under research permits in other states.

Trials indicate the proportion of the cat population destroyed can be variable ranging from 30% at Fortescue Marsh (collared cats=18) to 80% on Dirk Hartog Island (collared cats=15) in Western Australia (Parkes 2018a).

Based on small scale trials conducted on the DP Isthmus, around 66% of cats that encountered a bait, ate the bait, although this varied between trials (NRKI 2019). Seasonal differences in bait uptake by cats were also evident varying from 45% (May 2017), 62% (June 2017) to 79% (July 2017).

Curiosity™ is currently under assessment by the Australian Pesticides and Veterinary Medicines Authority (APVMA) for registration as an agricultural chemical product for cat control. Recent advice suggests the bait maybe approved for use in mid 2020.

Trials indicate the pulldown success from use of this bait has also been highly variable ranging from 0% at Karijini NP (WA) (8 cats with radio collars, none died) to 75% in French Island National Park (Vic) (8 cats with radio collars, 6 killed) (Johnston et al. 2013). It is proposed that the use of Curiosity™ will provide the main tool for the French Island rapid pulldown once the bait is approved.

Non-target impacts

There are two main concerns regarding bait uptake by non-target species. The first is that non-target animals eating the baits reduce bait availability for cats. To compensate, a greater number of baits are needed to make some available for the cats, adding cost to the program. The second is the impact of toxic baits on species susceptible to the poison. Non-target impacts need to be assessed at each location taking into account the species present in the target area, the likelihood they will eat the bait, and the likelihood they will be poisoned.

Three non-toxic trials of the Eradicat® sausage have taken place on KI and shown varying degrees of non-target uptake.

- Trials undertaken in bushland on a number of locations on western KI found 90% of non-toxic baits were taken by non-target species (Denny 2009). Of the encountered baits, cats
took 27% of the baits, goannas took 40%, corvids 32%, possums 13%, kangaroos 3% and wallabies 5% based on sand track monitoring. Two subsequent non-toxic trials have not detected any bait uptake by macropods. Denny (2009) also found substantial differences in bait uptake between seasons with cats taking more in autumn than in spring (Table 4.1).

- Trials on the Dudley Isthmus (2016/17) found ravens 20%, possums 7% and a grey currawong, magpie, bush rat and domestic dog took one bait each (0.6%). The species responsible for bait removal was unknown in 43% of cases.

- Hohnen et al. (unpublished data) found that non-target species accounted for over 99% of bait uptake in bushland in Flinders Chase National Park. Over 60% of all baits laid were taken by either the common brushtail possum, bush rat or Australian raven. In a further trial in November, Rosenberg’s goanna, southern brown bandicoot and western pygmy-possums also took baits. There were very few records of cats approaching the baits, possibly because of low cat densities.

Regarding the susceptibility of non-target species consuming the toxin contained within a bait, trials conducted by Hohnen (unpublished data) using rhodamine B contained within a non-toxic bait indicated that 100% of the trapped possums and 59% of bush rats ate the baits in the August trial and 33% of western pygmy possums, 83% of brush-tailed possums and 59% bush rats had eaten the baits in November.

Table 4.1 Proportion of baits taken by each species over three sampling occasions (Denny 2009). (Only baits which were taken by an identified species are considered).

<table>
<thead>
<tr>
<th></th>
<th>Oct</th>
<th>Nov</th>
<th>Mar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>10</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td>Corvid</td>
<td>4</td>
<td>7</td>
<td>33</td>
</tr>
<tr>
<td>Medium bird</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Possum</td>
<td>52</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>Wallaby</td>
<td>15</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Kangaroo</td>
<td>9</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Goanna</td>
<td>10</td>
<td>33</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4.2  The LD 50 for some of the species living on KL. There are two values for 1080 because of the substantial differences in tolerance of individuals from eastern and western Australia. The Eradicat bait has 4.5 mg of 1080 per sausage, and Curiosity™ has 78 of mg/PAPP per sausage.

<table>
<thead>
<tr>
<th>Reported oral LD50 values</th>
<th>LD50 (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1080</td>
</tr>
<tr>
<td></td>
<td>WA</td>
</tr>
<tr>
<td>Domestic cat Felis catus</td>
<td>0.4</td>
</tr>
<tr>
<td>Dog Canis familiaris</td>
<td>0.06</td>
</tr>
<tr>
<td>Sthn brown bandicoot Isodon obesulus</td>
<td>20</td>
</tr>
<tr>
<td>Tammar wallaby Macropus eugenii</td>
<td>5</td>
</tr>
<tr>
<td>Bush rat Rattus fuscipes</td>
<td>20-80</td>
</tr>
<tr>
<td>Mouse Mus musculus, albino</td>
<td>13</td>
</tr>
<tr>
<td>Brushtail possum Trichosurus vulpecula</td>
<td>&gt;5</td>
</tr>
<tr>
<td>Raven Corvus spp.</td>
<td></td>
</tr>
<tr>
<td>Black duck Anas superciliosa</td>
<td></td>
</tr>
<tr>
<td>Grey currawong Strepera graculina</td>
<td></td>
</tr>
<tr>
<td>Blackbird Turdus merula</td>
<td></td>
</tr>
<tr>
<td>Heath monitor Varanus rosenbergi</td>
<td>200–300</td>
</tr>
<tr>
<td>Starling Sturnus vulgaris</td>
<td></td>
</tr>
<tr>
<td>Australian magpie Gymnorhina tibicen</td>
<td>9.93</td>
</tr>
<tr>
<td>Galah Eolophus roseicapilla</td>
<td></td>
</tr>
</tbody>
</table>


The tolerance level to 1080 and PAPP is different among species and regions (Table 4.2). Felids and canids are highly susceptible to both toxins. In southwest Western Australia a number of native species have developed a tolerance to the toxin 1080 because it naturally occurs in native plants in that region. This is not the case in most of eastern Australia including Kangaroo Island where toxicology studies indicate most native species retain a low tolerance to 1080 (Twigg and King 1991, Twigg et al. 2003).

For some species, such as the Tammar wallaby, the tolerance is low for 1080 but high for PAPP. Conversely, the southern brown bandicoot has high tolerance to 1080 but low tolerance to PAPP.
There is no antidote if 1080 is consumed by a domestic dog but methylene blue can be used as an antidote for PAPP. Limited trials indicate prompt intravenous administration with the antidote can result in full recovery. At this stage, this antidote can only be administered by a veterinarian.

Trials to determine non-target species susceptibility to the Curiosity™ bait in Western Australia found evidence that southern brown bandicoots and large varanid lizards consumed the HSDV with the bait (De Tores et al. 2011). Corvids were also at risk in a trial at Roxby Downs (Johnston et al. 2014).

Use on Kangaroo Island

- Broad-scale use of Eradicat® is unsuited to KI conditions because of non-target impacts on species such as ravens, brushtail possums, and rodents.
- Curiosity™ bait is likely to be more suitable with less non-target species and an antidote for domestic dogs.
- The Curiosity™ cat bait is being assessed by the AVPMA and may be available for broadscale deployment by winter 2020.
- Use of Curiosity™ is likely to be limited for use between June and August (when average temperatures are below 15°C [http://www.bom.gov.au/climate/data]) to avoid non-target impact on goannas.
- Trialing of the use of Curiosity™ bait will be necessary before broadscale deployment. The Curiosity™ sausage has a different composition to the Eradicat® sausage, potentially affecting uptake. In addition, in the success of Curiosity™ bait uptake and efficacy to pulldown cats has varied among regions.

Recommendation

- Assess the target and non-target uptake of the Curiosity™ sausage bait on KI and determine the bait density required to ensure adequate encounter rates by cats in areas of bushland.
- Assess options for bait delivery in large blocks of bushland, particularly using aerial delivery.
- Assess the acceptability and practicality of hand baiting on smaller lifestyle bush blocks and on farmland.

4.2 Felixer™ (grooming) traps

The Felixer™ trap is a toxin delivery device. It uses sensors to discriminate between target and non-target species. Both the height and length dimensions of animals are used (Read et al. 2015, 2019). If identified, a gel is sprayed onto the target species from up to 4 m away containing 12 mg dose of 1080. The success of the device relies on the propensity of certain species to instinctively groom the sprayed area of pelage and, in doing so, ingest the poison. Cats are known to be fastidious with their oral grooming. The device automatically resets a total of 20 times before the sealed individual cartridges need to be replaced. It can be deployed in the field and only needs to be checked every few weeks. However, the device is large and expensive and careful installation on flat ground is required to ensure cats and non-target species are discriminated correctly.
Read et al. (2019) reported the Felixer™ sensor system had high specificity in being able to correctly discriminate target species (feral cats and red foxes) from non-targets under field conditions. All foxes (n=5) and 82% of feral cats (n=66) were correctly identified as targets. In a further toxic trial on KI, the Felixer™ traps detected and sprayed 65% of the cats (n=20) that passed in front of the device (Hodgens 2019).

**Non-target impacts**

The Felixer™ has undergone several algorithm upgrades that have improved target specificity of the device. During early non-toxic trials on KI the device correctly identified all brushtail possums (n = 89), corvid/pigeon (n = 39), bush stone curlew (n = 5), vehicle (n = 111) and adult people (n = 127) as non-targets. However, it incorrectly identified Tammar wallabies 9.6% (n = 218), poultry 17.7% (n = 62), kangaroos 4.4% (n = 90) and dogs 15.4% (n = 13) as a target (Read et al. 2019: Supporting Information). Following upgrades to algorithms in late 2018, non-toxic trials of the Felixer™ on KI during the Felixer versus Felis project recorded no incorrectly identified non-target species from 329 encounters (Hodgens 2019). However, during the toxic trial that followed on KI, three non-target individuals were sprayed with toxin; a lamb, a possum and a turkey. None were reported to have died from the toxin (Hodgens 2019).

**Use on Kangaroo Island**

- Considering the cost of each device and their current efficacy, Felixer™ traps cannot be considered a primary pulldown tool.
- Current use of Felixer™ traps on KI are under a research permit and ethics approval. There is an administrative vulnerability to rely on Felixer™ to traps as a sentinel control measure while they remain under research permit to a third party.
- Felixer™ could prove valuable in specific situations e.g. along barrier and guide fences or corridors, fence lines and habitat ecotones frequently traversed by cats.
- They are generally acceptable to landholders and the public more generally if set in safe locations away from people and domestic animals.

**Recommendation**

- The research and ethics approval requirements regarding the use of Felixer™ traps on KI need to be revised for Stage 2.
- The efficacy of the Felixer™ trap in the field needs to be improved. The inclusion of guide fencing wings to encourage cats to walk in front and perpendicular to the trap need to be trialed.
- Monitoring of non-target exposure needs to continue and adjustments to reduce exposure should occur if necessary.
- The efficacy of the device in association with the barrier fences to restrict movement and reduce immigration of cats across the Isthmus needs to be assessed.
- Protocols regarding set-up and maintenance of the device to ensure maximum efficiency need to be developed and implemented. Things to consider include the position in relation to the sun to ensure the solar panels are charged, and ground level to ensure the device is firing parallel to the ground.


4.3 Cage traps

Cage trapping is one of the most common and accepted forms of control for feral cats nationally and has been used extensively on Kangaroo Island. It requires limited expertise, although success can be improved using skilled operators. Cage traps also catch a wide range of native species and ethics considerations need to be applied for both project officers and the community i.e. any animal in a trap must be treated as if it is your own pet, any activity that is not suitable for a domestic animal is not suitable for a wild caught animal (Dog and Cat Management Board; D. Kelly, pers. com.).

Cage trapping is a labour intensive activity. Around 30 traps can be set and checked by one person daily (Rowley and Masters 2013; Parkes 2018b). Trap spacing depends on the home range size and density of target population and distances applied or advised in other studies range from 200 m (Parkes 2018b) to 700 m apart (Bengsen et al. 2012). NRKI (2019) suggest that control devices deployed during the Dudley Peninsula eradication operations should be placed no more than 650 metres away from any other control device which is similar to Bengsen et al. (2012). This means a trapping grid of 12-15 km² can be covered by one person per day.

Paton (1994) reported that trap success (CPUE) was much higher in winter and spring (4-7.5%) than summer and autumn at Murrays Lagoon (1-2%). This was not the case during cage trapping on the DP Isthmus where trap success was between 3.5% in Autumn 2017 and 3.9% in Spring 2016 (NRKI 2019). The highest trap success has been recorded in farmland on the DP where 21 feral cats were captured over 148 trap nights (CPUE = 14.2%) (Hodgens 2019). However, this last study was conducted around a carcass dump where the density of feral cats was high.

Non-target impacts

Non-target impacts of trapping are generally regarded as low because non-target species can be readily released. Ethical impacts can become significant if the trapping is poorly managed with traps left unchecked for extended periods. This problem is particularly important on KI because of the high non-target capture rate. Trapping programs on KI have found that cats accounted for around 20% of captures, nearly 70% of trapped animals have been possums, and the other 10% included a range of species such as the southern brown bandicoot and echidna, both EPBC listed species (Masters 2007) (Fig. 4.1).

On Kangaroo Island a number of coordinated community cat trapping programs have been implemented. Paton (2003) implemented one in the Emu Bay, Shoal Bay area from 1995 to 1997. Landholders (around 10 active participants) were given 1-3 cage traps and a log book and they were asked to set the traps during winter, record the effort and trap success, and record the number of cats they saw while travelling. In the first year the number of captures and the average weight of cats declined, in the second year few cats were caught but people set their traps less frequently because few cats were seen, with the average time per participant dropping from 49.5 hours in 1995 to 17 hours in 1997. Paton (2003) concluded that community cat management can be an important part of cat control programs but has limitations because continued enthusiasm for on-going control and monitoring diminishes as trap success declines.
This exemplifies why both the pulldown and the mop-up phase can be difficult to accomplish. He also found that the majority of the success was due to the efforts of a few individuals.

Fig. 4.1 Percentage and total number of each species caught in cage traps (from Masters 2007)

In a series of studies conducted over a 20 km² area on the DP Isthmus, a two week community trapping and monitoring program conducted in summer and later in spring 2011 resulted in a 42% and 46% pulldown of the cat population (Bengsen et al. 2011a; Southgate and Masters 2011). A repeat of the trapping and monitoring effort in autumn 2013 resulted in 15 cats being captured but no reduction in population size was evident when the population was monitoring two weeks later (Rowley and Masters 2013). High immigration most probably resulted in negligible change in population size. The area trapped consisted primarily of medium-size lifestyle blocks. Community trappers were happy to maintain their efforts over a period of two weeks but the project required an officer to pick up trapped cats for disposal which was difficult over the weekend. The project officer also distributed and collected data sheets and traps and conducted the camera monitoring of the population before and after trapping. Rowley and Masters (2013) provide a breakdown of the costs and effort required to run a similar short term program.

Achurch (2012) conducted consecutive tranches of trapping at three sites along the coastline of KI in an effort to reduce predation by cats on nesting little penguins. Each site extended along 0.7-1.2 km of coastline and trapping was conducted from May-July. Four nights of trapping were conducted each week (104 trap nights) over a three week period and this trapping effort was then reapplied after five weeks. In the first week, 10 cats were trapped and then two to three cats were trapped in each of the following weeks as well as each week during the second trapping period. Overall, there was no indication that the trapping effort resulted in a sustained
pulldown of cats in the areas trapped i.e. the cumulative catch did not asymptote against cumulative effort. These results indicated again the difficulty in achieving a substantial pulldown of a cat population with cage trapping over a smaller area.

Use on Kangaroo Island

- Community involvement in cage trapping programs has been successful in the past on KI but trapping periods need to be condensed (10-14 days) and well managed to prevent ethical issues, to ensure cats are euthanised quickly and data and equipment are maintained and well managed.
- While there is reasonable data on cage trap CPUE, the data are limited primarily to lifestyle blocks/ peri-urban areas and farmland. No information is available for bushland and urban areas.
- There is very limited information on whether an effective pulldown rate can be achieved with consecutive tranches of cage trapping effort

Recommendations

- Conduct consecutive tranches of cage trapping effort covering large areas in farmland, urban and peri-urban/lifestyle block areas to determine the level of pulldown that can be attained and sustained.
- Assess the willingness for community participation in a trapping program and the efficacy achieved with regular short trapping sessions of around 2 weeks.
- Assess the effect of adding other control techniques to cage trapping effort.

4.4 Soft-jaw (rubber-padded leg-hold) traps

Soft-jaw traps are commonly used for cat research and control programs in other parts of Australia (Reddiex et al. 2006; Denny and Dickman 2010). Leg-hold traps have been used across many habitat types and have proven to be an effective tool during mop-up stages of large-scale cat eradication projects to capture the last remaining individuals (Robinson & Copson 2014; Parkes et al. 2014).

Trap success for cats depends on the location. On San Nicolas Island soft-jaw traps were 12 –15 times more efficient than cage traps (Jolley et al. 2012) but in other studies such as on Tasman Island off Tasmania and Lake Burrendong in NSW, cage traps were as successful as soft-jaw traps in catching the last remaining individuals (Robinson et al. 2015; Molsher 2001). Short et al. (2002) in a study at Shark Bay (WA) noted that soft-jaw traps and cage traps caught cats at similar rates, but soft-jaw traps caught more adults and adult males in particular than cage traps. Cage traps caught mostly young cats scavenging around human settlements and rubbish tips.

Soft-jaw traps can be set to minimise non-target captures by setting them on raised platforms or adjusting the spring so larger animals can pull free. Non-target species can generally be released although there are reports that the traps can break the bones of birds and brush-tailed possums so local trials are needed to examine non-target issues.
Soft-jaw traps are used extensively in New Zealand where the NZ Department of Conservation recommends setting traps 100-200 m apart along linear landscape features, in isolated patches of cover or where prey abundance is high.

Soft-jaw traps are not registered for use on cats in SA and have not been trialed on KI previously, possibly because of the large number of non-target species and individuals likely to be captured. Soft-jaw trapping would probably be a useful tool during mop-up if the capture of non-target species can be minimised.

**Use on Kangaroo Island**
- Currently soft-jaw traps cannot be used without a research and ethics permit.

**Recommendations**
- Develop a research plan to trial the use of soft-jaw traps on KI and gain ethics approval.
- Trial soft-jaw traps to assess the capture rate and risk for non-target species, and the efficacy to capture cats in different habitat types and density.
- Assess the efficacy of soft-jaw traps compared to cage trapping and shooting taking demographics of captured cats into account.
- Assess whether soft-jaw traps are a necessity to complete mop-up operations.

### 4.5 Attractants and trap success

Visual, auditory and olfactory lures and baits are used to attract cats to cage and soft-jaw traps and *Felixer*™ traps. Lures have had varying success at increasing trap success of cats with conflicting results emerging from studies in different locations (Denny and Dickman 2010). There has been a number of trials on KI. Paton (1994) found no difference in the frequencies at which cats investigated different food baits (red meat, tinned fish, and tinned cat food). Bengsen et al. (2011b) also trialed a number of different lures (*Rudducks catnip spray, Cats me dead* anal gland, *Feralmone* synthetic, and fermented egg lure) to determine if trap success could be improved. They found none of the olfactory lures tested were any better in attracting cats than the control treatment of water. They also trialed sardines and chicken wings in traps and found they were of equal success. Factors that influence hunger are likely to vary among individuals, age classes and seasonal conditions, such that not all cats within a population can be expected to be equally susceptible to food-based lures (e.g. Paton 1994; Short et al. 2002). FAP auditory lures did improve effectiveness in attracting cats to sites, however, trapping success rates were only improved marginally (Bengsen et al. 2011b), that is, the cats were attracted to the area but didn’t necessarily go into the traps.

**Use on Kangaroo Island**
- No studies have shown a particular bait or attractant to be consistently superior in attracting cats to traps. Promising new attractants or lures should be tested rigorously against control treatments and with adequate sample sizes on KI before being adopted.
Recommendations

- The use of an attractant with a trap needs to be standardised and maintained during a pull-down or mop-up operation. Changing trap efficacy part way through an operation or nesting a lure trial within a program can confound results (see Appendix 2.1).

4.6 Shooting assisted with thermal-image scopes

Few studies report on the efficacy of shooting and there is no information relating to the efficacy of shooting to control cats on KI. Shooting can provide an effective control method in certain habitat types and some locations but is heavily reliant on the skills of the operator. With experienced personnel, shooting could be used as a pulldown technique in a range of habitat types where cats can be attracted to supplementary food. This may be sustained if cats and other non-target species can be clearly detected and identified using a thermal-image scope and the hunter can remain undetected. Hunting with the aid of a spotlight rapidly becomes ineffective because cats and other species can become weary of the light flashing across the landscape.

Landholders currently use shooting to control a range of feral and over-abundant native species including cats. They are often reluctant to allow unfamiliar people with guns onto their properties, limiting the involvement of amateur shooter groups in control operations. In general, hunting can be conducted by anyone with a gun license on properties where they have gained permission under the rules of their permit. Authorised officers with a class D licence can operate in peri-urban settings with police approval.

Generally, shooting is time consuming. Highly proficient hunters that understand the behavior of cats in different habitats can be much more effective than amateur hunters.

Use on Kangaroo Island

- Shooting is already an acceptable tool on KI but its use as a control tool is largely limited to open habitat types away from human settlement.
- Skilled local operators will be needed to make this technique effective in a pulldown operation. This depends of whether thermal-image scopes prove effective and a large proportion of individuals within a region can remain targeted over time.

Recommendations

- The use of shooting assisted with thermal-image scopes to achieve pulldown of the cat population needs to be assessed.
- The efficacy of attracting cats to supplementary food on farmland and open areas in other management units (MUs) as a means to improve hunting efficiency needs to be examined and compared with other control techniques.

4.7 Detector dogs to assist hunters

Detector dogs are trained to locate and pursue individuals of a particular species by following fresh scent and there are few non-target issues when undertaken by experienced operators.
Detector dogs are used primarily during day time activities as part of the mop-up operations. The dogs have been crucial in species eradication on Macquarie Island and have been used increasingly across Australia on a variety of conservation projects in areas such as the Kimberley and in Tasmania. However, there has been varying success and some failure with the use of dogs to locate cats on the Peron Peninsula (Morris et al. 2004), on Dirk Hartog Island and Currawinya predator-proof enclosure (K. Bradley pers. comm.).

Kangaroo Island has already started a program that aims to train detector dogs for community members to use during cat control. It is unclear how effective this technique will be during the mop-up stage of the cat control program. The difficulty of mop-up was highlighted when retrieving cats with radio-collars during Stage 1. Four cats each wearing a radio collar took over 40 hours, although an additional five non-collared cats were also destroyed in the process.

Use on Kangaroo Island

- A number of detector dogs trained on KI may soon be available to assist with cat control.
- A licensed hunter is required to work with the dogs to make this technique effective in pulldown or mop-up operations.

Recommendations

- The efficacy of using detector dogs with experienced handlers during the mop-up operation needs to be examined.

4.8 Exclusion fences

There are considerable costs and complexities in using a fence as a barrier to exclude pests like feral cats and foxes (Long and Robley 2004). Nevertheless, fences have been used effectively to exclude predators in large areas in Australia and internationally. Construction of such a fence inevitably excludes or contains other similar-sized and larger animals. The capital cost for a fence to exclude cats and foxes is expensive at around $15000 per km and there are high maintenance costs.

The approval process can be complex particularly if the path crosses multiple of tenures. One of the most challenging issues is to maintain the integrity of a predator-free area when gaps in the barrier fence are necessary because of waterways and roadways. No fence intended to exclude foxes or feral cats bisecting a public road has succeeded to halt incursions in Australia to date. Another issue is the containment of non-target species and funneling of their movement toward road crossings where they may become a hazard to traffic.

The barrier fence proposed to divide the DP from western KI will be porous at two points to enable thoroughfare of traffic. One of these points includes the major road linking western KI and the main service centre of Kingscote with the ferry terminal in Penneshaw. A 40 m fence gap is required at this intersection point. Other gaps in the fence are proposed to enable pedestrian or service vehicle access and the movement of native wildlife. There is the potential for the use of Felixer™ traps as a cat control measure to target cats moving through these gaps.

The potential of fencing to provide a management tool more generally needs to be assessed. Cheaper, lower fencing (~1 m high with footing and floppy top) attached to existing fences
would most probably be adequate to discouraging breaching and funnel most cats and other non-target species towards gaps set with *Felixer*™ traps. This approach may enable functional management units to be implemented.

**Use on Kangaroo Island**

- Construction of a fence is proposed for the DP Isthmus. Prevention of cat immigration will be challenging because the gaps in the proposed fence to enable traffic flow and the movement and dispersal of non-target species will also enable thoroughfare of cats. There is potential to control cats at some gaps using the *Felixer*™ traps.
- The use of cheaper guide fencing could provide a tool to control cats more effectively and limit immigration.

**Recommendations**

- The relative abundance of species encountering the fence and their response and direction of travel will need to be assessed.
- The efficacy of *Felixer*™ traps placed at gaps in the barrier fence will needs to be assessed.
- Measures to reduce cat density to reduce the number of individuals reaching the fence will need to be assessed.
- The overall efficacy of the fence to prevent immigration of cats from west to east will need to be assessed particularly when cat density is reduced on the eastern side of the fence.

### 4.9 Domestic cat control

Kangaroo Island has strong domestic cat legislation with the requirement that all domestic cats are identified, desexed, registered and contained. Although the legislation has been in place since 2005, there is still a need to determine how effective it is, particularly in confining cats to an owner’s property, and options to improve adherence to the By-law if needed.

**Recommendations**

- Work with the Kangaroo Island Council and cat owners on the DP to identify how many of the 20 cat owners are abiding by the By-law, particularly relating to desexing and confinement and what actions would assist cat owners to be fully compliant.
- A small working group of cat owners is needed to resolve issues. It will be important for all cat owners to understand that cat control will be undertaken within the urban areas and that any wandering cats will be at risk of control devices.
5. **Feasibility for cat eradication on the Dudley Peninsula**

5.1 **Comparison with other the islands**

The DP (371 km$^2$) is the largest area that has been proposed for cat eradication with human habitation in the world. In addition to the human habitation, the physical characteristics of the DP make it challenging: it is largely circular in shape and lacking insular sections which can easily be divided into discrete management units.

A feasibility assessment for cat eradication on Bruny Island (356 km$^2$) by Parkes (2018b) concluded it would not be feasible to eradicate feral cats in one pulldown event if baiting could not be used. As an alternative it was suggested that the island be divided into 10 management units for sequential eradication. He identified that the initial focus should be at an isthmus (the Neck) where cat density was high and impacting on nesting seabird colonies. Parkes (2018b) estimated it would take $526 \pm 455$ person days/10 km$^2$ to conduct an island eradication of cats on Bruny Island. More recently it has been decided that cat control rather than eradication be pursued on Bruny Island until eradication becomes more feasible (Kaylene Allan, Kingsborough Council).

A feasibility study for eradication on French Island (174 km$^2$) conducted by Park et al. (2017) found that the most feasible and cost-effective way to eradicate cats from the island was to bait first and mop-up using soft-jaw trapping, shooting and cage trapping. For this to happen, there needed to be changes in legislation in Victoria to enable the use of padded soft-jaw traps and the Curiosity$^{TM}$ cat bait. They suggested eradication could be achievable in 18 years once a suitable bait was available (Park et al. 2017, A. Morrison pers. com).

The cat eradication on Christmas Island (137 km$^2$) is considered feasible due to its smaller size and the recent development of bait delivery devices to reduce disturbance by crabs. It is anticipated that Eradicat$^\text{®}$ baits will be used. Ground bait delivery is being developed before trialling a broad scale baiting program and eradication (Algar et al. 2019). A sunset clause for domestic cat ownership has been implemented.

Dirk Hartog Is (620 km$^2$) is the first of the five island Safe Haven Project to successfully eradicate cats, despite its considerable size. The eradication of cats from the island was relatively straightforward because human settlement was absent, the landscape was relatively homogeneous and unproductive, and the island could be divided into halves with a non-porous fence to restrict cat movement during mop-up. This allowed for the extensive use of the Eradicat bait which could be aerially delivered for a rapid pulldown.

5.2 **Current technical feasibility for cat eradication on the DP**

5.2.1 **Removing cats faster than they can breed**

Central to successful eradication is the ability to pulldown a target population over an entire area or within discrete management units where immigration (reinvasion) can be prevented. If a management unit approach is used, sequential eradication of the population in each
management unit needs to be well coordinated, with immigration prevented in each treated unit, to achieve overall eradication.

In any area chosen for eradication, the pulldown rate of the target species must be greater than the recruitment plus immigration rate combined. This must exceed 60% for cats, but the higher the pulldown rate, the quicker eradication is achieved.

Cat eradication was slow on Macquarie Island. The initial phase commenced in 1985 and was expanded in 1998. Between 1985 and 1995, approximately 124 cats were killed per year and it was estimated that the recruitment rate matched the kill rate (Copson 2002), hence eradication would never have been achieved without greater effort. The pulldown rate was increased to 220 cats per year for the next three years, dropping to 99 cat kills in 1999, and a single cat (the last cat) shot in 2000 (Bergestrom et al. 2009).

For Kangaroo Island, Venning et al. (in review) used a stochastic offtake population model to examine the feasibility of cat eradication. With a 90% pulldown rate and a 50% maintenance cull rate, it was estimated that eradication could be achieved in eight years. With a pulldown of 80% followed by a 40% maintenance cull rate, ‘quasi-extinction’ could be achieved in 12 years but with only a 0.6 probability of success.

Considerable problems can emerge when low pulldown rates are adopted. Long programs result in operational and community fatigue and substantial risk for loss of ongoing funding. Learnt behaviour by cats and an increased ability of individuals to avoid detection and capture is also a considerable problem (Macdonald et al. 2019). Baiting is generally considered essential for the control of cats across large areas (Algar et al. 2019; Parkes et al. 2018b) because broadscale delivery can be achieved in a short period.

For cat eradication to be achieved on the DP, baiting will be necessary to target cats in largely inaccessible bushland. Baiting by hand could also be extended to farmland areas and lifestyle blocks with coordinated consultation and community approval (Table 5.1). However, prior assessment will be necessary to determine:

- the baiting density necessary to ensure sufficient baits remain available for uptake by cats following uptake by non-target species
- the susceptibility of non-target species to baiting
- the area over which baits can be used and delivered either by aerial drop or by hand-lay.

Similarly, further assessment is necessary to determine the contribution other control devices could provide to a pulldown. There is some CPUE and pulldown data available for cage and Felixer™ trap use but there is no information regarding the effect of ramping-up consecutive tranches of effort or extending effort spatially or the adding of another control technique. The effect of low cat density on the pulldown efficacy of each of these control techniques is also not known. As the densities decrease, control effort needs to increase as exemplified by the deer eradication program (Masters et al. 2018).
### Table 5.1 Situations when and where control devices are likely to be suitable

<table>
<thead>
<tr>
<th>Device</th>
<th>Currently available for use</th>
<th>Phase when most useful</th>
<th>Remote bushland</th>
<th>Urban/peri urban/ coastal</th>
<th>Rural/farmland</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Felixer</em>™ toxic traps</td>
<td>Yes, under research permit</td>
<td>Prevent reinvasion, mop-up</td>
<td>On roads, fences and tracks mostly</td>
<td>Secure locations only</td>
<td>Secure locations</td>
</tr>
<tr>
<td>Cage traps</td>
<td>Yes</td>
<td>Pulldown</td>
<td>Roads and tracks only</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Shooting + dogs</td>
<td>Yes</td>
<td>Mop-up</td>
<td>Patchy, along tracks and more open areas</td>
<td>Very limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Shooting + thermal</td>
<td>Yes</td>
<td>Pulldown and Mop-up</td>
<td>Patchy, along tracks and more open areas</td>
<td>Very limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Soft-jaw traps</td>
<td>No, maybe under research permit</td>
<td>Mop-up</td>
<td>Along access tracks mostly</td>
<td>Secure locations</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Curiosity</em>™ toxic baits</td>
<td>No, possibly available mid-2020</td>
<td>Pulldown</td>
<td>Aerial delivery or hand delivery in restricted areas</td>
<td>No</td>
<td>Targeted areas, under strict consultation, not broad scale</td>
</tr>
</tbody>
</table>

5.2.2 *Putting all cats at risk*

Not all control tools are available for use in every habitat on the DP and during every season. Table 5.1 summarises the tools available for the DP and the habitat type or locations where control devices are likely to be suitable.

Because of these differences, the DP has been divided into four management units (MUs) which reflect the practicality and permissibility of deploying control devices on the DP (Figure 5.1). Generally the MU’s include the western region against the Isthmus fence and the Strawbridge Point/Island Beach Peninsula (MU1), the bushland area (MU2), the farming area (MU3), and the townships (MU4). A description of each MU is provided in Appendix 5. The MUs also reflect broad differences in cat density on the DP with likely highest levels occurring in urban settings MU4, high levels on farmland MU3 and least in bushland MU2 and parts of MU1.
Eradication will be most difficult to achieve in large patches of bushland (MU2 and parts of MU1) without aerial baiting because of poor road coverage to access every cat. Bushland covers approximately one third of the DP (118 km²). The use of Curiosity™ is the potential solution to this. However, bait delivery will be limited to the coldest months (June-August) to exclude goanna exposure.

Despite cage trapping of cats being a management tool on KI for many years, there is still uncertainty around the CPUE of cage trapping in different habitat types and cumulative catch over extended periods of trapping. It is highly likely that the concurrent use of multiple techniques will be required to achieve pulldown to counter problems from wary cats. Ensuring all cats are put at risk of control requires an understanding of the likelihood an individual will encounter a device as well as the ability of the device to catch an individual. Assessing whether all individuals are exposed and put at risk of control becomes difficult when multiple devices are being used and spatial restrictions for the use of some also occur. Simulation models can be used to assess the optimal combination and spatial distribution of devices that will result in all individuals being placed at risk of removal (see Appendix 3.3). These types of tools are being...
used to aid predator and possum control work in the Hawkes Bay region New Zealand (Warburton and Gormley 2015; Glen et al. 2016; Gormley and Warburton 2017).

5.2.3 Preventing reinvasion

Preventing reinvasion is another central issue in eradication. Feral cats are adept at dispersing and recolonizing habitat (Denny and Dickman 2010). Reinvasion can jeopardise an entire eradication program particularly if it goes undetected and unquantified. Natural internal barriers on the DP are largely absent and there is no potential to easily isolate management units. There is some indication that cat density is different among habitat types but there is no information regarding cat movement or reinvasion rates and whether bushland habitat is acting as a sink for the cat population. Furthermore, little is known about the movements of cat individuals in low density situations on Kangaroo Island.

Given that a fence is going to be constructed across the DP Isthmus, considerable uncertainty remains surrounding the efficacy of such a barrier to mitigate reinvasion of cats from west to east. A thorough and systematic approach is required to examine and quantify cat reinvasion rates in response to different forms of management including the use of in-fence *Felixer*® traps at fence gaps and trapping on the western side of the fence. In addition, a comprehensive understanding of cat and non-target animal movement in response to the fence will be required.

The domestic cat population on the DP provides a potential node for reinvasion and recolonization after control. A By-law is in place on Kangaroo Island which requires domestic cats to be registered, desexed and confined to the property, however there is no information to indicate the extent of compliance and the likelihood that cats from the domestic, on-farm or ‘dumped’ population could join or contribute to the feral population.

5.2.4 Monitoring the population and detecting individuals at low densities

Techniques to monitor the pulldown of a cat population and other similar-sized predator species in response to management effort have been reasonably well tested and assessed in Australia and overseas (Bengsen 2011a, Robley et al. 2010). Remote cameras have emerged as the primary tool used to collect data and there are a range of design and analytical approaches that can be applied depending on the need to collect absolute or relative abundance as outlined in Appendix 4.1 and 4.2.

On KI, baited camera arrays have successfully been used to estimate absolute abundance of cat populations and also changes in response to management (Bengsen et al. 2011a; Southgate and Masters 2011; Rowley and Masters 2013; Hohnen, unpublished; NRKI 2019). Images captured were used to identify a large proportion of individual cats based on pelage and from the use of spatially explicit capture recapture or non-spatially explicit analytical techniques to estimate absolute abundance. These methods are labour intensive because of the time required to identify individual cats from images, and to collate and manage data and the camera arrays. These monitoring methods will probably be required to determine the pulldown efficacy of single and combined control devices particularly when cat density has been reduced to low
levels. This form of intensive monitoring will not be possible nor necessary when the DP-wide pulldown of cats is conducted.

Less rigorous approaches to broadly monitor the cat population during pulldown can be used with broader camera spacing to produce estimates of relative abundance and occupancy. However, this type of monitoring has not been extensively trialed on Kangaroo Island and there is little information on the detection rates to be expected for cats and other species in response to days sampled and the use or non-use of attractants and lures (see Appendix 3.2).

During mop-up, data from a range of techniques will need to be combined to determine population trend and assess the probability the target species remains extant. The analytical approaches available to accommodate data from a range of techniques are reasonably well developed and robust however, no surveys are being currently conducted that could contribute data for such an analysis. A number of non-camera-based monitoring techniques will need to be implemented and some sampling will need to be conducted while the cat population remains abundant. These potentially include track-based monitoring along beaches and the use of prepared sand-pads to record tracks, the engagement of people who travel fixed routes regularly at similar time to make observations e.g. couriers, the Cat App to capture the observational power of many citizens moving about the DP, and landholder interviews to provide a more localized and focused assessment (Appendix 4.4).

5.2.5 Ongoing community support and the benefits and costs from eradication

Bomford and Obrien (1996) indicated that ongoing community support for an eradication program requires clear evidence that benefits out-way the costs. Clearly, support for eradication effort will diminish if adverse or unacceptable outcomes emerge as a result of the removal of a species and if no agricultural or biodiversity benefits become evident.

Some planning is needed to identify how the benefits and costs of eradication can be best identified. It will likely take three or four years for the benefits to agriculture and biodiversity to emerge following a substantial reduction in cat numbers. Particular areas need to be identified where focal species such as brown bandicoots and Bassian thrush would likely respond and farmland areas where a reduction in Sarcosporidiosis would result in a tangible improvement in agricultural productivity. These areas need to receive sustained control effort throughout the program to enable biodiversity or agricultural asset recovery.

A number of perceived or real adverse outcomes could negatively affect existing community support for DP eradication program. These include the possibility of increased vehicle collisions with macropods at the Hog Bay road and fence intersection, increased black rat numbers around penguin colonies and rodent numbers on farms due to reduced predation pressure from cats, and an unsuitable resolution regarding domestic cat management. Poor interaction with the public, ineffectual or non-factual reporting of findings and inappropriate response to their concerns will also isolate the community rather than involve them.
5.3 Repositioning for Stage 2

It would be unwise to begin a DP-wide pulldown of cats until most of the issues identified in the above sections have been adequately addressed. Furthermore, the Curiosity™ bait is unlikely to be available for broad-scale use until mid 2020. Given approval delays are likely to occur and its use on KI will be restricted to winter, the earliest period possible for broad-scale baiting is likely to be winter 2021. This is the point when all other coordinated control effort needs to be in place and ready for the commencement of a DP-wide rapid pulldown of feral cats. Techniques to enable the mop-up also need to have been tested and made ready to apply.

In the 18 months prior there is an opportunity to conduct critical work to:

- ensure permits, approvals, practices and protocols are complete and equipment is fully functional to enable a smooth roll-out of control operations when required
- ensure that domestic cat owners are abiding by the Council By-laws
- begin sustained cat control effort on part of the DP to realise biodiversity and agricultural assets
- determine the combination of devices and the effort required to achieve a >80% pulldown in each MU
- determine the efficacy of the barrier fence and the amount of additional effort required to stem the reinvasion of cats from the west.

To conduct this work, we recognize that some of the MUs will need to be divided into smaller modules. These areas identify where a suite of control and monitoring measures can be practically applied with the resources available to test efficacy or sustain control effort.

The Island Beach Peninsula of MU1 would provide a suitable area to direct sustained control effort to enable recovery of several focal species. This area has recent reports of species such as crakes and rails and bandicoots. Similarly, a suitable area to receive sustained effort to assess the effect of cat control on improving agricultural production would be the Willson property in MU3 where work was conducted used during Stage 1.

It is proposed that a number of adjacent modules be selected in both MU1 and MU3 and that a single monitoring array be extended across these modules to produce an unbiased estimate of cat abundance. This needs to occur prior to the application of control effort using a particular device (or combination of devices) and again at the point when few or no captures result with additional effort. This process needs to be used to determine the efficacy achieved by a single device and when multiple devices are applied.

Modules in MU2 will be used to examine bait uptake by cats and non-target species. Non-toxic baits, laid by hand along access tracks within Conservation Parks, need to be monitored using cameras. The understorey vegetation cover in each module is different and sampling in both should identify if baiting density needs to vary accordingly. The bait trials in MU2 will need to occur in winter 2020 and pre-emptively address issues that could delay broadscale use in 2021.

Similarly, the trials identified to occur in association with the barrier fence are primarily to address issues that will limit risk or improve the efficacy to stem immigration.
6. Actions to achieve cat eradication on the DP

A schedule of activities that need to be conducted following and prior to the pulldown in winter 2021 are presented in Table 6.1. More description of where these activities could occur, what should be done, and why the activities are needed is presented in Table 6.2. Additional activities that would be beneficial to the program but have not been outlined in this plan are listed in Appendix 6.

Table 6.1 A schedule of activities that need to be completed for eradication over the four years. The shade of the colour indicates the intensity of effort. Question marks are placed in seasons where it is uncertain if any effort will be required.

<table>
<thead>
<tr>
<th></th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spr</td>
<td>Sum</td>
<td>Aut</td>
<td>Win</td>
<td>Spr</td>
</tr>
<tr>
<td>6.1 Project management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approvals, procedures, equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems for data management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic cat compliance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restrictions on control options mapped</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2 Dudley wide monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP camera monitoring grid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic surveys using sign</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP citizen monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3 Fence activities MU1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Felixer improvement trials (Kingscote)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kangaroo use and collision rates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immigration rate gap usage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collar cats for micro-movement (MU1.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Felixer efficacy trial on fence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess reinvasion rate, post vacuum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control popn west fence (MU1.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4 Strawbridge Pt Pulldown MU1.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor grid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulldown trial: trap V thermal shoot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mop-up trial: dogs + other techniques</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5 New technique trials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-toxic Curiosity trial (MU 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft-jaw trap trials (if time allows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.6 Pulldown trials MU3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor grid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulldown trial: trap V thermal shoot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.7 Pulldown trials MU4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community trapping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.8 DP pulldown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic baiting (aerial + ground)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best control techniques for each MU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.9 DP Mop-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP mop-up, all effective tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.1 Project management

A number of procedures, practices and protocols will need to be reviewed to ensure activities conducted in Stage 2 can progress smoothly. Some devices will need a research permit and ethics approval before trials can be conducted. For those trialed in Stage 1, conditions need to be revisited to ensure there are no limitations for continued use into Stage 2.

6.1.1 Approvals, procedures and protocols

The Curiosity™ cat bait will need a research permit and ethics approval for the initial trials. The use of the Felixer™ trap currently remains under research permit and the ongoing conditions need to be revisited to ensure a smooth transition to Stage 2. Use of soft-jaw traps to capture cats in SA will require approval from the Minister and a research permit and ethics approval will be required to conduct research to assess the efficacy as a mop-up tool. All staff using toxins and fire arms will require necessary training and approvals.

6.1.2 Practices and protocols

The existing protocols, practices and procedures will need to be reviewed to ensure they are current and suitable for the expanded program. These include Codes of Practice and Standard Operating Procedures. A Code of Practice for the Humane Control of Feral Cats has been developed and needs to be adhered to at all times (Sharp and Saunders 2012).

Standard operating procedures are currently available on the Invasive Animals CRC Pestsmart website for the following feral cat control methods:

- Ground shooting of feral cats (CAT001)
- Trapping of feral cats using cage traps (CAT002)
- Trapping of feral cats using padded-jaw traps (CAT003)
- Methods of Euthanasia (GEN001)

KINRMB/DEW protocols that may need revisiting for improved control techniques:

- Firearms handling and safety standards with the use of dogs and thermal scopes
- Certificates for detector dogs indicating appropriate training and level of skills.

6.1.3 Equipment functionality and data management

Stage 2 will require deployment and rotation of a large numbers of traps and cameras. It will be important to ensure this equipment is well maintained to standardize monitoring and control effort.

Similarly, data collection and analysis procedures need to be streamlined to ensure minimal time is spent on handling control and monitoring data. Software such as Irfanview to conduct preliminary scanning of camera images and databases such as CPW Photo Warehouse or Camelot to manage and analyse datasets need to be investigated. Photos of people and/or vehicles will need to be deleted to comply with privacy requirements.
6.1.4 Domestic cat control across the DP

It will be important to determine the proportion of domestic cats (across the DP) that are registered and compliant with the Council by-laws. Effective domestic management will need to be developed and fully in place to protect domestic cats from being destroyed during control operations, particularly in MU4 where the majority of domestic cats live. These actions are also extremely important to prevent domestic cats contributing or becoming part of the wild population. Additional procedures will need to be developed regarding the importation or visitation of domestic cats to KI.

6.1.5 Property access and restriction mapping

Gaining access to properties including farms, lifestyle and large peri-urban blocks will be crucial to achieve cat eradication. DP-wide mapping is needed to identify where particular devices cannot be deployed and when deployment cannot occur because of seasonal access restrictions e.g. parts of farming properties may be restricted during lambing or inaccessible during winter. Of particular importance is the identification of locations where firearms and aerial baiting can be used on properties and whether hand baiting with retrieval of unconsumed baits would be permitted. An approach to collect these data will need to be wide-ranging, systematic and ongoing to accommodate changes in ownership.

6.2 Dudley wide annual monitoring

6.2.1 DP Camera grid

A camera array should be established across the DP to sample each of the four MUs and used to derive occupancy and detection estimates for feral cats and select native species. Ancillary non-camera survey techniques and techniques used to collect opportunistic data should be benchmarked against the estimates derived from the camera grid.

A 2 km grid should be established across the sample area given that the 95% MCP feral cat mean home range size estimate was 3.8 km$^2$ (NRKI 2019). The home range size estimates for individuals tracked for <80 days were much smaller than the mean home range size. Where possible, a camera should be placed in each grid. At least 100 cameras should be distributed. Any surplus or additional cameras should be set in MU4 to boost camera density with an aim to estimate the number of individual cats (based on pelage) are present in urban areas where densities have not been estimated to date. The array should be re-established and monitored annually during summer. Initially, the array should be unbaited and set for 21 days. Longer sampling periods may be required to boost the number of detections if detection rate is low.

6.2.2 Systematic surveys using sign

Monitoring techniques that can use sign, such as track imprints to detect cat occurrence, can be used to estimate occupancy and detection. Sign surveys are often more sensitive than camera sampling but experienced observers are necessary to ensure species are accurately identified. Sandy sections of a beach or prepared sand pads across road ways can be surveyed for tracks of cats and other species including echidna, bandicoot, goanna, Tammar wallaby, possums, rats,
corvids, and hooded plovers (Appendix 4). Sampling should occur on multiple consecutive days and coincide with the systematic surveys and enable benchmarking with the DP camera array sampling.

6.2.3 Citizen cat monitoring

The Feral Cat scan app. www.feralscan.org.au/feralcatscan/default.aspx provides an opportunity for the public to register sightings of cats. If well publicized, a two week sampling period over summer could be used to collect cat distribution data on the DP and more broadly on KI. It could be developed into an annual monitoring event to coincide with the camera array monitoring to estimate cat abundance and trend. The sightings captured with the use of the technique become more valuable as the cat population declines and during and after mop-up. This type of opportunistic data can also contribute to estimating whether the population remains extant (see Appendix 4.4).

Similarly, cat sightings and their locations can be requested from landholders on farms or lifestyle blocks while re-enquiring about permission to gain access to properties and to conduct control procedures. It would be worth considering if a hotline phone number for the sightings of cats, similar to the ‘dob in a deer’ initiative would help target the last remaining cats in the mop-up phase of the program.

6.3 Isthmus fence activities: MU1

The fence activities will be centered predominantly in MU1 and involve modules MU1.2 and MU1.3. The third module (MU1.1) includes the Island Beach area from Rocky Pt to Strawbridge Point and the Pelican Lagoon Conservation Park (Fig. 6.1).

6.3.1 Felixer™ trap improvement trial

Felixer™ trap efficacy needs to be improved substantially to function as an effective within-fence control measure. Currently up to 35% of cats are not being registered by the device as a target because their movement in front of the trap is angled or interrupted. Guide panels need to be designed, and trialed to encourage continuous movement of cats perpendicular to the placement of Felixer™ traps. The most effective design will need to be incorporated into the Isthmus barrier fence construction where non-road gaps occur. The guide panel trials need to occur as soon as possible. The waste disposal facility near Kingscote would provide an ideal location to conduct these trials assuming cat numbers are reasonably high.
6.3.2 Kangaroo use near the fence and collision rate pre and post fence construction

Prior to construction of the barrier fence, wildlife movement and abundance (particularly kangaroo abundance) needs to be monitored in the area proposed for the barrier fence. Cameras spaced 250 m apart in an array (3 km along the road either side of the barrier fence location, and a width of 1 km) and sampled for one month pre- and post-fence construction may provide sufficient sampling effort to assess changes to the pattern of wildlife movement.

Wildlife-vehicle collision rates (based on insurance claims or reportings) along the Isthmus need to be collated for at least a 12 month period prior to fence construction to compare with collision rates post construction.

6.3.3 Immigration rate and gap usage

The relative abundance of species encountering the barrier fence, the use of gaps and their response and direction of travel needs to be investigated. This information is required to assess whether the barrier fence will act to funnel animals towards the Hog Bay Road and if mitigation measures need to be implemented. Data collected from cameras set along the fence and set at
gaps in the barrier fence could be used to estimate the immigration rate of cats and non-target species.

6.3.4 Cat movement and microhabitat use pre and post movement through the fence

There is a need to determine accurately where cats are breaching the barrier fence and the use of micro habitat during movement pre and post fence encounter. This information will improve habitat management to discourage passage and provide better targeting of control effort.

Cameras cannot provide data with sufficient fidelity and accuracy. Determining the route taken by cats fitted with GPS collars set to capture locations frequently will be required. Cats will need to be captured west of the fence, collared and released. Maintaining around 10 collared cats in the Isthmus area west of the barrier fence is also critical to achieve activities 6.3.5-6.3.6.

6.3.5 Felixer\textsuperscript{TM} efficacy pre- and post-pulldown

The efficacy of Felixer\textsuperscript{TM} traps with guide panels to target cats moving through gaps in the barrier fence will need to be assessed. Data on movement and fate of collared cats passing through gaps in the fence with exposure to Felixer\textsuperscript{TM} traps is required to assess the efficacy of these traps under field conditions, as undertaken in Stage 1 for the original design. Alternatively two Felixer\textsuperscript{TM} facing different angles might be considered.

6.3.6 Fence efficacy post east-side pulldown

Cat eradication on DP will create a vacuum and result in increased cat immigration pressure from west to east. The efficacy of the barrier fence (including Felixer\textsuperscript{TM} trap) to prevent cat immigration will need to be determined in response to highly reduced cat density east of the barrier fence. Data on the incidence of cat movement from west to east is required and can be acquired from cameras set on either side of the fence and from tracking collared cats. To create a vacuum east of the barrier fence, tranches of cage trapping and shooting effort will be applied in MU1.2 as described in Section 6.4.

6.3.7 Fence efficacy post west-side pulldown

Additional control of the cat population in MU1.3 on the western edge of the Isthmus will be required if the barrier fence (including Felixer traps) cannot prevent cat immigration to the DP. Initially, tranches of cage trapping (see Section 5.2.4) between the Pennington Bay Rd and the barrier fence should be implemented to determine if this effort can reduce immigration to zero. Monitoring the fate of collared cats and other uniquely identified cats is needed to determine whether overall control effort (trapping plus barrier fence) can prevent immigration.

6.4 Isthmus and Island Beach pull down and mop-up: MU1

In addition to the activities associated with the barrier fence, the effect of a sequential pulldown using cage traps and thermal-scope shooting will be conducted in the three MU1 modules.

This approach will be used to determine the effort required to achieve an 80-90% pulldown of the population using a single technique and if necessary whether it can be achieved by adding
another control device. MU1 also provides an opportunity to examine the effect of increasing the control area using a single technique to reduce immigration.

The characteristics of the MU1.1 make it an important and useful location to focus control effort for the recovery of biodiversity assets: the area has a high retention of native vegetation and recent records of key indicator native species (bandicoot, hooded plover, echidna, goanna) and it is also the most insular portion of the DP. Continued control effort would likely achieve a sustained pulldown of cats and a reduction in cat abundance in MU1.2 which would potentially stem the rate of reinvasion. As mentioned in Section 6.3, MU1.2 and MU1.3 will also be the focus of activities surrounding the barrier fence.

MU2 runs along the eastern boundary of MU1. The rate of cat immigration between MU1 and MU2 is unclear but it is known that cat density is low in bushland (NRKI 2019).

6.4.1 Pulldown monitoring

To monitor the effect of control activities, a 650 m grid will be used to guide placement of cameras. Around 60 cameras will be required to cover MU1 initially. It may be possible to reduce the number of camera set if it becomes evident that individuals are being ‘over-captured’. Monitoring should occur initially in 21 day tranches. Longer periods may be required if it becomes evident that known individuals are not being detected after 21 days of sampling. Monitoring should occur if a substantial change to the regime of control effort within a module has occurred or when the cumulative removal clearly shows an asymptote against cumulative effort. It is important to determine the cat population abundance and/or occupancy when an asymptote has occurred and before a different type of control effort is applied. The possibility of using a less rigorous monitoring regime should be assessed and relative abundance measures may prove adequate to track the population.

6.4.2 Pulldown in MU1.1, MU1.2 and MU1.3

A pulldown using a tranche of cage trapping effort should be conducted initially in MU1.1. Following the initial tranche of effort, another should follow 3-4 weeks later. An assessment should then be conducted to determine whether cumulative captures begin to plateau with cumulative effort. If an asymptote is evident and monitoring can show that an 80-90% pulldown has been achieved, mop-up effort can commence.

If no asymptote is evident, the options to apply additional control effort depend on how well activities in relation to the barrier fence have progressed. If the circumstances suit a pulldown on the east-side of the fence (see Section 6.3.5 and 6.3.6), then tranches of trapping effort need to be extended to cover MU1.2 to begin the creation of a vacuum (i.e. habitat devoid of cats). If the pulldown in MU1.2 needs to be delayed, shooting with thermal-scopes should be introduced to MU1.1 to determine whether the addition of this control device and effort can achieve and sustain the required pulldown of the cat population to enable mop-up to commence. When circumstances suit the pulldown of the cat population in MU1.2, tranches of cage trapping effort and, if necessary, shooting with thermal-scopes should occur.
When circumstances suit or necessitate the pulldown of the cat population in MU1.3 (see Section 6.3.7), tranches of cage trapping effort should be applied in this module using a similar systematic approach applied in the other modules.

6.4.3 **Mop-up trial in MU1.1**

The location of surviving cats will be identified from known sign/sightings and the use of detector dogs accompanied by a hunter. In addition, focussed cage trapping and thermal shooting will be used to destroy the remaining survivors. At the end of the trial, a re-assessment will be undertaken to improve the approach where possible. The use of baits (when approved) to target areas such as the Pelican Lagoon Conservation Park may be required.

### 6.5 Bushland Curiosity bait trial: MU2

MU2 is important because it represents a potential buffer between MU1 and the large farmland block of MU3 (Fig. 6.2). Immigration from MU2 must be halted to achieve cat eradication in MU3.

Limited trials for bait uptake by cats have been conducted on the DP and none using the *Curiosity™* bait (the composition is similar but slightly more alkaline than the *Eradicat* bait). The conservation lands under management by DEW provide an opportunity to trial bait uptake. However, there is limited road access and, unless the blocks are long unburnt, access by foot is difficult. Two modules are identified in MU2. MU2.1 coincides with the Dudley Conservation Park, much of which was burnt less than 20 years ago. The understorey remains thick but a number of tracks provide access. MU2.2 includes parts of the Simpson Conservation Park which has remained long-unburnt (>50 years) and the understorey is relatively open. Both areas have been used recently to estimate cat populations so the area is reasonably well known for logistical considerations.

#### 6.5.1 Persistence of toxin plus shell

Concern remains within the community about the length of time sausages containing a HSDV pellet (plus PAPP) remain intact and, similarly, the time taken for an independent HSVD pellet (plus PAPP) to degrade. While the AVPMA indicates PAPP is unlikely to persist in the environment (AVPMA 2015), trials to assess the decay rate of a sausage and the HSVD pellets in MU2 during winter conditions should be conducted.

#### 6.5.2 Non-toxic trial to determine bait density

A trial will be needed to identify the uptake of baits by non-target species and the proportion remaining available for uptake by cats. This trial is required to estimate the bait density that is needed during the pulldown phase.

Non-toxic *Curiosity™* baits will need to be hand laid in bushland (MU2.1 and MU2.2) along tracks and firebreaks approximately 200 m apart to simulate the density of aerial distribution of baits, typically 50 baits km$^{-2}$ (Algar et al. 2011, Johnston et al. 2014). Bait uptake will need to be monitored using a camera stationed at each bait to determine the encounter rate and the likely
uptake rate by non-target species and by cats. This will provide information on the acceptance of the bait by various species.

**Fig. 6.2** Two proposed management modules within MU2

### 6.6 Farmland trial pull down: MU3

Six modules have been identified in MU3 (Fig. 6.3). The trials proposed could be applied in any two adjacent modules. However MU3.1. and MU3.2 have been nominally chosen as the modules where activities should begin because intensive work was conducted there during Stage 1, there is existing support from the landholders, and high Sarcosporidiosis rates have been recorded from sheep on the farm. The neighbouring module for MU3.1 could be MU3.2 or MU3.4. An objective for MU3 would be to achieve sustained pulldown at least in one module (nominally MU3.1) during the entire program. This would enable sufficient time to realise a substantial reduction in Sarcosporidiosis infection rate in sheep on the property following cat control.
6.6.1 Monitoring

To monitor the effect of control activities in MU3.1 and MU3.2, the establishment of a 650 m grid is proposed to guide placement of cameras. Around 50 cameras will initially be required to cover these two modules. Other monitoring procedures need to follow those applied in MU1 with initial 21 sampling day tranches. Longer sampling periods should be used if a large proportion of known individuals remain undetected. Similarly, the area should be resampled if a substantial change to the regime of control effort within a module has occurred or when the cumulative removal clearly shows and asymptote against cumulative effort. It is important to determine the cat population abundance and/or occupancy when an asymptote has occurred.

6.6.2 Pull down trial in MU3.1 and 3.2

Aspects of the pulldown trial for MU3 are similar to those proposed for MU1. A pulldown using a tranche of cage trapping effort should be conducted initially in MU3.1. Following the initial tranche of effort, another should follow 3-4 weeks later. An assessment should then be conducted to determine whether cumulative captures begin to plateau with cumulative effort. If an asymptote is evident and monitoring can show that an 80-90% pulldown has been achieved, mop-up effort can commence (using the same approach identified in MU1.1). If no asymptote is evident after an additional (and third) tranche of effect, night shooting with thermal-scopes should be introduced to MU3.1. This approach is needed to determine whether the addition of control effort using another device can achieve and sustain the required pulldown of the cat population to enable mop-up to commence.

On MU3.2, the reverse process should be applied: tranches of control effort should begin with night shooting using thermal scopes followed by cage trapping.

If the combination of cage trapping and night shooting cannot reduce and sustain a low population in both MU3.1 and MU3.2, the next step is to increase the spatial area where control is being applied and extending control into MU3.3 and MU3.4. This assumes that reinvasion of cats from adjacent bushland is minor compared to immigration from adjacent farmland.

If cage trapping and shooting do not achieve the required pulldown, then options for ground baiting in farmland will need to be considered.
Fig. 6.3 Six proposed management modules within MU 3.

6.7 Urban/peri-urban: MU4

Cat control in urban areas is currently limited to cage trapping and this form of control has been embraced by the community in the past. A systematic community trapping program will need to be developed within the MU4 townships to determine trapping efficacy. This should also allow the public to engage with broader aspects of the program, raise issues and concerns, and participate in the development of protocols and logistics prior to the pulldown. It will be important to use community information to identify areas within the townships where cats feed and take refuge.

In each community, a pulldown trial should aim to use at least 30 cage traps set at a maximum of 500 m apart for four nights per week over a period of 3-4 weeks. At the end of each four night period, the CPUE and the cumulative catch curve will need to be calculated to determine the point when few or no captures result with additional effort. This information will be required to estimate the trapping effort necessary to apply during the DP-wide pulldown.

Secondary monitoring techniques will be important to implement in this management unit (Appendix 4) and the final stages of the eradication will rely heavily on community sightings. Camera trapping to uniquely identify cat individuals could be used pre- and post- trapping.
6.8 Pulldown DP-wide

Prior to winter 2021, the program should assess the feasibility of achieving an 80-90% pulldown followed by the mop-up of feral cats across the Dudley Peninsula. The relevant questions will include:

- Can cat immigration across the Isthmus from western KI be halted?
- Can devices be applied to adequately pulldown cats in MU1, MU3 and MU4?
- Can the use of the Curiosity™ cat bait adequately pulldown cats in MU2?
- Is the community adequately embracing domestic cat management and the entire eradication program?

If considered feasible, the best combination of devices and the intensity and extent of delivery to achieve rapid pulldown of the cat population should be known by the winter of 2021. Mitigation measures should be in place to respond to reinvasion events.

Three weeks prior to the commencement of control in winter 2021, the DP-wide camera monitoring grid needs to be re-established and activated.

To optimize baiting efficacy, the baiting campaign needs to be coordinated to enable concurrent aerial bait delivery in large blocks of bushland and hand delivery, where permissible, in smaller bushland blocks and farmland. Some fine scale monitoring of bait uptake will be necessary in different bushland areas and possibly farmland areas. The capturing and collaring of cats within the bushland areas prior to baiting should be considered to determine the proportion of cats that died as a result of consuming baits. Residual baits will need to be collected where hand baiting has occurred. Another tranche of baiting may be necessary depending on the extent of pulldown recorded following the initial bait drop. All baiting will need to occur during winter months when goannas are least active and general food availability for cats would be expected to be low.

In areas where baiting is not permissible or sparsely allocated, tranches of the most effective combination of devices will need to be applied just prior to the commencement of baiting. The decision to continue trapping and shooting effort within parts of a MU should be made in relation to the cumulative catch curve and the DP-wide camera monitoring of relative abundance.

6.9 Mop-up and validation

Opportunistic reports provided by the public and systematic sampling will be needed to identify the parts of the DP in which cats persist. In addition, it may be useful to instigate a hot-line number for people to report cat locations. A ‘dob in a deer’ approach proved effective during the deer eradication program on KI.

The use of detector dogs accompanied by a hunter, focussed leg-hold trapping (if permissible) and spotlight and thermal-scope shooting will be used to locate and ‘mop-up’ surviving cats. Spot use of Curiosity™ baits may also need to be considered. Indicator dogs could be used to locate scats. Planning has to adapt as results become apparent.
Continuation of the DP-wide camera grid will be important to monitor the change in relative abundance of focal native and non-native species.

To estimate probability that cats remain extant, the amount of time since the last cat was culled, the last recorded accurate sign or sighting during systematic survey work and from opportunistic reports can be taken into consideration (Appendix 4). This is the stage of an eradication program when it is valuable to:

- apply the range of survey techniques such as sign surveys along beaches and on sand pads across tracks at previously surveyed locations
- request couriers to recommence recording cat sightings along roads
- regularly prompt landholders to report any cat sightings on their properties or surrounds
- publicise and encourage the public to upload any cat sightings via the phone Feral Cat app.

Stopping rules are needed to define points when the control and monitoring effort are halted. This may be simply stated as the number of consecutive surveys when no sign was detected. The most beneficial types of survey to detect cat presence from those conducted need to be selected. The cost of wrongly declaring eradication success and the cost of continuing surveillance effort need to be considered (Ramsey et al. 2009, Ramsey et al. 2011, Ramsey and Will 2012).
**Table 6.2**  Summary Table of the activities to be completed for the eradication of cats on the DP.

Activities that need to be conducted to prepare for the pull down, and eventually the mop-up of cats on the DP. This should be used in association with the temporal roll out as outlined in Table 6.1.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Where</th>
<th>How</th>
<th>What to do</th>
<th>Why</th>
<th>When to stop</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years 1 to 2: preparing for the pull down</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.1 Project management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approvals, procedure and protocols</td>
<td>DP</td>
<td>Review existing research permits, practices and procedures Stock take of equipment and protocols Review of data management to ensure streamlined collation and analysis</td>
<td>To prevent delays in future activities and ensure processes are time efficient</td>
<td>Ongoing</td>
<td></td>
</tr>
<tr>
<td>Domestic cat compliance</td>
<td>DP</td>
<td>Engage Island wide cat owners Promote compliance with By-laws</td>
<td>Proportion of cat owners compliant. Develop achievable cat containment for owners Develop reporting methods for visiting cats or restrictions on visiting cats</td>
<td>To stop recruitment from the domestic cat population and death of domestic cats during control operations Stop recruitment from imported cats</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Property access restrictions mapped</td>
<td>DP</td>
<td>Talk to landholders Collate and map. Identify tools available based on landholder acceptance and property access</td>
<td>To identify what devices can go where. How best to layout control devices under identified constraints</td>
<td>Ongoing to accommodate changes in land ownership</td>
<td></td>
</tr>
<tr>
<td><strong>Dudley wide annual monitoring (6.2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP camera monitoring grid</td>
<td>DP</td>
<td>Camera trapping Grid area, camera 2 km apart covering (approx. 100 cameras), unbaited.</td>
<td>To establish relative and absolute measures of cat and target native spp abundance on the DP</td>
<td>Conduct annually for 21 days. Possible constant use in the mop-up</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Where</td>
<td>How</td>
<td>What to do</td>
<td>Why</td>
<td>When to stop</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------------</td>
<td>------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td><strong>Systematic surveys using sign</strong> 6.2.2</td>
<td>Beaches or sandy tracks</td>
<td>Beach section monitoring</td>
<td>Apply protocols and monitor on select beaches (presence and absence of cats and key native species)</td>
<td>Assess cat detectability with technique when cats are widespread and abundant</td>
<td>Conduct annually for one weekend overlapping with DP-wide camera monitoring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand pad monitoring</td>
<td>Select sandy tracks to carryout systematic sand pad monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Citizen cat monitoring 6.2.3</strong></td>
<td>DP</td>
<td>Land holder observations</td>
<td>Engage willing landholders to record cat and key native species observations</td>
<td>Assess cat and key species detectability with technique when cats are widespread and abundant</td>
<td>Collect information annually during DP-wide camera monitoring for 2 weeks to a month</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feral Cat app</td>
<td>Utilise cat App and publicise, collect cat presence records</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fence activities MU1 (6.3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Felixer trap improvement trial 6.3.1</strong></td>
<td>Kingscote Dump</td>
<td>Felixer trap with camera traps</td>
<td>Test placement and design of guide panels to direct cat in front of Felixer to maximise trigger rate</td>
<td>Efficacy of felixer traps needs to be improved from current &lt;65% to &gt;95%</td>
<td>When no more efficiencies can be gained</td>
</tr>
<tr>
<td><strong>Kangaroo use in fence area and collision rate 6.3.2</strong></td>
<td>Isthmus area MU 1.2 MU 1.3</td>
<td>Use camera array</td>
<td>Install camera array to estimate relative abundance Use insurance information to track any changes in accident rates</td>
<td>To assess changes in kangaroo abundance once the fence is installed To be clear on accident rates which maybe raised as a community issue</td>
<td>Stop a month after instalment Ongoing after fence construction</td>
</tr>
<tr>
<td><strong>Immigration rate and gap usage 6.3.3</strong></td>
<td>MU 1.2 MU 1.3</td>
<td>Camera trapping at entry/ exit gaps</td>
<td>Position cameras to determine clearly individuals moving east or west through gaps in the fence and parallel and perpendicular to the fence at several locations Identify individual cats based on pelage</td>
<td>To assess the immigration/emigration rate of cats pre-pulldown (pre-vacuum) To determine the gaps animals use and whether some are favoured</td>
<td>21 days monitoring per season. Reassess to determine whether additional effort needed</td>
</tr>
<tr>
<td>Activity</td>
<td>Where</td>
<td>How</td>
<td>What to do</td>
<td>Why</td>
<td>When to stop</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
<td>-----</td>
<td>------------</td>
<td>-----</td>
<td>--------------</td>
</tr>
<tr>
<td>Cat microhabitat movement through the fence 6.3.4</td>
<td>MU 1.3 MU 1.2</td>
<td>Radio-collar cats in MU1.3 west of the fence</td>
<td>Fit at least 10 cats, preferably young males, with GPS collars with short interval fixes. Need 30 days of collar life and fixes ~15 min apart</td>
<td>Cameras and Felixer cameras detect imperfectly, little reliable data on CPUE of Felixer traps Need to accurately identify where breach locations occur</td>
<td>Reapply collars and track until clear patterns emerge</td>
</tr>
<tr>
<td>Felixer efficacy following improvements pre pull down trial 6.3.5</td>
<td>MU 1.2 MU 1.3</td>
<td>Felixer trap and camera traps</td>
<td>Position Felixer traps at fence gaps Collar cats to determine death rate from poisoning by Felixer</td>
<td>Gaps to enable non-target spp movement; Felixer traps used to selectively kill cats Collared cats needed to determine success of triggering events (CPUE) and distance/direction travelled by cats hit with toxic gel</td>
<td>Until the proportion of successful triggers has been determined or control starts in MU 1.2</td>
</tr>
<tr>
<td>Fence efficacy post east-side pulldown 6.3.6</td>
<td>MU 1.2</td>
<td>Data from cats wearing GPS collars Camera trapping Felixer data</td>
<td>Retrieve movement data of collared cats pre- and post-pulldown in MU1 Utilise camera traps either side of the fence</td>
<td>To identify breach locations, and route habitat used by cats prior and after breach</td>
<td>Reapply collars/ cameras clear patterns emerge</td>
</tr>
<tr>
<td>Fence efficacy post west-side pulldown 6.3.7</td>
<td>MU1.3</td>
<td>Best control methods identified in previous trials in MU 1.1 and MU3.1</td>
<td>Tranches of control effort to pulldown population in MU1.3</td>
<td>To bring the cat immigration rate across the Isthmus down to zero</td>
<td>Ongoing while fence remains porous</td>
</tr>
<tr>
<td>6.4 Isthmus and Island Beach pull down and mop-up: MU1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulldown monitor 6.4.1</td>
<td>MU1</td>
<td>Camera trapping</td>
<td>Grid area camera 650 m apart covering 30-40 km² Clarify data management and processing</td>
<td>Need to get accurate estimate of population abundance pre and post control</td>
<td>Conduct 21 day monitoring</td>
</tr>
<tr>
<td>Activity</td>
<td>Where</td>
<td>How</td>
<td>What to do</td>
<td>Why</td>
<td>When to stop</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------</td>
<td>------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Pulldown control 6.4.2    | MU1   | Cage trapping                           | For each control device apply a repeatable tranche of effort, initially using a single control device  
If no asymptote, repeat with device or add alternative device | Identifying best method for pull down  
Identifying CPUE for each device at different cat densities and different length of device exposure.  
Cats will learn to avoid device and efficacy will differ with cat density | Stop when cum-catch curve asymptotes, device is no longer effective or no cats remain |
|                          |       | Shooting with thermal scopes            |                                                                           |                                                                      |                                                                               |
| Trail mop-up 6.4.3        | MU1   | All possible devices including indicator dogs |                                                                           | To be implemented when >80% of popn removed or cats remain only in patchy locations | When population extinct                                                       |

**6.5 Curiosity bait uptake trial**

<table>
<thead>
<tr>
<th>Determine the breakdown rate of the HSDV and PAPP toxin under KI conditions 6.5.1</th>
<th>MU2</th>
<th>Place sausages and HSDV pellets and monitor decay</th>
<th>Trail decay of pellets under winter conditions in MU2.1 and MU2.2</th>
<th>Public concern that unconsumed HSDV pellets containing PAPP will persist in the landscape and/or PAPP remains toxic</th>
<th>Winter 2020</th>
</tr>
</thead>
</table>
| Conduct non-toxic trials 6.5.2                                               | MU2 | Hand bait and identify uptake by cats and other species.  
Bait density required | Carry out trials in MU2.1 and MU2.2 (different fire ages) | Success and impact of the bait are unknown for KI  
Uncertain whether sufficient bait remain available for cat uptake or if cats eat baits.  
Estimated baiting density needed for aerial drop after taking non-target uptake into account | When trial of sufficient size has been conducted to assess likely efficacy |
### 6.6 Farmland trial pull down: MU3

<table>
<thead>
<tr>
<th>Activity</th>
<th>Where</th>
<th>How</th>
<th>What to do</th>
<th>Why</th>
<th>When to stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulldown monitor 6.6.1</td>
<td>MU3</td>
<td>Camera trapping</td>
<td>Grid area camera 650 m apart covering 30-40 km². Clarify data management and processing</td>
<td>Need to get accurate estimate of population abundance pre and post control</td>
<td>Conduct 21 day monitoring</td>
</tr>
<tr>
<td>Pulldown control 6.6.2</td>
<td>MU3.1 Mu 3.2</td>
<td>Cage trapping, Thermal scope shooting</td>
<td>For each control device apply a repeatable tranche of effort, initially using a single control device If no asymptote, repeat with device or apply alternative device</td>
<td>Best method for pull down identified Identify CPUE for each device in each MU, at different cat densities and different length of device exposure. Cats will learn to avoid device</td>
<td>Stop when cum-catch curve asymptotes, device is no longer effective or no cats remain</td>
</tr>
</tbody>
</table>

### 6.7 Urban/peri-urban MU4

| Cage trapping in urban areas 6.7 | MU4   | Engage community for cage trapping in urban areas | Distribute a minimum of 30 traps for a three week period. Develop program which encourages the community trappers to continue to trap, and collect data | Maximise efficiency of cat control in urban areas | Once protocols and logistics are in place for mop up |

### 6.8 Pulldown Year 2-3

| Pulldown 6.8 | DP | All effective devices | Baiting in winter plus simultaneous application of all devices as needed | To rapidly remove cats in the most efficient way possible | When cats are patchy or no longer being caught |

### 6.9 Mop-up implemented

| Mop-up 6.9 | DP | All effective devices plus hunters with detection dogs. | Focus on patches where cats persist following pulldown Identify cats killed based on pelage etc. Utilise community and systematically collected data to assess locations still remaining | Remnant cats may have become wily and learnt to evade some devices Need to compare cats killed with those known to be alive | Stop when all known individuals have been killed. |
7. References


Bool NM, Page B and Goldsworthy SD (2007) What is causing the decline of little penguins (*Eudyptula minor*) on Granite Island, SARDI.


O’Donoghue PJ (1978) Factors influencing the epidemiology of the ovine sarcosporidioses; and the development of Sarcocystis tenella in specific-pathogen-free sheep. PhD. University of Adelaide.


Southgate RI and Masters P (2006) 'The relative cat density on Kangaroo Island and the relationship to Toxoplasmosis levels in sheep.' Kangaroo Island Natural Resources Management Board, Kingscote.


Venning K, Saltré F, and Bradshaw CJA (in review) Predicting feral cat reduction on Kangaroo Island using stochastic population models. *Biological Invasions*.


Appendix 1  Conceptual model describing the current and potential impacts of cats on Kangaroo Island

1.1 Conceptual models used to understand the interactions and complexities of the system

Conceptual models are critical in field ecology to identify key components of a system and show the connections and dependencies among different components. They are used to identify the short-comings in our knowledge and guide the development of questions to address these short-comings (Austin 2007; Lindenmayer and Likens 2010).

Two conceptual models are presented here. The first (Fig. A1.1) displays the critical attributes of the system, including the key species and habitat types of importance. It describes the current situation outlining the interaction between feral cats and their prey, and diseases impacting on livestock and other species. The second model (Fig. A1.2) illustrates the changes that would likely occur in the system following cat removal.

The models recognise that cats affect production in the area of primary industry, house-hold amenity and conservation and biodiversity in the following ways:

- primary industries: sheep, grain, free-range eggs and viticulture
- house-hold amenity: nuisance value from pests
- eco-tourism industry: visitor satisfaction and perception of commitment to management e.g. when cats are obvious in high conservation areas such as the sea lion colony
- threat levels for endangered species and other biodiversity.

The models also identify a range of key habitat types and the broad suite of species potentially impacted by cats through predation, competition, or diseases spread by cats. Cats predate on invertebrates, reptiles, a range of bird and small mammal species, including introduced black rats and house mice (Burbidge and Manly 2002; Town et al. 2006). Competitors of cats include tiger snakes and goannas, corvids, currawongs and black rats. Toxoplasma gondii (Toxo) and Sarcosystis gigantea (Sarco) are the key disease species spread by cats affecting sheep and native animals.

Recognised effect on agriculture

The negative effect of feral cats on agriculture, off-farm and household utility and native species is symbolised by a downward arrow in Fig. A1.1.

Cats drive down the profitability of sheep production through the hosting and dispersion of the protozoans Toxoplasma gondii and Sarcosystis gigantea, which is a substantial issue on KI (O'Donoghue and Ford 1986). Toxoplasma gondii can result in increased abortion rates of lambs and S. gigantea causes white cysts to form in the meat making it unpalatable (Ford 1986). Cats feeding on sheep carcasses infected with T. gondii left lying in a paddock become infected. The protozoa reproduce in the cat and the oocytes are passed on in the cat faeces to reinfect the
sheep when they consume the spores deposited on the grass (Dubey 1995, 1996). Spores can remain viable for 18 months.

**House mice** do not currently have a substantial impact on grain production on KI (L. Dohle pers. com.) with only localised baiting programs being undertaken. House mice are seasonally abundant on the Island and widespread. **Black rats** and house mice are a major food item of cats on KI (Doherty *et al.* 2015) and it is assumed that cat predation plays a part in limiting these species in rural landscapes.

Feral cats are recognised as predators of **chickens** and pullets and impact on the three free-range egg producers currently on Kangaroo Island (F. Fryar pers. com.).

A nationwide sample of **viticulture** and **horticultural** growers suggested that birds reduce productivity (Tracey and Saunders 2003). On KI, the main pests for vineyards are possums but birds, primarily little ravens, currawongs, starlings, sparrows and native passerines such as silver-eyes can also cause damage (S. Bigwood; V. Bates pers. com.). Most vineyards already manage these pests using fence electrification to exclude possums and netting to reduce avian pest damage.

Several introduced birds may be limited by cat predation including blackbirds, Guinea fowl, turkeys and peacocks. **Peacocks** have already been identified as a pest on KI with control activities underway.

On agricultural land, **ravens** feed on carrion including road kill, culled wallabies and kangaroos and dead lambs/sheep, and compete with cats for this food.

Dead sheep left in the field are identified specifically because of their significant role in the spread of sarco and providing a food source for cats and ravens.

**Recognised effect in bushland and coastal landscapes**

The southern brown **bandicoot** *Isoodon obesulus obesulus* is listed as endangered nationally (Woinarski *et al.* 2014) and has a fragmented distribution on KI although it occurs in a broad range of habitats (Paull 1993, 1995; Jones *et al.* 2010). This species is eaten by cats on KI and probably limited by cat predation.

Bush rats **Rattus fuscipes** are common on the KI and are not considered negatively affected or limited by cat predation (Robinson and Armstrong 1999).

The heath **goanna** *Varanus rosenbergi* was once common in many higher rainfall, cooler areas across southern Australia but is declining. It is considered vulnerable to extinction in SA and cats have been identified as a threatening process. On Kangaroo Island, 75% of hatchlings are eaten by cats in their first year (Rismiller pers. comm. 2016).

**Echidnas** on KI belong to a distinctive sub-species *Tachyglossus aculeatus multiaculeatus* which is considered endangered under the EPBC Act (Woinarski *et al.* 2014) primarily because it is an isolated population which is heavily preyed by cats. Over a ten year period, 20% of burrow young were killed by cats on Kangaroo Island (Rismiller 1999).

Little **penguin** *Eudyptula minor* have declined dramatically in some locations in Southern Australia. The decline has been attributed to a number of factors including cats, goannas and
rats (Bool et al. 2007; Weibkin 2011). Control of predators has decreased penguin mortality in several colonies including Phillip Island and Middle Island, Victoria (Dann 1992).

Hooded plovers are widespread around the KI coastline and the population size is around 250 birds, which equates to 25% of the SA population. The species is listed as vulnerable nationally with a variety of threats to eggs and chicks identified including predation by corvids, gulls, rats, and cats (Weston 2003).

A number of bush birds are predated by cats. Among these, the Bassian thrush and painted button quail are ground-based birds and are considered threatened by cat predation on KI (Robinson and Armstrong 1999; Willoughby et al. 2001; Baxter 2015). The Bassian thrush is listed as vulnerable under the EPBC Act.

Ravens (including currawongs) are widespread predators of bush birds, reptiles and small mammals in coastal and bushland areas and may compete with cats for food. Ravens have been recognised separately as consumers of carrion and road kill and are likely to compete with feral cats.

Black rats are considered a predator of bird fledglings and eggs and compete for resources with native species (Caughley et al. 1998, Town et al. 2006).
Fig. A1.1  The impact of feral cats on fauna, economic returns and household utility. The arrows indicate currently perceived positive (up) or negative (down) impact. A circle beside an entity is suggesting cats have negligible effect.

1.2 Conceptual model describing potential impact following cat eradication

Predicted effects on agriculture

A number of desirable and undesirable outcomes become evident if feral cats are removed from the landscape (Fig. A1.2):

- Sarcosporidiosis would be eliminated resulting in no trimming of meat or condemning of carcasses by abattoirs and an increase in profit. Toxoplasmosis would also be eliminated.
- Loss of free-range chickens from cat predation would be eliminated.
- In some parts of SA house mice can reach extraordinary densities causing economic damage to standing crops and stored grain, households and infrastructure (Caughley et al. 1998). Less cat predation pressure could enable house mice and black rat numbers to increase.
- An increased in abundance of species such as starlings and native birds (e.g. silver eyes, corvids) could occur with less cat predation pressure.

Predicted effects on native and introduced fauna in bushland and coastal habitat

The elimination of cats will affect the abundance of a number of native and introduced mammal, bird and reptile species in bushland and coast habitats. Some of these could become significant predators or competitors of the remnant native species.

- It is expected that cat elimination will result in an increase in black rat numbers posing a greater threat to penguins and other ground nesting birds on Kangaroo Island. Black rats have become significant predators of seabird species on islands where cats have been eradicated (Town et al. 2006).
- It is expected that a substantial reduction in cat abundance will result in an increase in bandicoot numbers.
- It is expected that cat removal will result in an increase in the abundance of bird species such as the painted button-quail and Bassian thrush. Some bush birds may also be limited currently by predation from ravens and currawongs. A reduction in cat numbers will potentially make more food available (mice, carrion) and enable ravens and currawongs to increase in abundance producing secondary impacts on native species occurring in bushland and coastal areas.
- Echidnas and goannas would increase but are unlikely to be a good indicator species overall because their populations are slow growing.

Feral cats preferentially hunt in relatively open areas that have been recently burnt and heavily grazed where their hunting success is higher (McGregor et al. 2014, McGregor et al. 2016).
Fig. A1.2 The expected impact on fauna and economic returns and household utility following the eradication of feral cats. The arrows indicate positive (up) or negative (down) impact. A question mark against an entity is suggesting the effect is unclear.
Appendix 2  Methods to standardize and describe effort and effect

2.1 Monitoring settings and treatments

Most of the analysis methods used to describe the population size, trend or dispersal, assume the probability of each individual being caught remains constant over time. Changing the device settings, e.g. camera traps etc. can invalidate analysis methods and alter repeatability. Similarly, including a raft of nested trials within an operation e.g. testing the attractiveness of two baits, can confound results and diminish the power of a trial.

2.1.1 Trap settings

Bait type, trap type or device setting need to be standardised during a treatment. Trap cleaning or the use of sprays to mask human scent should be applied equally to all devices used during a treatment. The frequency that a bait or attractant is replaced must be maintained throughout the trial. If there is thought to be a better way to carryout control then this should be trialled against the old method and assessed for CPUE using an experimental approach.

2.1.2 Active v passive monitoring

Capture or detection efficacy of a device can often be increased if an attractant is used.

However, actively attracting an individual while monitoring can produce complex behavioural changes that can affect capture probability over time. For example, individuals may initially be attracted to an audio or visual lure at a camera site but may ignore the site in the following days if no reward is found. In more extreme situations, individuals may actively avoid devices if they associate them with bad experiences such as trapping and being sprayed by toxic gel.

Passive monitoring approaches usually result in no or minimal changes to animal behaviour and thus, detectability remains unaffected. However, detection rates from a passive monitoring approach may be very low per device and monitoring can become ineffectual. Consequently, eradication programs sometimes include attractants with monitoring devices to increase detection rates.

2.2 Describing control effort, efficacy, impact and outcome

2.2.1 Trap effort

Trap effort describes the number or density of ‘traps’ (cage traps, cameras, track plots, baits etc.) set per day or unit per area. The costs relating to trap effort include bump-in time, rebait or re-battery, and bump-out time plus animal processing time in the field and data and image collation & processing. Descriptors for trap effort for a range of control or monitoring techniques are presented in Table A2.1. Camera trap rate or cage trap rate is sometimes expressed as the number of independent captures per 100 trap nights.

A tranche of effort identifies the number of ‘traps’ that can be operated per day with the resources available and the number of days that this effort can be sustained. For example, it is
feasible for one person to set and clear, rebait and process animal captures from 30 cage traps per day for 10 consecutive days, providing 300 trap days. Another tranche of effort would result in 600 trap days of cumulative effort. The costs for each tranche equate to 11 days including bump-in, clearing, and pump-out. For remote camera monitoring, a 40 camera array set for 15 days and rechecked twice may take two person days to bump-in, 2x1 day to refresh attractants/down load memory cards etc, one day to bump-out and three days to process and collate images. One tranche of camera trapping would result in 40x14 = 560 trap days and the costs equate to 8 days of labour.

Table A2.1  Describing and costing trapping effort

<table>
<thead>
<tr>
<th>Device</th>
<th>Effort</th>
<th>Catch</th>
<th>Cost for deployment (and ~practical limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cage traps</td>
<td>trap days</td>
<td>trap⁻¹day⁻¹</td>
<td>30 traps set or service person⁻¹ day⁻¹</td>
</tr>
<tr>
<td>Shooting</td>
<td>hours</td>
<td>person⁻¹hr⁻¹</td>
<td>6 hours person⁻¹ day⁻¹</td>
</tr>
<tr>
<td>Felixer traps</td>
<td>trap days</td>
<td>trap⁻¹day⁻¹</td>
<td>2 hrs trap⁻¹ person⁻¹ to place, relocate or service</td>
</tr>
<tr>
<td>Bait</td>
<td>number deployed</td>
<td>baits⁻¹day⁻¹</td>
<td>baits set person⁻¹ day⁻¹ or baits km⁻²</td>
</tr>
<tr>
<td>Camera traps</td>
<td>trap days</td>
<td>trap⁻¹day⁻¹</td>
<td>30 deployed day⁻¹</td>
</tr>
<tr>
<td>Track pad</td>
<td>pad days</td>
<td>pad⁻¹day⁻¹</td>
<td>30 pads day⁻¹</td>
</tr>
<tr>
<td>Road kill</td>
<td>km surveyed</td>
<td>km⁻¹ day⁻¹</td>
<td>4 hrs day⁻¹</td>
</tr>
<tr>
<td>Beach surveys</td>
<td>beach section</td>
<td>section⁻¹day⁻¹</td>
<td>6 sections person⁻¹ day⁻¹</td>
</tr>
</tbody>
</table>

2.2.2  Catch per unit effort (efficacy)

This descriptor is relevant to a particular control device or trap and it describes the number of individuals removed or captured per device or trap set per time unit. Catch per unit effort (CPUE) is an important parameter to collect because it indicates the expected level of pulldown if a particular device was used with a tranche of effort. It is sometimes referred to as average trap success.

The CPUE estimates are scale-specific and will vary with the size of plot, the target species density and possibly non-target species density. The trap settings and bait type will affect trap efficacy. Bait uptake or device encounters do not necessarily equate to the number of individuals culled and encounter rates with devices or baits should not be extrapolated to catch/cull rates without supporting evidence. Capture or recorded death of known individuals i.e. using radio collared individuals is necessary to determine cull rate using baits or Felixer traps.

The description of CPUE needs to include scale-specific information and at least the trap effort used to derive the estimate. Ambiguous reporting of device efficacy arises because the information used to represent catch and/or effort is unclear. For example, CPUE can be described based on the number of traps deployed or based on the number of traps available once non-target capture has been taken into account (conditional).
2.2.3 Cumulative-catch curve

This descriptor compares the cumulative catch against the cumulative effort expended (Fig. A1.1). If the gradient of the curve does not asymptote, the rate of off-take is not sufficient to exceed rate of replacement through recruitment or reinvasion. Greater effort needs to be applied with the device or alternative removal techniques need to be applied (see Ramsey and Will 2012). The catch-effort curve can also be used to estimate population size at a point in time and trend if a number of conditions are met (Caughley 1977).

**Fig. A2.1** Cumulative catch-curve reproduced from Ramsey and Will (2012).

2.2.4 Density-impact functions

This describes the change in abundance or relative abundance (response variable) in relation to a defining variable (e.g. control/treatment/ trapping effort). If trapping effort is represented over time, the shape of the function indicates the rate of population growth or decline. An annual off take greater than 0.6 during pulldown is required to eradicate a feral cat population (Hone et al. 2010). The shape of the density-impact function has important implications for management, the transferability of the control from one module to another and expansion of the program. Abundance may not decline at all with little trap effort, decline with significant trap effort but then asymptote indicating the remaining population has become resistant to trap effort (Fig. A2.2).
2.2.5 Cost–benefit monitoring

Cost–benefit analyses have the effort-outcome relationship as an implicit foundation (Hone 2017). Monetary units are assigned to both effort and outcomes.

The INFFER (Investment Framework for Environmental Resources) framework was developed to enable assessment of benefits and costs of resource management. It has been used to conduct a feasibility assessment of benefits and costs of eradicating feral cats from French Island (Park 2017) and to assess the benefits and costs of options to control the impact of cats on Bruny Island Tasmania. Typically, an INFFER analysis examines a range of different alternative scenarios or projects that provide insights into the relative cost-effectiveness of the various options.

We include this approach because the methodology provides a structured approach to assess the likely cost of feral cat control to the likely net benefit of agriculture or biodiversity. This may become an important consideration if continuation of the eradication is expected to have a very long trajectory. The recent work from French and Bruny Islands identifies a range of cost assumptions for specific scenarios that are comparable to the program for KI.
2.3 Describing characteristics of the cat population

A population undergoing management or environmental pressure will exhibit changes in their life history characteristics. If the pressure is sustained, the population will respond through selection and undergo evolutionary change. This is one of the empirical principles of applied ecology and management identified by Hone et al. (2015).

Some of the short-term changes may become evident quickly and obviously and these changes can be used to monitor success and areas of weakness in control operations. Evolutionary changes tend to manifest more gradually and subtly.

The age structure of the population, particularly the proportion of juveniles within a year cohort, provides a very clear indication of the potential for recovery, recruitment and growth of a population. For example, reproductive condition of females is a useful indicator of the presence of males (Campbell et al. 2011) and the age of foetuses and offspring can indicate when the last males were active. Condition of individuals also provides a good indicator of future fecundity and survivorship whereas the identification of individuals from unique markings and recapture provides an opportunity to estimate longevity and survivorship.

Females reach sexual maturity at 10-12 months weighing 2.5 kg, while males reach sexual maturity later at 12-14 months, weighing 3.2-3.8. Gestation lasts 65 days, with litters averaging 4.4 kittens and an average birth weight of 102 g (Dormer 2017). She used the following criteria to process and record information of feral cats:

- Age class can be assigned based on weight and tooth condition where juveniles are not fully grown (females < 1.9 kg, males <2.2 kg); sub-adults are fully grown but have not bred yet (females 1.9–2.5 kg, males 2.2–3.4 kg) and adults are fully grown and have bred (females > 2.5 kg, males > 3.4 kg). Age can be confirmed by examination of teeth: sub-adults have sharp white teeth and adults have yellowing, blunt or missing teeth.
- Body condition can be assessed from the regression of body mass over femur length, which has been shown to be a reliable indicator of cat body condition.

A protocol needs to be developed to ensure that each individual is uniquely identified and relevant data are collected or samples collected when a new cat is captured or recaptured including photography of both sides, scanning for pit tags and ear tagging; collecting whisker samples to check for biomarkers: Rhodamine B when appropriate; and the collection of samples for genetic analysis: blood, tissue biopsy.
Appendix 3  Collecting data on movement, immigration, population size and optimising capture effort

3.1  Cat movement and immigration

To accurately determine the pattern of movement of cats within and among habitat types, immigration rate, home range size or the fate of individuals taking a toxic bait or sprayed with toxic gel requires individual cats to be fitted with radio-transmitting collars.

The procedures required to capture, fit radio collars, collect location data and recapture cats are labour intensive and requires expertise. However, the procedures are applied frequently in wildlife management and considerable effort during Stage 1 was spent tracking cats to determine home range size. With radiotracking, only adults are usually monitored and there is little information on movement and habitat use of juveniles. There are risks in applying collars to individuals that are still growing.

Records of uniquely identifiable individuals via opportunistic sightings or from images captured using a spatial array of remote cameras can also be used to assess movements of individuals and habitat use but identifying individuals based on pelage is time consuming and recapture rates can be low.

Understanding the dispersal capacity and behaviour of a species is critical during an eradication program because:

- Reinvasion is a major factor that can hamper success of a program. Understanding the survival rate of individuals exposed to a control barrier or imported (accidental or assisted) is necessary to understand the control and biosecurity effort required to stem immigration.
- The pulldown of a population creates a ‘habitat vacuum’ with conditions different to neighbouring non-treated habitat. This can affect the rate and pattern of spread by individuals. This information can assist assessing resources required for mop-up operations if an incursion occurs. Numerous studies of vertebrate pest control programs have demonstrated a vacuum effect (Bengsen et al. 2011a; Comer et al. 2018). Long distances moved by feral cats in other study regions show that cats are readily able to colonise areas.
- Juveniles (particularly males) disperse at weaning. This diffuse rate of habitat colonisation is needed to understand recolonisation of habitat from resident individuals.
- Fencing will play an important part in the eradication program and the behaviour of individuals confronted with a predator-proof fence and gaps in a fence will be important to understand.

There is often limited information on dispersal of individuals because stressed or unsettled individuals move much larger distances than those occupying a stable home range. Collecting dispersal information is likely to be more costly and time consuming than collecting information on home range. Dispersal should not be confused with local movements of adults within a home range.
3.2 Setting camera arrays

Robley et al. (2008) found camera trapping to be the most robust means to detect feral cats in a study that compared encounter rate and detection probability of cage traps, leghold traps, a DNA sampling device, a heat in-motion digital camera and sand plots.

Appropriate spatial placement of camera traps is especially important for population estimates (Meek et al. 2014). There are three approaches:

- systematic (along pre-determined transects)
- random or stratified random allocation
- deliberate biased placement and clustering to identify known individuals or monitor den use.

The spacing between camera trap sites determines the independence of observations between locations and this, in turn, depends on the home range size and movement characteristics of the target species.

Various approaches have been developed to estimate animal density from camera trap data. Some analytical procedures used to estimate population size such as capture-recapture modelling rely on individuals being recaptured by other cameras within an array (non-independent) hence cameras are spaced at distances less than a species home range width. Other procedures such as point estimates are used to estimate abundance using binomial mixed models (Royle 2004).

The other factors that affect the collection of data and the detectability of target species include the type of camera, the camera settings and the positioning of cameras and whether or not an attractant is used. These factors can affect the statistical reliability of a study if assumptions of equal detectability among camera locations are violated.

Camera trap spacing used in feral cat population studies range from 500m-3 km apart (Table A4.1). Camera arrays do not follow a strict grid pattern and hollow grids, where impenetrable or inaccessible habitat is avoided, can remain effective (Nicholls and Glen 2015).

3.3 Optimising trap placement and layout

Data on population abundance, spatial distribution and detection probabilities of different monitoring techniques should be used to design the optimal monitoring methods to use throughout the course of the eradication program (Ramsey and Will 2012). This is particularly important for the design of cage trap or camera trap arrays used in control and monitoring operations. Simulation techniques can be used to determine the optimal amount and spatial distribution of devices that will result in all individuals being placed at risk of removal for least effort.

A spatially explicit trap simulation tool has been produced to aid predator and possum control work in the Hawkes Bay region New Zealand (Warburton and Gormley 2015; Glen et al. 2016; Gormley and Warburton 2017).

The parameters of \( \sigma \) and \( g_0 \) are produced in home range and spatially explicit capture-recapture analysis and are key to optimization of trapping design (Efford 2004; Glen and Byrom 2014;
Ramsey and Will 2012). The actual probability of an individual being captured depends on the likelihood an individual will encounter the device ($\sigma$) (i.e. the distance between its home range centre and the trap device), as well as catchability value according to the device ($g_0$). In other words, $g_0$ is the probability that a device placed at the centre of the animal's home range will detect an animal on any given day (Efford 2004). The likelihood an individual will encounter a trap $\sigma$ is proportional to its home range size and $2.45\sigma$ equals the radius within which an individual is likely to be found 95% of the time or 95% home range area of an individual equals $6\pi\sigma^2$ (Gormely and Warburton 2017; Warburton and Gormely 2015). Individuals with large home ranges are more likely to encounter traps than an individual limited to a small home range.

A high $\sigma$ value means traps can be spaced further apart. If $\sigma$ is low an animal is unlikely to be captured unless a trap is placed near the middle of its home range and traps must be set closer together to ensure every resident animal has at least one trap close to the centre of its home range. A high $g_0$ indicates that relatively little trapping effort should be required to capture an individual; this may mean small numbers of traps and/or trapping only for short periods. Conversely, if $g_0$ is low we can expect that large numbers of traps would need to be set for long periods to increase the probability of catching the target animal (Glen and Byrom 2014).

The actual probability of being captured can be estimated using the function

$$p = g_0 \exp(-d^2/2\sigma^2)$$

Where $d$ is the distance between trap and the home range centre, $g_0$ is the per-night catchability when the trap and home range centre locations coincide (i.e. $d = 0$) and $\sigma$ is proportional to the estimated home range size of the species.

**Key findings**

Home range size is known for lifestyle blocks and $g_0$ and $\sigma$ estimates are known for bushland and farmland areas (Table A4.2). There are no data for urban and peri-urban parts of the DP.

The density at which control or monitoring devices for feral cats are deployed should reflect home range areas, to ensure that each cat within a treatment area has a reasonable probability of encountering a device. The lack of consistent differences between sexes and study sites in home range and movement characteristics indicates that most adult cats should be equally susceptible to encountering control or monitoring devices deployed throughout their environment. If core activity areas are substantially smaller than estimated total home ranges, control devices should be deployed at sufficient density to ensure that there are no holes in the treatment area large enough to encompass a cat’s core area. A spatial arrangement should ensure that no device is farther than about 500-800 m from its nearest neighbour. This equates to a density of about $>1.7$ devices per square kilometre if devices are evenly distributed.
**Table A3.1** Camera trap spacing, sample period and settings which have been used to monitor feral cats on and off KI

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample area (km$^2$)</th>
<th>Traps</th>
<th>Sample period</th>
<th>Distance apart</th>
<th>Passive/active Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Willson R.</td>
<td>6</td>
<td>29</td>
<td>30 #</td>
<td>500m</td>
<td>30 cm</td>
</tr>
<tr>
<td>Stage 1 Simpson</td>
<td>6</td>
<td>16 (4)</td>
<td>74 #</td>
<td>1 km</td>
<td>30 cm</td>
</tr>
<tr>
<td>Stage 1 Dudley</td>
<td>8</td>
<td>21 (6)</td>
<td>28</td>
<td>1 km</td>
<td>30 cm</td>
</tr>
<tr>
<td>Stage 1 Sandhurst</td>
<td>1.5</td>
<td>12</td>
<td>61 #</td>
<td>500m</td>
<td>30 cm</td>
</tr>
<tr>
<td>Bengsen et al. (2011)</td>
<td>16</td>
<td>36</td>
<td>15</td>
<td>~800 m</td>
<td>bait</td>
</tr>
<tr>
<td>Comer et al (2018)</td>
<td>768</td>
<td>44</td>
<td>21</td>
<td>3 km</td>
<td>olf.+visual 30 cm</td>
</tr>
<tr>
<td>Nichols&amp;Glen (2015)</td>
<td>40</td>
<td>21</td>
<td></td>
<td>500m</td>
<td>olfactory 5 cm</td>
</tr>
</tbody>
</table>

( ) locations with dual cameras  
# density appeared to asymptote at ~21 days except for Dudley

**Table A3.2** Estimates for g0, sigma and density for feral cat from a range of studies

<table>
<thead>
<tr>
<th>Species</th>
<th>g0</th>
<th>Sigma</th>
<th>Density</th>
<th>Habitat</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>0.91</td>
<td>179</td>
<td>0.12</td>
<td>Farm/bushland</td>
<td>KI Flinders Chase</td>
<td>Hohnen (unpublished)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.06</td>
<td>412</td>
<td>0.57</td>
<td>Farm/bushland</td>
<td>KI Flinders Chase</td>
<td>Hohnen (unpublished)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.09</td>
<td>147</td>
<td>0.42</td>
<td>Bushland</td>
<td>KI</td>
<td>Hohnen (unpublished)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.11</td>
<td>228</td>
<td>0.24</td>
<td>Bushland</td>
<td>KI</td>
<td>Hohnen (unpublished)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.14</td>
<td>200</td>
<td>0.53</td>
<td>Bushland</td>
<td>KI Simpson CP</td>
<td>Berris et al.(2019)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.13</td>
<td>370</td>
<td>0.21</td>
<td>Farmland</td>
<td>KI</td>
<td>Berris et al. 2019</td>
</tr>
<tr>
<td>Cat</td>
<td>0.1</td>
<td>149</td>
<td>0.45</td>
<td>Farmland</td>
<td>KI</td>
<td>Hohnen (unpublished)</td>
</tr>
<tr>
<td>Cat</td>
<td>0.09</td>
<td>176</td>
<td>2.99</td>
<td>Farmland</td>
<td>KI Willson River</td>
<td>Berris et al. (2019)</td>
</tr>
<tr>
<td>Possum</td>
<td>0.05</td>
<td>63</td>
<td>0.5-3.0</td>
<td>Farm/bushland</td>
<td>NZ</td>
<td>Warburton&amp; Gormley (2015)</td>
</tr>
<tr>
<td>Possum</td>
<td>0.09-0.11</td>
<td>40-41</td>
<td>varied</td>
<td>varied</td>
<td>NZ</td>
<td>Efford et al. (2000)</td>
</tr>
</tbody>
</table>
Appendix 4  Estimating abundance, occupancy, detectability and population growth

4.1 Absolute abundance and density

*Importance*

Absolute abundance is the number of animals estimated to be present and this number is necessary to estimate density. Density estimates are important and useful parameters in eradication programs. The estimates can be compared directly with other studies and locally, they provide a standard to relate relative abundance estimates.

However, it is important to recognise that the methods to estimate absolute abundance may not perform well in all circumstances, particularly when the abundance of animals is very low (as may occur following a control operation), or when the detection probability of a species is very low (Robley et al. 2008). Determining density is time consuming and expensive to conduct, far more so than activities to determine relative abundance (Caughey 1977).

Absolute abundance can be estimated by mark-recapture analyses, point counts, distance sampling counts of individuals or removal methods (Ramsey and Will 2012). Remote cameras can be used to derive data suitable for mark-recapture analyses and point counts.

Mark-recapture has become the most widely adopted approach in recent times however it is labour intensive. Images are used to individually identify cats based on pelage pattern captured by remotely set cameras. The location and recapture of identified cats relative to unknown cats in subsequent sampling is used to estimate absolute density using spatially explicit capture-recapture models. The use of camera trapping to estimate feral cat density has been applied on KI (Berris et al. 2019, Bengsen et al. 2011a) and widely applied to estimate absolute abundance in Australia and New Zealand.

Ramsey and Will (2012) describe the process estimate population abundance using point counts of individual cats obtained from randomly placed camera traps using binomial mixed models developed by Royle (2004).

*Key findings and relevance for Stage 2*

Cat densities can range from 0.03 km\(^{-2}\) during drought periods in desert regions of Australia, to >750 km\(^{-2}\) in urban/peri-urban areas. (see Dormer 2017 and Denny and Dickman 2010)

Highest densities have been reported from areas associated with humans where the animals can exploit habitats where food and opportunity for shelter is abundant. Cats can also achieve high densities on small islands. Density tends to decline as island size increases (Hohnen 2016).

The cat densities found on KI fit within the bounds of densities recorded on farmland and bushland from mainland parts of Australia (Paton 1994; Bengsen et al. 2011a; Hohnen, unpublished data; Berris et al. 2019).
Density estimates derived from capture-recapture analysis indicated density was as variable in bushland as it was on the margin between bushland and farmland. (Hohnen unpublished data; Berris et al. 2019).

**Issues and gaps**

Uniquely identifying individuals based on pelage is time consuming and costly.

Camera arrays are generally limited to 20 km\(^2\) or less because of the cost of individual cameras and time required to establish, download and process images.

Robust estimates depend on sufficient individual and recapture rates being recorded.

Estimates of density can usually be produced during the pulldown phase of eradication while individuals remain relatively abundant. They are usually inappropriate during the mop-up phase when animals are scarce.

A crucial assumption of mark-recapture models is that animals are equally catchable. There are a range of techniques to test whether this assumption is violated.

Feral cat density is known for lifestyle blocks and \(g_0\) and \(\sigma\) estimates are known for bushland and farmland areas. There are no data for urban and peri-urban parts of the DP.

### 4.2 Relative abundance and occupancy

**Importance**

Techniques used to estimate relative cat abundance form an essential component of eradication programs because they are usually less costly to implement and are more sensitive when individuals become less common. Indices of relative abundance are widely used in programs that monitor the impact of feral animal control in Australasia (Reddiex et al. 2006, Comer et al. 2018).

To derive indices of relative abundance, individuals do not need to be uniquely identified or counted. Instead, counts of animal sign or catch-effort estimates or non-standardised counts of animals can be used to track changes in a population if a relationship to density is known to be approximately linear.

Most indices are direct manifestations of animal activity (Caughley 1977) and problems arise when the amount of activity detected does not reflect true abundance and density. The relationship between relative and true abundance is generally closest when the population is sparse. However, reliance on indices has been criticised because the relationship between the index and absolute abundance is usually not tested and monitoring programs involving indices of abundance seldom demonstrate that they have sufficient power to detect the desired changes in population abundance (see Robley et al. 2008). It is essential that indices be calibrated against contemporaneous absolute abundance estimates.

Estimating occupancy has become widely used in studies of wildlife and the effect of management. It can be defined as the proportion of sites throughout a landscape that are inhabited by a target species (Field et al. 2007). Rather than giving an estimate of population
size, occupancy models calculate the probability of a site being occupied. This estimate depends on abundance and the ability to detect the species. Repeated sampling at a site enables estimation of detectability.

There is usually a good relationship between animal abundance and the amount and extent of habitat occupied (McKenzie et al. 2006) but occupancy is unreliable to confirm a species’ absence (McKenzie 2005). If a control operation is successful, both detection and occupancy measures should reduce. Occupancy models can also estimate population growth and rates of local extinction and colonization with successive season of sampling. If predator control is effective, local extinction rate should match or exceed colonisation rates (Bengsen et al. 2014).

Occupancy estimation and modeling can be conducted using script in R or PRESENCE in accordance with techniques developed by MacKenzie et al. (2006). Their approach considers detection of a species at a site as the product of factors that affect occupancy including site-specific features (eg. habitat type and patch size) and those that affect detection including sampling-occasion features (eg. plot conditions or observer). Repeated sampling of locations is used to develop an unbiased estimation of detection and occupancy. The model framework can accommodate missing values (i.e. occasions when plots were not surveyed), sampling occasion and site-specific covariates. Multi-season models can be applied to examine population characteristics and estimate occupancy and growth parameters.

Alternative approaches to estimate a relative index using camera data have been applied including random encounter methods (Rowcliffe et al. 2008) and relative abundance indices (Bengsen et al. 2011a) but these ignore detectability and depend on additional assumptions (van Hespen et al. 2019). An approach devised by Royle and Nichols (2003) extends occupancy modeling to estimate abundance by exploiting the feature that heterogeneity in abundance can be modelled as heterogeneity in detection probability. Standard occupancy surveys incorporate detection probability directly into the estimation process.

Techniques to develop a range of catch-effort estimates are outlined below and their role in monitoring becomes more important during the mop-up phase of an eradication program. The main technique to monitor the decline of the cat population during the pull-down phase is use of occupancy modelling with data from camera trapping.

Comer et al. (2018) found occupancy analysis using camera trapping data was an effective approach to detect changes in feral cat occupancy over time and the effectiveness of aerial baiting for landscape-scale removal of feral cats during a five year program.

The use of techniques to estimate relative cat abundance has not been extensively applied on Kangaroo Island. Taggart et al. (2019b) monitored 11 sites on Kangaroo Island and 11 sites on the adjacent mainland to compare cat relative abundance. At each site, 3-5 cameras (potentially five different types) where simultaneously deployed 100 m apart each with both an olfactory and visual lure. Cat relative abundance estimated using the Royle–Nichols abundance-induced heterogeneity model (Royle and Nichols 2003) was found to be over 10 times greater on Kangaroo Island than the mainland. Estimated detection rates (detections camera⁻¹ day⁻¹) on Kangaroo Island were 0.037 compared to the mainland 0.002.
Feral cat detection estimates from an unbaited, unlured camera array (15-30 camera spaced 500 m apart) designed primarily to monitor deer in plantation forestry was 0.005 detections camera\(^{-1}\) day\(^{-1}\) (Southgate and Florence 2018).

Southgate and Masters (2006) used track monitoring to compare relative cat abundance among urban/peri-urban areas, bushland and farmland/lifestyle blocks.

Data on cat sightings collected by a courier while travelling along major roads on KI over a five year period was used to assess the seasonal variation in cat detection (Masters 2007).

### 4.3 Population trend and growth rate

**Importance**

The growth rate or trend of a population is simply a description of the steepness a population is increasing or decreasing. Estimating changes in relative abundance or absolute abundance over time is a crucial procedure in eradication and wildlife management programs. When the instantaneous rate of increase \(r=0\) the population is stable, \(r>0\) indicates the population is increasing and \(r<0\) indicates it is declining. Buchmaster and Hone (2015) state that impacts on feral cat prey need to be defined in terms of the instantaneous rate of increase \((r)\) of the prey population against cat abundance at the local or management unit level.

**Key analysis and output**

The observed instantaneous rate of increase can be calculated by regression for two or more estimates of absolute or relative population size. The estimates for each period need to be made with similar procedures and sample effort.

The rate of growth \(r_m\) is the maximum rate at which a population could increase when no resource is limiting. In most situations the observed rate of increase is below \(r_m\). The estimate must have a time unit attached (Krebs 1989).

The observed instantaneous rate of increase can be calculated by regression for two or more estimates of population size as outlined by Krebs (1989). These can be

\[
    r = \frac{\log(N_{t1}) - \log(N_0)}{t}
\]

where \(N_0\) is the population size at the beginning of the period of interest and \(N_{t1}\) is the population size \(t\) units of time later. The population at \(N_{t1}\) can be predicted if \(N_0\) and \(r\) are known.

\[
    N_{t1} = N_0e^r
\]

The rate of growth expressed as \(r\) is positive if \(r>0\) and negative if \(r<0\). A population doubling each year has \(r=0.693\), a population halving each year has \(r=-0.693\), and a stable population has \(r=0\). The value of \(r\) converts easily from one unit of time to another adjusted

\[
    r_s = r_o*(t_s/t_o).
\]
For example, $r_0$ measured over a specific period of time $t_0$ days can be converted to an estimate of annual growth rate $r_1$ using $t_0=365$

The finite rate of growth $\lambda$ and the exponential rate of growth $r$ are simply different ways of presenting the same rate of change

$$\text{Lambda } \lambda = e^r$$

An annual rate of growth for $\lambda$ is centered around 1. A population declining at a finite rate of 0.5 has an instantaneous growth rate of $-0.693$. Lambda $\lambda$ does not convert easily from one unit of time to another.

### 4.4 Probability of remaining extant

**Importance**

An inherent problem in the late stages of most eradication programs is being able to assess whether a target population is still declining and determine the performance of control and monitoring effort (Ramsey et al. 2009; Ramsey et al. 2011). Typically return on control and search effort diminishes during eradication because remnant individuals can become more evasive with hunting pressure and difficult to detect and monitor at low abundance (Pople et al. 1998; Bayne et al. 2000; Courchamp et al. 2003).

The probability that a species remains extant can be estimated by combining data derived from multiple techniques within a Bayesian modelling framework (Ramsey et al. 2009; Solow et al. 2011). Lee (2014) extended a model developed by Thomson et al. (2013) to incorporate sightings made with survey effort and opportunistically where there is uncertain detection and veracity. The model was developed within Excel and provides a familiar spreadsheet format and relatively simple interface for data entry and output of estimates. The model enables users to enter definite sightings (e.g. capture records), observations from up to three types of survey, and up to five types of opportunistic uncertain observations. The ability of each technique to detect the presence of a species with a set amount of effort needs to be estimated while the target species is abundant. This approach was used to estimate the probability that feral goats remained extant at the end of an eradication program on KI (Southgate et al. 2018).

**Key parameters, procedures and sampling effort**

Methodologies used to estimate the probability a species remains extant depend on knowing the detection probability of the different monitoring techniques. The use of uniquely marked individuals or animals wearing GPS radio-tracking collars can be used to estimate detectability. Similarly repeat sampling or double counts can also be used. The feral cats scan is an example of an opportunistic survey approach and track monitoring of pads or sections of beach provide examples of non-camera survey techniques.

**Feral Cat Scan**

This App provides an opportunity for the community to record feral cat sightings. [www.feralscan.org.au/feralcatscan/default.aspx](http://www.feralscan.org.au/feralcatscan/default.aspx). The type of presence-only sighting data can be used to indicate the distribution of species. The data provided is of limited value during the
pulldown phase of an eradication program because it cannot be used to accurately inform trend. But the data becomes important during the mop-up phase.

Data from this type of approach becomes more useful if:

- the public is well informed about the timing of an upcoming survey and how to contribute
- the survey period is a discrete period of time e.g. two weeks and infrequent i.e. annually to maintain interest but prevent fatigue
- specific areas are identified where sighting data would be particularly valuable
- the public is informed about the findings from the survey.

**Track pads**
Sand pads set across access tracks where traffic volume is very low can be used to capture the imprints of traversing species. Medium to large species can be identified based on the characteristics of foot imprints (Moseby et al. 2009). The technique is passive and useful to detect species when their density is low. Southgate and Masters (2006) conducted a survey of cat activity using track pads to assess association with the level of *Toxoplasmosis* in maiden ewes. In total, 28 sites were surveyed and at each site 25 plots spaced more than 100 m apart were sampled on two consecutive mornings. Each plot consisted of a 1.2 m strip of prepared trackable sandy surface across the width of the access track. Filling sand was added if the existing surface substrate was not suitable to adequately register imprints of the target species.

**Beach walks**
Hooded plover monitoring that has been conducted on KI (1985 onwards but with standardised methodology from 2000). Hooded plovers sighted on a designated beach are counted on a single day by an observer every two years and over 40 designated beaches on KI have been recognized.

It is proposed that monitoring of designated beaches be extended to record the presence-absence of track imprints of feral cat, possum, wallaby, goanna, corvid and magpie and pacific gull. The presence absence of species sighted can also be recorded.

Transects need to be roughly 500 length (i.e. 250 m out and return) with in a 30 minute period (i.e. standardize search time and distance). Parts of the beach where the substrate is most suitable to register animal tracks should be used.

Monitoring of the transects should be conducted when there has been light wind and no rain for 3 days prior to and on the day of sampling.
Appendix 5  Management units

Eradication of cats from the DP needs to consider the different strategies that can be used in areas of different land uses. Hence, it is proposed that the Dudley be divided into four Management Units (MUs) that reflect access difficulties and the type of control devices likely to be permitted (Fig. A5.1). In additional, management units reflect parts of the landscape where part of the cat population could be more easily contained because of natural or man-made boundaries or features (Table A5.1).

---

Fig. A5.1  The management units proposed for the Dudley Peninsula

### 5.1 Management Unit 1: Island Beach/DP Isthmus

This MU is bounded to the east by the Sandhurst Track; and to the west by the Pennington Bay Road. It contains largely urban and rural living blocks and importantly includes the proposed cat barrier fence dividing the DP from western Kangaroo Island. MU1 also includes the Pelican Lagoon Conservation Park. Immigration of cats from the west must be halted in this MU to achieve eradication on the remainder of DP. It provides an area of sufficient size and habitat quality to contain significant biodiversity assets (hooded plovers, goannas, echidnas and
bandicoots) that will most likely respond to cat control. The Island Beach/Strawbridge Point peninsula provides an opportunity to achieve sustained cat control and possibly localized eradication using trapping and shooting because of its insular features. Previous cat control work has been conducted in the area and the community is largely supportive.

5.2 Management Unit 2: Bushland

This area covers the Dudley, Simpson and Lesueur Conservation Parks managed by DEW, and an area used for cattle and wine grape production. It includes several large properties with heritage agreements. Most of the area is covered by native vegetation and used for conservation. It contains areas of sufficient size for biodiversity assets to respond to cat control. Control of cats is difficult in MU2 because of reduced accessibility and ability to use conventional devices such as cage traps, however cat density is evidently low in areas where bushland has a thick (dense) understorey. Broad scale baiting may be possible to apply in large parts of this MU once a suitable bait becomes available. A substantial reduction of cats in both MU1 and MU2 will significantly reduce immigration to MU3.

5.3 Management Unit 3: Farmland

This is the largest MU on the DP extending east from the Dudley Conservation Park, and north from the Simpson and the Lesueur Conservation Parks. Sheep production is the dominant land use. A large proportion of the land has been cleared of native vegetation but shelter belts and patches of native vegetation are widespread. It contains several areas of sufficient size where agricultural assets would respond to cat control. Shooting and trapping are suitable for use in this MU. Good support and cooperation for cat control has already been developed on some large properties in MU3.

5.4 Management Unit 4: Urban

This area is relatively small encompassing primarily Penneshaw, Baudin Beach and Island Beach-Sapphire Town communities. Penneshaw is particularly important because it has high densities of domestic and feral cats persisting together and is a transport and accommodation node. MU4 needs specific management to prevent immigration of cats from off-Island, and to ensure no recruitment occurs from domestic cats (currently 20 registered on DP). Cat control may result in an increase in some biodiversity assets such as penguins. Trapping will be the main form of control on this MU. Because of the large size of most MUs and limitation of resources available for control and monitoring, the larger MUs are divided further into modules which will be small enough for effective management. These modules will also provide specific opportunities to test and monitor control efficacy and where possible, will reflect parts of the landscape where part of the cat population could be more easily contained because of natural or man-made boundaries or features.
Table A5.1  The characteristics of Management Units identified on the Dudley Peninsula

<table>
<thead>
<tr>
<th>Management unit name</th>
<th>Area (km²)</th>
<th>Primary land type</th>
<th>Primary vegetation</th>
<th>Containment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU1 Island Beach/Isthmus</td>
<td>48</td>
<td>Urban/ Rural lifestyle</td>
<td>Uncleared</td>
<td>Semi-contained/porous</td>
</tr>
<tr>
<td>MU 2 Bushland</td>
<td>~130</td>
<td>Conservation</td>
<td>Uncleared</td>
<td>Porous</td>
</tr>
<tr>
<td>MU 3 Farmland</td>
<td>~190</td>
<td>Farm land</td>
<td>Cleared</td>
<td>Porous</td>
</tr>
<tr>
<td>MU 4 Urban/ lifestyle</td>
<td>3.3</td>
<td>Urban</td>
<td>Cleared</td>
<td>Porous</td>
</tr>
</tbody>
</table>
Appendix 6  
**Additional research needs**

There are a number of areas that need further clarification for successful eradication:

- Further information can be collected on cat habitat usage and movements in bushland and along thorough fares and coastlines. This will allow fine-tuning of the trap density and location.

- Response of black rats on coast lines near penguin colonies and methods to control them. This work could follow on from work carried out by (Achurch 2012).

- More detailed studies on native species likely to respond to low density cat populations e.g. ground nesting birds such as the Bassian Thrush, Painted Quail, or fast breeding threatened species such as the southern brown bandicoot and bush stone curlew.

- Social research into peoples' attitudes to stronger domestic cat management and possible biosecurity measures that could be implemented to stop the importation of cats.

- Analysis of cat genetic samples to identify if DNA samples can be used to identify cat population structure in bushland versus agricultural land versus townships. This would build on early genetic sampling (Bengsen 2011b) which found there was some difference between cats on located west of the Isthmus compared to the eastern population (Sarre, unpublished. data.) Samples have already been collected from 185 cats and stored in the Canberra University genome library. Further work could be developed to allow genetic analysis to identify the identification of cats from scats, particularly in the mop-up stages of the program.

- Clearer, more accurate approaches to measure changes in disease levels of Sarcosporidiosis and Toxoplasmosis in sheep flocks following cat reduction are required.

- Further work on the effect of better farm management i.e. reduction of food resources for cats, particularly sheep carcasses, on disease levels in sheep is required within a cost-benefit analysis framework e.g. INFFER.

- Following on from Patrick Taggart’s work, further studies to validate whether the soil pH, clay content, or cat density is the biggest contributor to the levels of Sarcosporidiosis in sheep.

- Other methods to stop immigration through the barrier fence.