Recommendations for the effective monitoring of cats and wildlife as part of an enhanced cat management program on French Island.

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Table of Contents

Cover page photos;

- Preparation of 'Sticky Wicket' hair snare.   Lewin's Rail (*Lewinia pectoralis brachipus*).
- Feral Cat (*Felis catus*).   Detector dog and cat skeleton.
- Cat prints and scat   Radio-tracking feral cats

Introduction

The arrival of invasive predatory species, such as cats (*Felis catus*), onto islands causes population decline and extinction of insular wildlife species. Islands provide critical habitat for biota worldwide with fauna particularly susceptible to predation and other impacts that follow the arrival of invasive species. The introduction of domestic cats onto islands inevitably leads to self-sustaining feral populations becoming established that compounds the threats to wildlife. There is increasing global awareness of these impacts which has led to the development of tools and strategies to reverse the loss of wildlife by removing cats from islands (Nogales *et al*. 2004; Campbell *et al.* 2011; Parkes *et al*. 2014). The Database of Island Invasive Species Eradications reports that there has been 100 islands globally from which cats have been removed, with 20 of these in Australia (DIISE 2017). Diligent planning is critical for successful species removal programs to have the best chance of success and to minimise unintended consequences that may occur as a result of the program, such as release of other invasive species, i.e. rabbits. This necessarily requires engagement with land owners and stakeholder agencies to ensure that project objectives are realised.

Trapping of cats has been undertaken on French Island as part of routine pest management control activities for decades. This was primarily undertaken at strategic locations by Parks Victoria to provide a short-term reduction in the predation of seabirds (M. Douglas, pers. comm.). This work was supplemented by research studies associated with the development of the Curiosity® bait during the early 2000's. These included several studies that were undertaken to investigate the behaviour of stray and feral cats on the island, and culminated in the conduct of the first field efficacy study of the *Curiosity*® bait in 2008 (McTier, 2000; Johnston *et al*., 2007; Johnston *et al.* 2011). In 2010, Parks Victoria was successful in obtaining funding from the Port Phillip and Westernport Catchment Management Authority (PPWCMA) for the conduct of a more comprehensive trapping program (Norvick 2015). This was further enhanced in 2012 by conduct of cat trapping and spotlight shooting throughout the freehold tenure coordinated by French Island Landcare Group. The combined program has continued to the present day and has resulted in the removal of >1000 cats. Importantly, the community has demonstrated their support for the program by arranging for the de-sexing of their pet cats as well as permitting access to land. A review of the cat removal database was commissioned by Zoos Victoria, (Johnston 2017).

The Australian Government, represented through the Office of the Threatened Species Commissioner (Department of Environment and Energy) has recognised the environmental significance of French Island. This led to the nomination of French as one of five Australian islands from which feral cats should be eradicated (Australian Government 2015a; G. Andrews, pers. comm). Funding has been vested with the PPWCMA to conduct conservations with the French Island community about a proposal to eradicate feral cats from the island in addition to continuing the ongoing cat control effort. A cost:benefit analysis indicated that eradication delivered the most favourable option against less intensive management objectives (Park *et al*., 2017).

French Island is located in Western Port, Victoria and covers 170 km^2. The French Island National Park covers 110 km^2 is the largest land use on the island and includes areas of inter-tidal zone within the park (Weir and Heislers 1998). The 2016 Australian Census reports that 119 residents live on the island and there are numerous properties owned and managed by absentee landholders (Australian Bureau of Statistics, 2016).

The PPWCMA commissioned the development of a long-term and scientifically robust environmental monitoring program to support and validate the proposed eradication project on French Island.

This plan shall provide the necessary detail to:
- Understand the baseline abundance and distribution of feral and stray cats on French Island;
- Understand the extent to which feral cats are having an impact on significant species at a population level;
- Understand the impact of direct works and management actions on the abundance and distribution of feral cats; and
- Understand the impact and effectiveness of these works and management actions on the significant species that are impacted by feral cats.

Distribution of cats on French Island.

Cats can be grouped into categories according to how and where they live. The descriptions provided in the 'Threat Abatement Plan for Predation by feral cats' (Australian Government, 2015b) have been utilised in this plan:

Feral cats are those that live and reproduce in the wild (e.g. forests, woodlands, grasslands, deserts) and survive by hunting or scavenging; none of their needs are satisfied intentionally by humans;

Stray cats are those found in and around cities, towns and rural properties; they may depend on some resources provided by humans but are not owned; and

Domestic cats are those owned by an individual, a household, a business or corporation; most or all of their needs are supplied by their owners. If the confinement of domestic cats becomes more common, the category of a domestic cat may need to be divided to confined and unconfined cats because the potential for these two groups to impact on native fauna is different.

Cats from each category are present on French Island and it is likely that a proportion of cats may transition from one category to another throughout their life. Cats kept loosely as 'farm cats' will fall between the stray and domestic categorisation. This could include taming of feral cats / kittens to live as domestic cats or alternatively cats transitioning from domestic situation to feral animals – the latter is often the result of landholders abandoning cats behind when they leave the island (M. Johnston, pers. obs.).

Field observations, trapping records and data sourced from cats fitted with radio-tracking collars indicate that cats are able to exploit habitats across French Island. The trapping records of cats caught by Parks Victoria and Landcare, (summarised in Johnston, 2017), demonstrate a widespread distribution throughout the island, including on Tortoise Head (Figure 1). Earlier studies collected data from feral cats fitted with radio-tracking collars provided greater detail on the ranging behaviour through freehold and National Park estate (McTier 2000; Johnston *et al.* 2010). Interestingly, two cats exclusively used the saltmarsh and adjoining melaleuca for the duration of the 2008 study (Figure 2).
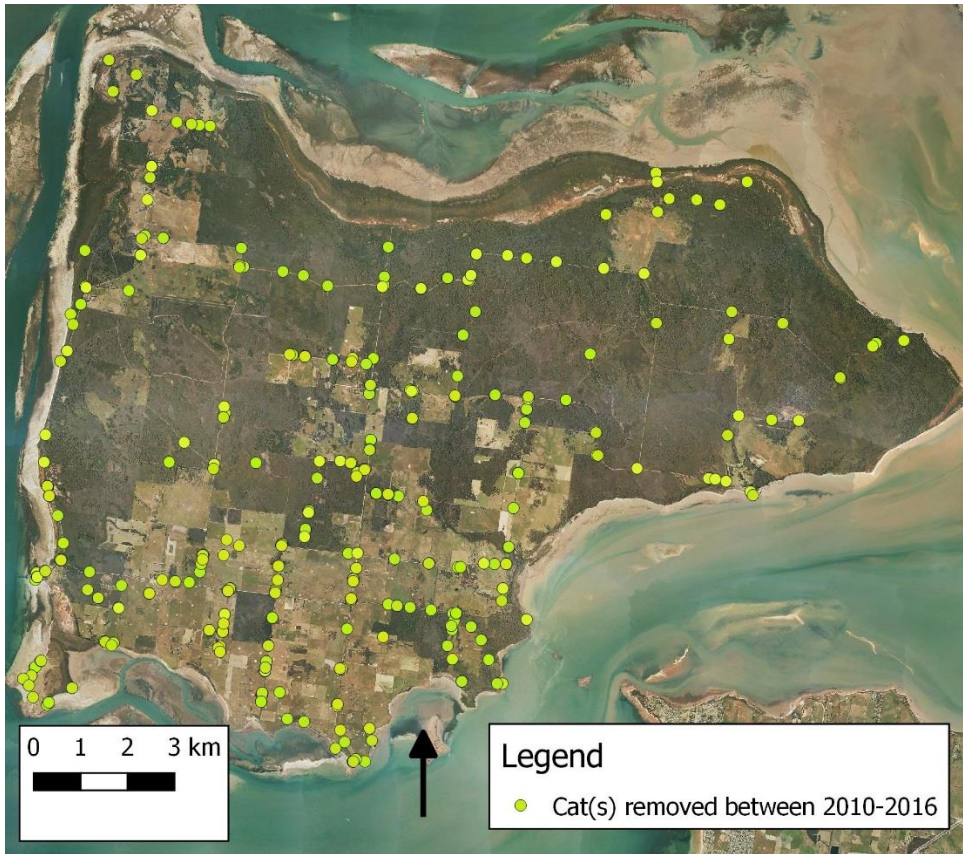
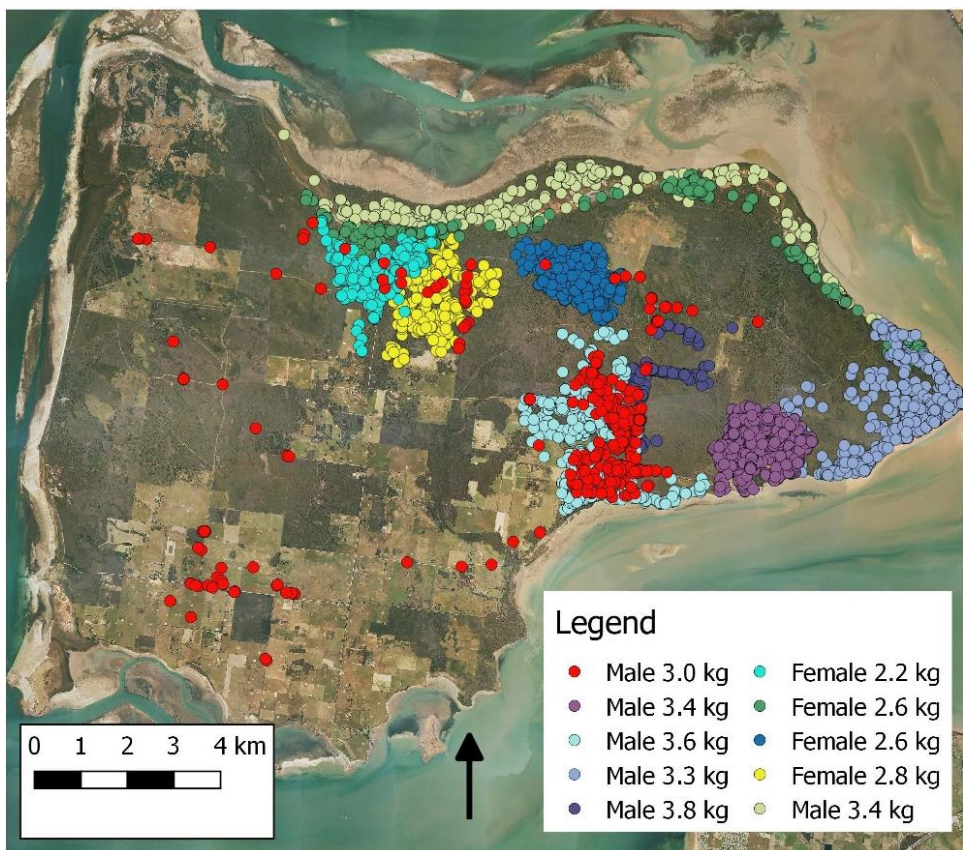**Figure 1. Sites of cat captures on French Island 2010-2016.**

Figure 2. Locations used by feral cats fitted with GPS radio-collars in 2008.

Cat prints have been frequently observed on beaches, such as Albions, Spit Point, Fairhaven, Rams Island, etc. where cats forage along the high tide line as well as access seabird roosts. Parks Victoria staff have reported observing cats and/or footprints using the mangroves on northern coast and through the isthmus to Tortoise Head (T. Easy and A. Ledden, pers. comm.). Cats have been routinely trapped on Tortoise Head with nineteen cats removed by Parks Victoria between 2010 - 2016 (see Johnston, 2017).

A program to cat calculate abundance would benefit from use of multiple methods to establish a more accurate estimate. Use of a single technique is more prone to error or bias reflecting device avoidance or seasonal changes in behaviour. A program to monitor change in the cat population must necessarily be sufficiently sensitive to detect cats in all areas of the island throughout the term of the project, i.e. during the control and surveillance phases. The use of multiple tools to monitor cat presence on French Island will contribute to a more robust dataset and demonstrate progress towards project objectives.

The baseline is ideally measured prior to the commencement of management activities for the invasive species. It provides a snapshot of the current condition of the 'asset' and offers a simple metric that progress towards operational objectives can be measured against. It is therefore of interest to project administrators and funding bodies that are required to deliver the greatest environmental outcome for the available financial resources.

The removal of feral cats from the island is expected to reduce the predation that native wildlife populations experience. Disease impacts associated with *Toxoplasma gondii* infection should also be expected to decline as the reproductive cycle of the parasite is broken. However, the demonstration of 'recovery' in wildlife and livestock during an invasive species removal project can be complicated by other factors. These may include climate-related factors (especially rainfall), fire events, disease, physical barriers (including cleared vegetation) as well as life cycle factors for the wildlife species along with the impact of natural predators.

In addition, the behaviour of all animals in the system should be expected to change as the project progresses. The monitoring program needs to remain sensitive to this as it has an obvious impact on the control effort required to capture the last few cats. In the latter stages of the cat removal program on Dirk Hartog Island (Western Australia), both adult and sub-adult cats exhibited long distance ranging presumably in search of mating opportunities placing lesser emphasis on the maintenance of a territory.

The proposed monitoring tools recommended for use on French Island involve cameras, scat detection dogs and hair snares for collecting DNA. Accurate data management is critical of recording of removed cats (via trapping and shooting) along with incidental observations. Additional techniques are also proposed that will encourage community engagement with the program.

Cat Monitoring Techniques

Cameras.

Trail cameras are commonly used for monitoring of wildlife species globally. Originally designed for the recreational hunting market, they are now an essential tool for wildlife managers that provide a minimally intrusive method of monitoring a broad range of species, i.e. both the target and non-target species. They often photograph interesting behaviours, encounters between different species and predation events (Figure 3).

Figure 3. Cat predation of a Lewin's Rail (*Lewinia pectoralis brachipus)* photographed on Tasman Island, Tasmania (Sue Robinson, DPIPWE).

Cameras require some basic understanding of their method of operation in order that best results are achieved. Camera sites should be prepared during establishment and regularly maintained throughout the program to provide the most efficient installation for collecting the data. The camera instruction manual should be carefully reviewed with particular reference to the various configuration options and learning about the 'trigger zones' that apply to the particular camera in use (Figure 4). Pruning vegetation at the site, both in front and behind the camera, that will cause false triggers will also improve the efficiency.
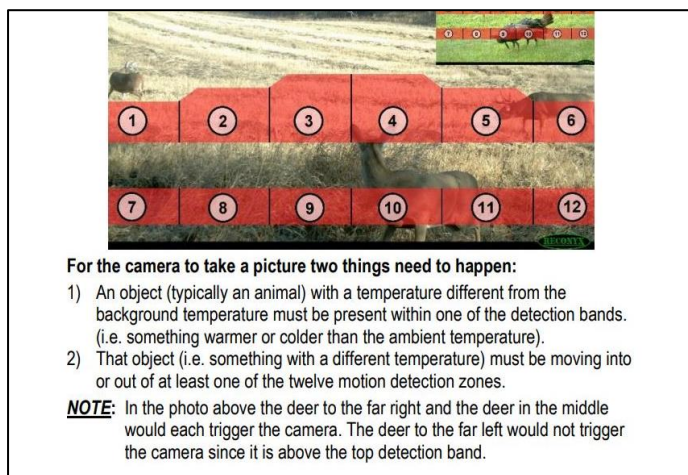

Figure 4. Excerpt from Reconyx camera manual showing trigger zones.

The cameras should be mounted horizontally, as opposed to vertically or angled 45°, as this allows for a greater field of view and a trigger zone of predictable shape. A plastic tent peg and stainless-steel bolt, washer and wingnut provide a robust mounting mechanism at a height suitable for feral cats (Figure 5). Cameras should be sited to allow for greatest detection of cats as well as other species that use the track alignment – the detection of wildlife species on these cameras will contribute to the monitoring of their abundance. Cameras should be operated continuously. The 'Scrape' setting in Reconyx cameras (Reconyx Ltd, Wisconsin, USA) takes five photos every detection and continuous operation.

Figure 5. Typical hardware used in a camera installation for feral cat monitoring.

Cameras on French Island should be set along existing access tracks. Cats are known to utilise these alignments and it is highly unlikely that there are cats that will remain within dense vegetation on the island once they attain dispersal age. As such, there is little to be gained by creating tracks into dense vegetation for the purposes of establishing a camera site. In fact, this may well be counter-productive in that it creates an entry point and track that supports hunting for cats into the 'interior' of the vegetated area.

At most of the suggested sites, the width of the tracks is too large for cameras to monitor the entire area span. It is recommended that cameras are positioned to survey the vehicle track alignments and use the unslashed vegetation as the 'background'. Cats will use the worn pad of the vehicle track as well as the vegetated edge so it is preferable to survey both of these areas whenever possible. Native fauna will also utilise the edge and cameras will contribute useful presence data on species such as long-nosed potoroos (*Potorous tridactylus*) and birds in these areas. Aiming of the camera in a southerly direction, where possible, will reduce the number of photos that are triggered by the sun rising.

Cameras may be equipped with a lure or left as is. A food lure should <u>not</u> be used as this will decay and attract attention from corvids, invertebrates, etc. which will reduce attractiveness to cats. A ~2 mL amount of real cat urine is known to be attractive to cats at camera sites. Evaporation can be reduced by using a small vial and water crystals. Lures sourced from other feline species, such as

bobcat (*Lynx rufus*) and lynx (*L. canadensis*) are commercially available but are not recommended in roles to detect *Felis catus*. Camera lures may be cycled to keep the site 'novel' by alternating the lure with an audio lure, such as the Feline Audio Phonic (Westcare Incorporated, Nedlands, WA), or visual lures including feathers or tinsel.

Locating cameras on track alignments simplifies the servicing of cameras but does also increase the chance of vandalism and / or theft. Interference, vandalism and theft of cameras is commonly reported globally (Meek, 2017) and there is some potential for this also on French Island given the proposed locations and visibility of the devices. However, the number of visitors and limited transport alternatives to the island should reduce tampering issues. There is currently little that can be done to reduce the loss of data and devices from a determined thief. Simple deterrence measures can include the use of a ground anchor to secure the camera to the site (Figure 6). The recommended camera model, Reconyx HC600, has a coded lock-out function which disables the camera functionality if it is tampered with, rendering it useless to a thief, but it does not stop the theft or loss of data. Engaging with the French Island community by involving local residents (school students, employing local labour), for example will assist with outreach and ownership by the community. Cameras can also be damaged by wildlife species, i.e. corvids pecking lenses, and also natural events such as fire. As such, cameras should be viewed as a depreciating asset that is subject to considerable wear and tear. Devices placed in exposed coastal locations are also prone to corrosion of sensitive components.

Figure 6. Simple cable and ground anchor used to deter camera theft on Dirk Hartog Island.

Cameras are not benign or 'covert' devices – they are readily detected by cats, along with many other species which respond with either investigatory or avoidance behaviour (Meek *et al*., 2014). It is not known what the cats are detecting, whether it be the sound of operation, the infra-red array, the square shape, or the smell associated with the site. Infrequently, cats have been observed, via footprints, deviating off track alignments multiple times to avoid camera sites and then re-joining the track a short distance beyond (C. Tiller, pers. comm.). Few tracks on French Island are sufficiently sandy to hold prints and as such this camera avoidance behaviour is likely to go undetected. Nonetheless, this behaviour must be acknowledged when drawing conclusions from photo databases. Absence of detections does not necessarily indicate absence of presence – thus a network of appropriately spaced cameras that are maintained over long duration will provide higher confidence in the results achieved. Greater statistical power can be achieved from cameras when two devices are present at each site as this improves the ability to photograph individuals from two sides which aids in 'recognition' of the individual.

Identification of individual cats may be possible based on differing pelage patterns (Bengsen *et al.,* 2011) but there are several potential sources of error that confound the use of cameras to determine the actual cat abundance in a site. This can be a time consuming task. The use of black light flashes (infra-red) on cameras leads to lower quality images for evening photos which often leads to motion blur (Figure 7). Cameras can be purchased with white light flashes to improve the photos but will be potentially more aversive to animals. The presence of black-coloured cats within the population limits differentiation of individuals, although some patterns may be observed under black light flash.

Figure 7. Black light flashes frequently leads to motion blur but can reveal patterns in black pelage.

It is recommended that camera servicing, involving lure change should be undertaken to suit project requirements. During the pre-baiting, post-baiting and follow-up trapping phases it may be preferable to service cameras on a monthly cycle. This permits ongoing feedback to trapping crew. However, the routine may be less frequent during the surveillance phase to a seasonal approach, i.e. four times per year.

An array of cameras, spaced at 1 per 2 km^2, is recommended for cat and wildlife detection across the island (Figure 8). This spacing is based on GPS-derived activity data collected from feral cats in a 2008 study as well as studies at other island sites (Algar *et al.,* 2011). Importantly, each cat has at least one camera within in its home range and should therefore be detectable (Figure 9). These activity data were collected at a time that the cat population would be expected to have maintained relatively stable home ranges. At this time, the cats were observed to have typical home ranges during the data collection period of between 2.4 and 28 km^2. As the eradication program progresses, it should be expected that breeding age animals will range further in search of mating opportunities. Detection of cats will become increasingly infrequent as the population decreases. Although, an attractive lure, such as cat urine, supplied at camera sites will remain interesting for cats as they range around the island looking for mates with established territories. This network will be sufficiently sensitive to detect cats throughout the term of the project.
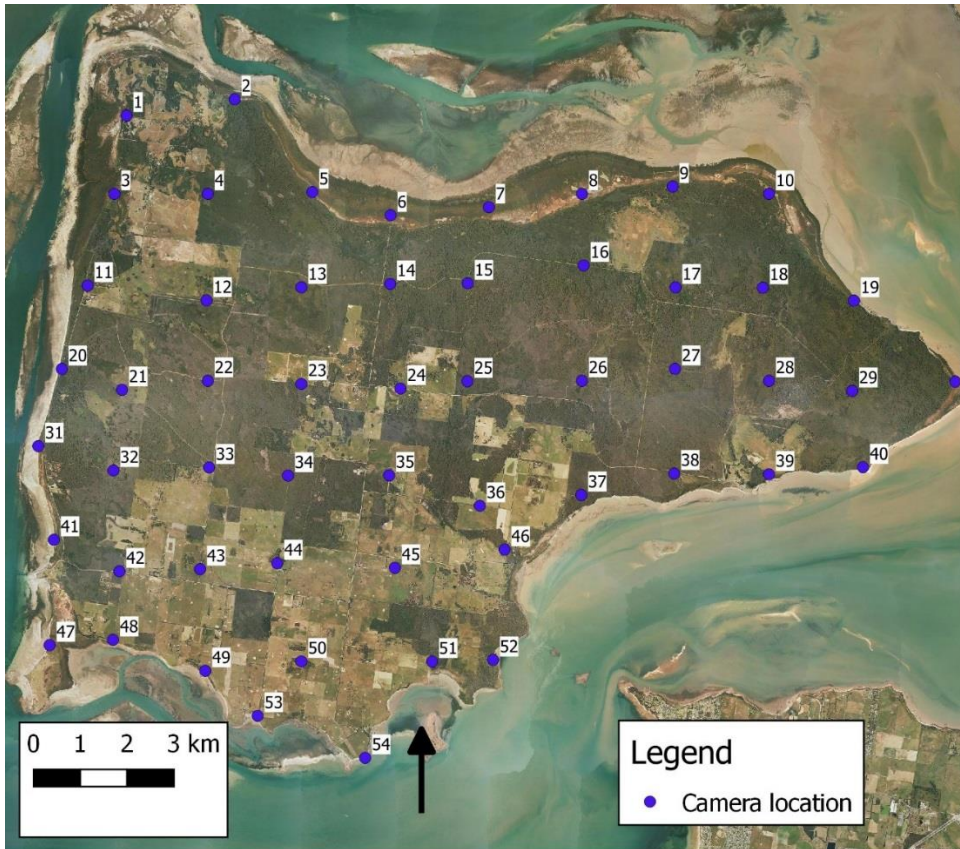
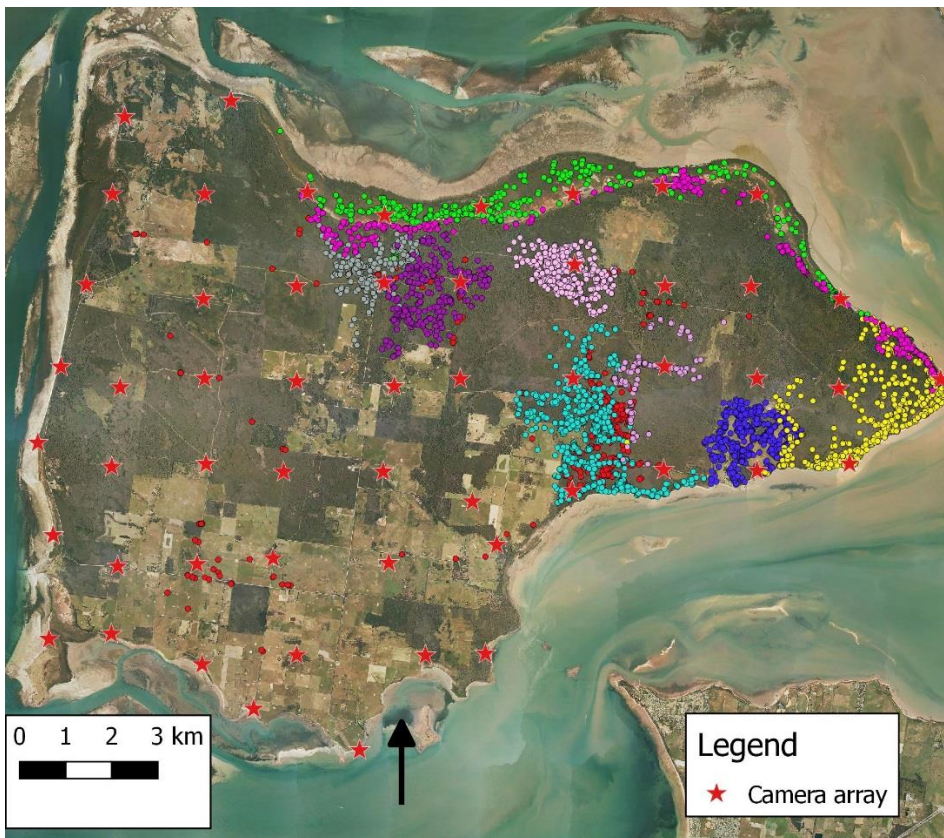**Figure 8. Recommended camera array for feral cat monitoring**

Figure 9. Proposed camera array contrasted with 2008 feral cat GPS data.

Analysis of collected images should be undertaken as rapidly as possible to keep the workload manageable. Owned cats should be identified with control work undertaken to remove the feral and stray cats. A photo manipulation package such as Irfanview provides an efficient viewing media for preliminary scanning of photos. Databases such as CPW Photo Warehouse or Camelot can be then used to manage and analyse datasets. The use of these software packages will assist in calculating detections of all target species (both cats and wildlife) that inform the progress towards the operational objectives.

Photos of people and / or vehicles should be deleted to comply with privacy requirements. A greater number of NiMh batteries and SD cards, suggest x1.5 the camera fleet requirement, should be purchased to facilitate efficient changeover / recharging procedures.

Detector Dogs

Given the track surfaces on French Island will generally not hold cat prints, then alternate techniques are required to add confidence to the progression towards eradication. The collection of cat scats will form a useful technique to contribute to the overall project dataset. Cat scats are physically different from scats of other species present on French Island, other than domestic dogs which may be quickly eliminated from the collection if the dog had had been fed a commercially prepared diet. Scats should be collected by project staff and labelled with the location and date. The scats should be stored frozen in labelled bags and may be subsequently used for dietary analyses. It is possible to use scats for genetic identification of individuals but this is generally limited to fresh scats.

Scats can be reasonably readily collected when there is an abundance of cats by observant walkers along track alignments (M. Johnston, pers. obs.). However, the task of locating scats will become increasingly difficult as the cat population is reduced. In order, to standardise the collection of scats and ensure that as many scats as possible are collected then the all scats surveys should be aided by trained detector dogs. Dogs are being increasingly used in Australia to support environmental research projects given the sensitivity of their olfactory senses and desire for reward (Johnston *et al.*, 2016). Detector dogs do not pursue their target species but are rather work an area seeking the target, in this case, scats. When located, they adopt a 'focussed response' seated posture to indicate the target to the handler (Figure 10). The dog is then rewarded with a favoured toy for a short period before continuing to search.

Figure 10. Detector dog sitting in the 'focussed response' position where a cat scat was located.

French Island has in excess of 200 km of vehicle track can be readily accessed throughout the public land estate along with ~75 km of coastline. Cats are known to forage along the coastline to access the food resources. The use of detector dogs and sign searches (footprints, scats, kills) will be effective at identifying cat presence in in these areas. A series of transects should be nominated in consultation with the dog team and then searched seasonally throughout the project with each transect walked once per season. Each seasonal collection, i.e. four surveys per year, would form an index of scats that could be scored throughout the project with the expectation that that the number of scats collected will decline towards zero assuming equal search effort between surveys - with the exception of areas surrounding properties that maintain owned cats.

An appropriately trained dog team should be contracted to conduct this work throughout the term of the active control project. This could be arranged as tender for the conduct of works throughout the project or via a daily charge-out rate. A longer-term contract is preferable as this contributes to maintenance of the dog team and consistent survey effort. They can then subsequently contribute, as an independent organisation, to the review and declaration of eradication success. Dogs and handlers must both wear GPS loggers so that individual search effort can be tracked. Pongo, i.e. blended cat faeces and urine, used at trap sites should always be collected when the trap site is removed to reduce false positives that will distract the dogs.

The conduct of scat searches in an area that has recently been baited does constitute a serious hazard to working dogs. This hazard could be mitigated by use of two methods. The first being to insist that working dogs wear muzzles while within a bait cell. This does not appear to hinder the dog's ability to work as the dogs used on Tasman and Dirk Hartog Islands were always muzzled when out of their pens. The second approach is to encourage the dog handlers to train their dogs to avoid consuming baits by use of aversive stimuli in non-toxic baits.

Use of a PAPP-based poison bait, such as Curiosity®, will provide an improved opportunity for recovery of accidentally poisoned dogs through use of rapid-acting emetic and/or antidote, i.e. Blue Healer®. Other hazards to dogs, such as snakes, can be minimised by undertaking the scat searches during the early morning (0300 – 1100 h). This technique was used successfully in the Dirk Hartog Island surveys over three seasons and also allowed the dog handlers to simultaneously conduct spotlight surveys using high powered head torches.

DNA-based identification of individuals

The use of a non-invasive hair snare has the best potential for estimating actual population size. The 'Sticky Wicket' technique uses three timber stakes situated at the end of a 'channel' that runs parallel to the direction of the track (D. Algar, pers. comm.). The stakes are pressed into the ground so that they are ~60 cm high and positioned in the ground at an angle so that they spread out as they rise, being 7 cm apart at the base and 12 - 15 cm apart at the top. Placing the posts in such a manner presents less of a physical barrier to animals so that they will be more willing to enter the channel. The stakes are covered with double-sided adhesive tape (Stylus, 40 mm '740') to capture hair as the cat walks through the channel (Figure 11). Collected hair is removed with sterilised forceps and sealed inside a paper envelope. This is then placed within a ziplock plastic bag and stored in a freezer to reduce DNA degradation.
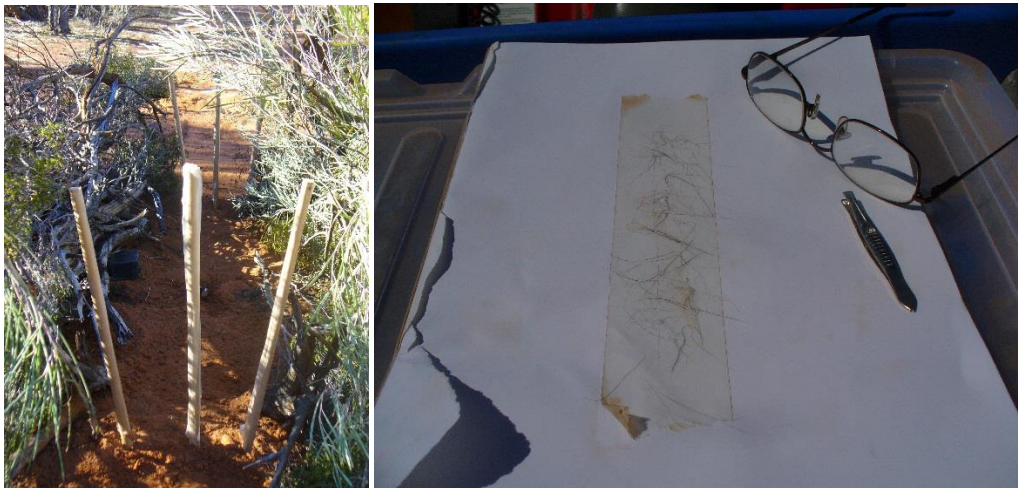

Figure 11. A walk-through 'Sticky Wicket' hair snare and collected hair (Neil Hamilton, DBCA).

These should be installed at a similar spacing as per cameras to create a network of monitor tools that alternates between the two methods every kilometre of track (Figure 12). The 'Sticky Wickets' only need to be operated once or twice annually depending on project reporting arrangements, although this technique may also be used as a proxy for monitoring baiting efficacy if the use of VHF tracking collars is not supported.
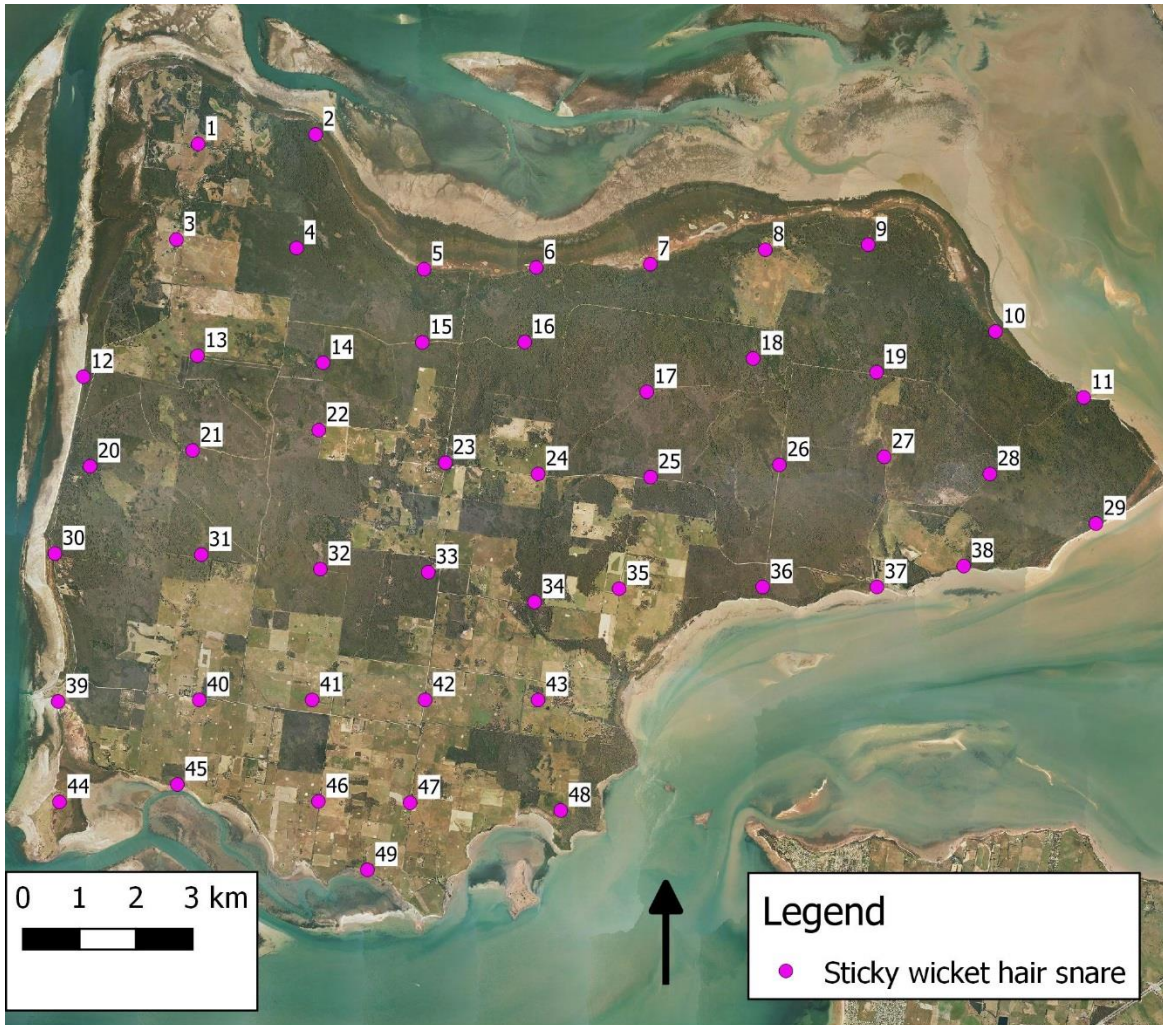
Figure 12. Recommended locations for 'Sticky Wicket' hair snares.

Capture of hair from multiple cats on the same tape will complicate analysis of these samples. Each site should therefore be visited daily.

DNA can be sampled from domestic cats by use of a mouth swab. Collection of DNA from cats across the island can also be used to look at relatedness between individuals as well as detect the arrival of new animals into the population. A relationship needs to be established with a laboratory capable of processing cat DNA samples.

Incidental observations

The French Island community, including skilled visitors such as the Friends Group and Wader Study Group, should be encouraged to report all sightings of cats to project staff or alternatively log the sighting on a register such as Feral Cat Scan or a locally managed equivalent. Typically, caution is required during the interpretation of community derived data due to the unknown reliability of data (i.e. review the feral cat reports in urban Melbourne on Feral Cat Scan), however, this is less likely to be an issue for use on French Island other than for observations of owned cats. While the incidental observation data will be biased towards the freehold areas of the island, they will contribute a useful data source. At the time of report preparation, there is only one cat sighting recorded on the national database (Figure 13). Only basic details need be recorded for incidental observations, namely; date/time, colour, age class (adult / kitten), location (GPS). This information should be stored in an active database, geographic information system or software application such as *Fulcrum*

where the data can be reviewed. The sightings data can be used to inform control crew (trapping, shooting) as well as observing trends in detections over time.

Figure 13. 'Feral Cat Scan' reported observations for French Island (Nov 2017).

Capture records.

Accurate recording of cats removed from the island through trapping and shooting form a critical dataset. Similarly, owned cats arriving or leaving the island permanently should be part of the control effort as these data are integral in reporting the success of the program. Photos, morphological details and DNA samples should be kept. The carcasses may be retained for other studies such as diet, parasite loads, etc. Back-up copies of the project data should be made regularly.

Capture records for non-target wildlife species should also be managed in the same database as analysis of this dataset can indicate trends in population abundance. Further information and a template for data recording is provided in Appendix 1.

Confirming eradication

The purpose of investing in monitoring is to document the progress towards project objectives. The anticipated decrease in cat detections over time from each of the monitor tools will increasingly lead to nil detections. A two year period is commonly used as the term of the surveillance period after which 'eradication' can be confirmed (Parkes *et al*. 2014). During this period, the various monitoring techniques are undertaken with the expectation that no detections are made. However, a rapid response is necessarily made to investigate and remove any cats detected. It is essential that operations crew and project administrators remain committed to the successful outcome of the project objective during this time.

Biostatistical advice, from people with expertise in species removals from islands, is warranted throughout the project to assist with reporting and overall project monitoring towards the objective. The timing of this proposed work on French Island coincides with a project funded by the Centre for Invasive Species Solutions that seeks to develop a straightforward software interface for field practitioners that will provide a near real-time analysis of data throughout the eradication program. Preliminary discussions with the project group have suggested that collaboration could deliver mutually beneficial outcomes.

Removal of domestic pet species, such as cats and dogs (*Canis familiaris*), from populated islands is more complicated than on unpopulated islands. The proximity of French Island to the mainland allows for relative ease of access. Sexually entire cats may be brought onto the island at any time. It will become a responsibility of cat owners to adhere to Responsible Pet Ownership guidelines (RSPCA, 2017) and this may be fostered by other members of the French Island community.

Monitoring of baiting success.

The simplest method to assess the proportion of the cat population that was removed during poison baiting programs is to capture and fit radio-tracking collars to a proportion of feral cats within the bait cell. Capture and fitting radio-collars should be undertaken several weeks prior to baiting as this allows the cat to resume pre-capture behaviours (Figure 14). The status of collared animals (i.e. alive / dead) must be confirmed the day prior to application of baits. The status can be confirmed remotely using VHF radio tracking techniques. Daily status checks can then be undertaken for ~10 days to determine the status of the sample population after baiting. The proportion of cats that die as a result of the baiting program is used as an analogue for the percentage reduction of the entire population within the bait cell. Additional information on the ranging behaviour can be acquired by fitting GPS radio-collars. This information is useful in defining the activity of cats at the time of baiting and inform whether surviving cats were within the bait cell in the days immediately following baiting, i.e. when baits were attractive and palatable. Note that it is uncommon to encounter dead cats after a baiting program unless they were previously fitted with a radio transmitting collar.

Trapping must be undertaken without the use of food lures to avoid bias of the study population towards individuals that are more likely to consume carrion / bait. Traps should be placed within the core of the bait cell to increase the probability that the collared animals will remain within the bait cell. People involved in this work need to competent in trapping, sedation techniques, handling and fitting of radio-collars to feral cats. This work requires preparation of permits for Animal Ethics Committees, with the proposed work also reviewed by DELWP and DEDJTR under Wildlife Act, National Parks Act and Prevention of Cruelty to Animals Act. At the time of preparation of this report, it is expected that a regulatory block exists that would complicate this style of work relating to the apparent 'abandonment' of trapped feral cats.

Figure 14. Release of a radio-collared cat as part of Curiosity® bait efficacy monitoring study.

Cats that survive a baiting campaign can usually be readily recovered using VHF guided hunting. This procedure requires two people, one to locate the cat using VHF tracking while the shooter is called in when the cat can be approached sufficiently close to obtain a clear shot. Alternatively, a delayed-release toxic device (Tick-Tock, Scientec Research Pty Ltd, Warrandyte, VIC) could be implanted in the collared cats. These devices are formulated with a pharmaceutical coating that degrades at a pre-determined date and then releases the poison (M. O'Donoghue, pers. comm.).

Domestic cat GPS.

The advent of cheap GPS logging devices has facilitated numerous studies into the ranging behaviour of owned cats. These are being increasingly being undertaken as citizen science projects with the processing of data undertaken by a local organiser. The devices are usually fitted to a pet cat harness and are priced at ~$90 each. The accuracy of data sourced from these cheap units is suitable for understanding the basic habits of owned cats (Figure 15). The batteries are sufficient to operate the GPS devices for 3 - 5 days depending on the logging interval selected but can be readily recharged for longer operation.

The community, via school students or junior Landcare, might be interested to fit these collars to cat(s) that on the island. Very limited financial and logistical support would be required to set up a local project that uses these devices. The data collected could be used to educate students as part of STEM subjects as well as the broader island community about where owned cats roam. The CatTracker (South Australia) project has a comprehensive website, including resources for teachers, that describes the use of these devices (Roetman *et al.,* 2017). This study involved 443 cats that had worn the GPS device for at least five days resulting in a range of learnings for both the study organisers and the owners of the cats. Phillip Island Nature Park is also supplying these devices to

interested local residents to better understand the behaviour of owned cats and simultaneously involve community members in the project (F. Gigliotti pers. comm.).
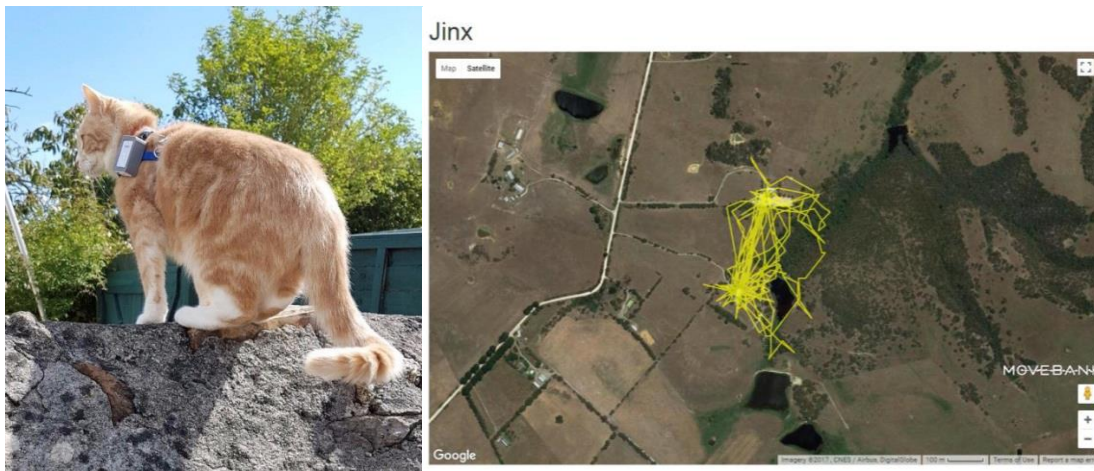

Figure 15. An owned cat wearing a GPS harness and example data set (Roetman *et al.* 2017).

Impact on Agriculture

The impact that cats have on wildlife species via predation is broadly understood and there are is some support for mitigation of these impacts in Victorian state legislation. Cats also cause impacts on wildlife by spread of infectious disease, such as *Toxoplasma gondii*. Cats are an obligate host in the life cycle of *T. gondii,* a parasite that causes severe disease in mammals and birds, both domestic and wildlife species. At least two of 17 Eastern Barred Bandicoots (*Perameles gunii*) released on French Island in 2012 became infected with toxoplasmosis and died (Groenewegen, 2015).

However, impacts associated with cat / livestock interactions on agricultural enterprises are infrequently discussed despite the cause of these impacts being known for decades. Sarcocystis is another parasite that has no immediate impact on sheep health but causes cysts that results in downgraded carcasses at slaughter. Feral cats cause substantial economic losses sheep graziers on Kangaroo Island (South Australia) through the spread of sarcosporidiosis and toxoplasmosis (Natural Resources Kangaroo Island 2015). Some Kangaroo Island producers have estimated a 65% reduction in the value of their meat through the spread of sarcosporidiosis annually. The extent to which these diseases impact on grazing enterprises on French Island is not known.

Zoos Victoria are investigating the prevalence of *T. gondii* on Phillip and to a lesser extent French Island (K. Adriaanse, pers comm.). Pending interest from graziers, it would be possible to undertake a project that examines seroprevalence in sheep on French Island. Blood samples would be taken to investigate presence of *T. gondii* antibodies. This could also involve collection of aborted foetuses, neonates, placenta and analyse them for presence of *T. gondii* DNA. This latter work would be more involved as it necessitates rapid detection of abortions and collection of carcasses but would be indicative of a toxoplasma-induced abortion. An assessment of the degree of *T. gondii* infection within the cat population could be made by also analysing cat scats and/or the soil directly underneath them for presence of oocysts.

Rabbits

Rabbits (*Oryctolagus cuniculus*) form a dietary staple for cats throughout Australia (Jones and Coman, 1981) and it is expected that there will be concern within the community that rabbit populations will increase in response to the progressive removal of cats. As rabbits directly impact on agricultural enterprise via competition for pasture, damage to assets (i.e. pasture, dam walls) then the project should attempt to index the rabbit population seasonally.

Replicated spotlighting surveys on pre-determined transects will provide a satisfactory method for this. The guidelines for standardised spotlight surveys should be adopted (Mitchell and Balogh, 2007). These include transect marking with reflectors, similar time of operation, vehicle speed and data recording. With respect to French Island, the surveys should be undertaken quarterly and repeated over 3 - 5 nights of suitable weather per session. The routes chosen for the rabbit surveys will benefit from access to private property given that much of the National Park is not suitable for spotlighting due to height of vegetation. Discussion with landholders will be required to negotiate access to sites for the conduct of this work. As surveys will need to be conducted throughout the year, an All Terrain buggy (Side by Side) might be a preferred operating platform given the reduced damage that these vehicles create on wet pasture as compared to conventional 4WD vehicles.

Weather, especially rainfall, disease outbreak and active rabbit control are several factors that should also be recorded alongside the rabbit monitoring as they have a direct impact on the rabbit population that can be counted during spotlight surveys. Ideally, rabbit control would not take place in areas proximate to the spotlight survey transects. Similarly, the presence and extent of dead rabbits indicating disease outbreak (Myxoma and RHD) should be recorded.

Rainfall is a key driver for the environmental productivity in natural systems and it is likely that this has a greater influence on rabbit abundance than predation pressure exerted by cats. However, this must be measured before claims of altered rabbit / cat balance can be argued. Meteorological data are currently collected at sites on and around French Island and these should be stored locally by the project. The Bureau of Meteorology maintains three stations in the region with two on Phillip Island (Rhyll and the Phillip Island Nature Park) as well as another at HMAS Cerebus naval base. Parks Victoria also has a weather station at the French Island depot. It is possible that there are other privately-owned weather stations situated on the island with data that may be accessed on request. Purchase of stand-alone weather stations that report their data autonomously to websites such as [Weather Underground](#) could be considered to collect data from sites around the island, such as Gartsides, Redbill Creek and BlueGums. Existing records should be collected and securely stored.

Cat urine collection

One of the significant resources used in monitoring and control of feral cats is urine and faecal material. The urine from all cats trapped on the island is currently collected and stored for trapping purposes. However, this 'commodity' is not commercially available but can be collected from cat shelters and supportive cat owners. It is recommended that a discussion be started with owners of domestic cats on French Island that might see a reliable supply of these critical resources being collected locally.

Ground-nesting birds

French Island supports rich bird diversity with over 240 bird species recorded (Quinn and Lacey 1999). Of these 240 species, approximately 130 breed on French Island and ~32% are ground nesting. In a recent study, Woinarski *et al.*, (2017) concluded that the likelihood of a bird species being killed by a cat was highest for birds restricted to islands, if their body mass was 60 – 300 g and if they nested and foraged on the ground.

The removal of feral cats from French Island is predicted to have a positive quantitative effect on the survivorship of ground-nesting bird species and their distribution. Ground-nesting birds can be divided into two groups—conspicuous and cryptic. Of the secretive (cryptic) ground nesting birds, three are listed under the Victorian Threatened Species Advisory List (Department of Sustainability and Environment Victoria, 2013); Australasian Bittern (*Botaurus poiciloptilus*) and King Quail (*Excalfactoria chinensis victoriae)* are classified as endangered, Lewin's Rail (*Lewinia pectoralis pectoralis*) is classified as vulnerable. Most sightings of cryptic ground-nesting birds are anecdotal, or presence is confirmed by reports of carcasses found due to cat predation. An example of these findings is Lewin's Rail. Reports of feral cat predation on Lewin's Rail on French Island (C. Chandler, pers. comm.) are consistent with the predation of Lewin's Rail on Tasman Island by cats (Figure 3), and the worldwide trend of a higher than average extinction rate of Rallidae species on islands (Steadman, 2006).

The more conspicuous ground nesting birds such as Purple Swamphen (*Porphyrio porphyrio*), Dusky Moorhen (*Gallinula tenebrosa*), Cape Barren Goose (*Cereopsis novaehollandiae*) and Masked Lapwing (*Vanellus miles*) are also potential key indicators of recruitment success or failure associated with cat predation. The body mass (weight) of these species is over 300g (Woinarski *et al.*, 2017) reducing their risk of predation by cats, however successful recruitment will be a key indicator for their chicks and eggs.

As feral cat numbers decline, recovery of bird species will be dependent on many factors including but not limited to life history, suitable habitat and current population status. If cat predation was the only limiting factor affecting a species with a low age to sexual maturity, recovery would be rapid (Robinson *et al.*, 2015).

Seabird species and migratory shorebird species are being significantly affected by many threats on migratory pathways and in breeding areas including feral cats. Ongoing monitoring of these species will continue by the Friends of French Island National Park (FOFI), Victorian Wader Study Group (VWSG), Parks Victoria and international partners. This report is aimed at monitoring terrestrial species.

Monitoring techniques for birds on French Island

Monitoring of bird species will not be limited to ground-nesting birds however some monitoring methods are guild / behaviour specific. All bird species observed will be recorded. Surveys will however, bias areas of existing high conservation value and potential value that include nesting records (Figure 16).

Figure 16. Heifer Swamp, French Island. Habitat for ground nesting bird species. Species known to inhabit Heifer and Little Heifer Swamp include Little Pied Cormorant (*Microcarbo melanoleucos)*, Black Swan (*Cygnus atratus*), Black-fronted Dotterel (*Elseyornis melanops*) and Dusky Moorhen (*Gallinula tenebrosa*).

Most conventional monitoring techniques to describe occurrence patterns and estimate population trends rely on observational data, and are well suited to large, widespread and / or abundant species. These observations are important for ecosystem monitoring and management, however this can lead to gaps in monitoring small populations, strict habitat specialists and highly cryptic species where an absence of observational records need not indicate actual absences. Cryptic ground-nesting birds such as quails (Phasianidae and Turnicidae), rails and crakes (Rallidae), bitterns (Ardeidae) belong to a group of notoriously cryptic species that fall into the latter category (small populations and habitat specialists). This group may be exposed to population changes that may be going unnoticed due to their cryptic nature. Threats such as changes in climate, reclamation of wetlands, inappropriate fire regimes and invasive mammalian species such as cats (Woinarski *et al.*, 2017; Garnett *et al.*, 2011) pose challenges to effectively monitor and infer with high confidence species absence. Locally, on French Island the population of ground-nesting birds is subject to seasonal environmental water, native and invasive predators and fire (wild and controlled). Methods that sufficiently survey all species or species-specific monitoring are therefore required. As cats pose significant threats to ground-nesting birds, specific indicators to monitor potential impacts and recovery are required.

We recommend implementing a combination of monitoring methods to;

 1. Increase the existing survey effort (i.e. FOFI, VWSG) temporally and spatially to result in a high detection probability of ground-nesting bird species.

2. Provide reliable, consistent and cost-effective monitoring by implementing novel techniques while still contributing to existing survey database protocols (e.g. BirdLife Australia, Atlas of Living Australia).

3. Reduce impacts of disturbance on species and habitat by using acoustic sensors and camera traps, in comparison to prolonged human survey effort and flushing surveys.

4. Enable high confidence when inferring absence, i.e. absence = absence rather than we did not look hard enough (high survey effort).

5. Quantitatively analyse control and monitoring phases of the cat program specifically targeting ground dwelling birds as an indicator (ground dwelling bird index).

Two hectare point surveys

Point surveys are a passive monitoring method (Bibby *et al*. 1992) recording all species seen and heard during a 20-minute period in 2 ha. A 2 ha survey is biased towards observing conspicuous and common species, inclusive of conspicuous ground nesting birds. These observations provide a significant monitoring dataset, representing bird assemblage and abundance. This is a standardised BirdLife Australia monitoring protocol, and data collected on French Island can continue to significantly contribute to the BirdLife Australia database and Atlas of Living Australia bird assemblage pre and post eradication of cats. These data would be in addition to the contribution of observations by the FOFI and VWSG.

Call-playback surveys

Call-playback surveys are used to elicit a response from a target species (Bibby *et al*., 1992). Most cryptic wetland bird species are detected primarily from their vocalizations (Conway and Gibb 2005; Watson, Znidersic and Craig, 2017). A call-playback protocol could be instigated at the duration of point count surveys at minimal cost. This would therefore mitigate bias on passive data collected prior to playback protocol. A 'stopping rule' (Watson, 2003) would be implemented if the species was detected prior to the call-playback to reduce potential impacts. AEC and NP permits would be required to undertake call-playback.

Acoustic Monitoring

Autonomous acoustic recording minimises the potential of biases associated with survey reliability affected by surveyor skill, calling behaviour of target species and weather conditions. Long duration acoustic monitoring is becoming an increasingly popular approach to extend survey effort, effectively allowing high resolution monitoring of multiple sites simultaneously (Farina and Gage, 2017).

An appropriately trained acoustic field technician should be contracted to conduct this work throughout the term of the active control and monitoring project, including the analysis. Deployment of sensors on a micro level will be based on prior experience and knowledge of sound propagation in different habitat structures, potential exposure of sensors to extreme weather conditions and call elements of target species (harmonics or simple structure). The subsequent contribution, as an independent organisation will provide measurable outcomes (ground nesting bird index) and data processing management and processes.

Acoustic sensors (autonomous recording units) passively collect data, reducing impacts on species behaviour and extending manual data collection capabilities over an increased temporal and spatial scale. No habitat modification will occur as placement will be on a metal stake approximately 0.50 - 1.5 m from the ground (Figure 17). The placement location will be inconspicuous however this does not guarantee tampering with or theft. Acoustic sensors will be pre-programmed to record continuous audio for their battery life of 10 days at a sampling rate of 24,000 Hz.

Figure 17. Acoustic sensor deployment.

The resultant accumulation of data ('big data') however, necessitates a reliable automated process for analysis and interpretation. In collaboration with Queensland University of Technology, a high-quality recognizer for Lewin's rail contact call "kek kek" is available and the group have recently identified species-specific acoustic signatures (Figure 18) in false colour index spectrograms (Figure 19) (Towsey *et al.,* in prep). Acoustic data can also be reviewed manually via audio or grey scale spectrograms. The high volume of data collected requires computers with sufficient power to process these data. There are currently no over the counter package that can detect species to the high confidence level of this group, nor are able to access the code for false-colour index spectrograms.

The false-colour index spectrograms will enable broad scale ecosystem monitoring as generated images use specific algorithm indices. These can monitor broad scale changes in bird, insect and amphibian vocalizations. Figure 18 illustrates the daily soundscapes and that some species can be identified by their unique vocalization 'signature'.
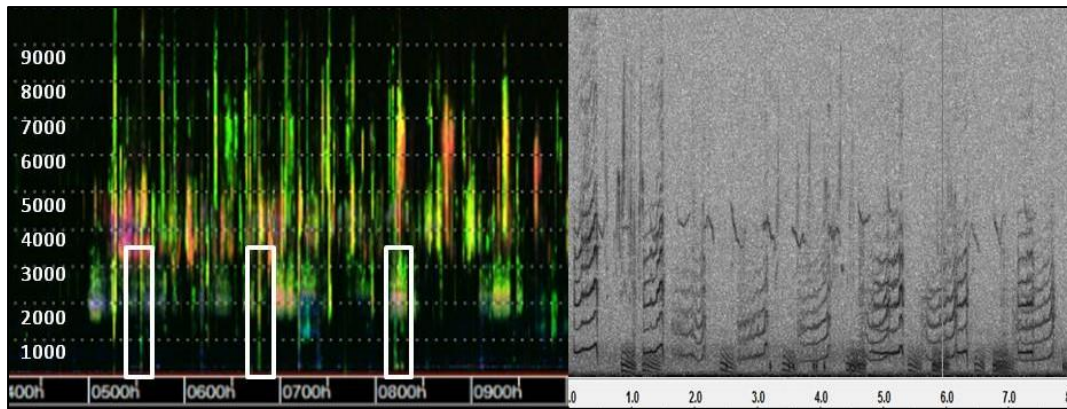
Figure 18. LDFC spectrogram (left), visualizing five hours of acoustic data and a grey-scale spectrogram (right) of 8 seconds duration of the 'grunt' and 'wheeze' vocalizations from the same time period. Lewin's Rail grunt and wheeze calls occur at 05:35, 06:48 and 08:07 (green vertical line in a frequency band approximately between 100 - 3500 Hz). In both images the X axis represents time and the Y axis frequency Hz.
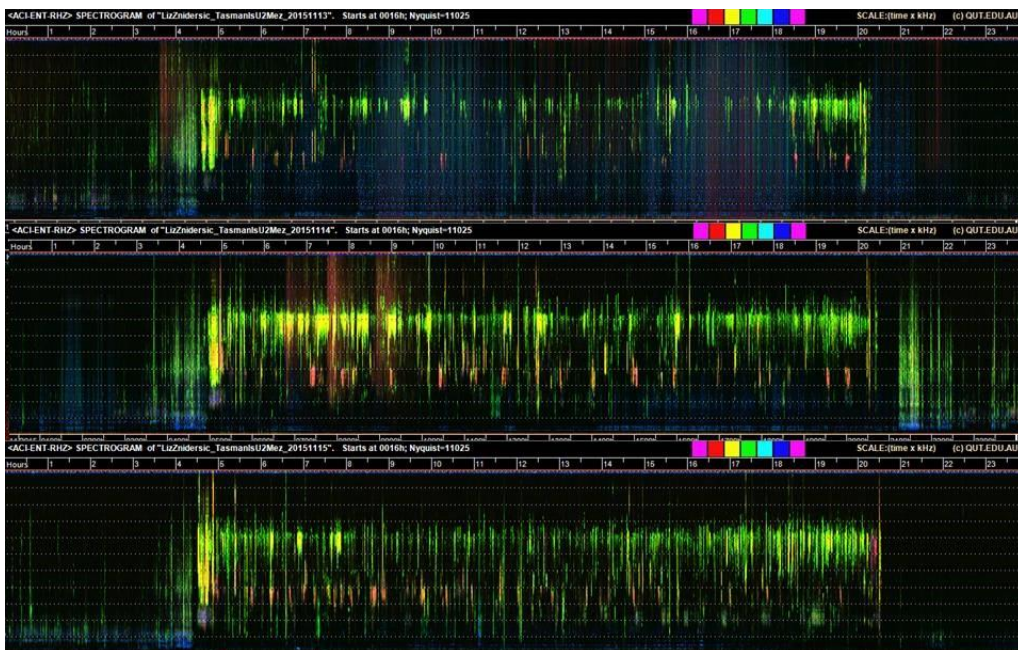

Figure 19. False colour index spectrogram showing three consecutive days of 24 hour acoustic recording (X axis showing 24 hour period, Y axis frequency in Hz).

Camera traps

A camera trap array is recommended to be divided among a sample of acoustic sensor sites each survey period. Cameras will be unbaited and strategically biased (non-uniform placement) to increase detection probability of target species (Znidersic, 2017; Meek, 2014b). Minimal or no habitat modification will occur as camera placement will be on existing animal thoroughfares and wetland margins. Cameras will be positioned low to the ground, on wooden or metal posts and in dense habitat (Znidersic, 2017).

Camera traps are of benefit to detect and monitor ground dwelling birds that seldom vocalise and to collect behavioural data (Figure 20). Similar procedures are recommended for analysis and storage of data as with 'cat cameras' described above. Analysis of collected camera trap images will be

undertaken as rapidly as possible during and after each site visit. This will identify presence of the target bird species, including recruitment and ongoing monitoring of these rarely documented events and provide assurance that the project is achieving the operational objective.
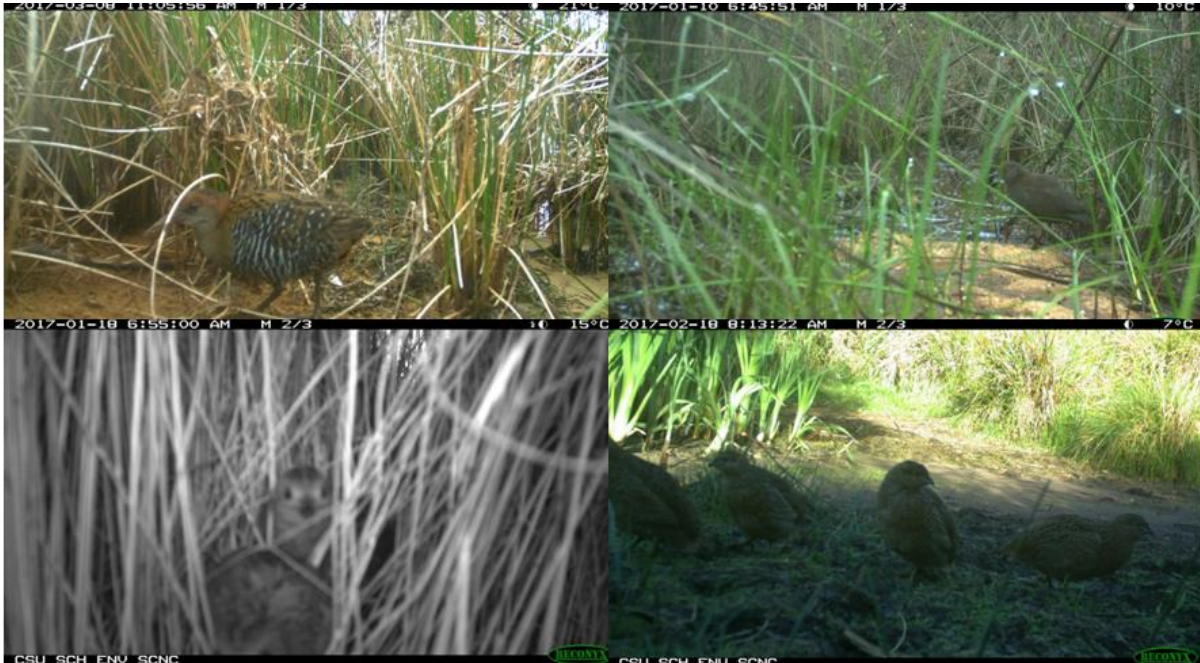

Figure 20. Camera trap images of Lewin's Rail (top left), Spotless Crake (top right), Brown Quail (bottom)

Roadside slashing surveys

Tractor slashing of grasses on roadside verges has historically flushed quail species (D. Stephenson and C. Chandler pers. comm.) on French Island. Although providing only fleeting glances of potential ground-nesting species, this could be of benefit identifying distribution of quail species. To harness this valuable data, we recommend facilitating a training session to provide information to assist with species identification, to distribute identification literature / diagrams and sighting record sheet / email correspondence details. The recording of observations would require a GPS (available on some smart phones) and correspondence with bird monitoring technician. Observers would be advised of disturbance issues affecting follow up monitoring. Monitoring of identified sites would be with low disturbance methods during the next survey by technicians.

Recommendations

1. Collect a baseline of monitoring data. A survey during the 2017/2018 (December 2017, January 2018) bird breeding season would be provide baseline data in the expectation that the cat eradication project will develop further throughout 2018. This survey would be

conducted over a ~10 days collecting 2 ha observations, acoustic recordings and camera trap images.

2. Implement a ground-nesting bird index. Prior cat eradication programs have not included detailed pre- and post-cat eradication fauna studies. French Island has the opportunity to implement this monitoring and provide a definitive record for comparison in subsequent years.

3. Monitoring locations
    a. Historic ground-nesting bird locations (Quinn & Lacey, 1999; O'Brien, 2006) and locations ground-truthed with similar habitat structure.
        i. 50 - 60 sites targeted
        ii. monitoring replicated annually at each site
        iii. Sites may change from draft plan due to rainfall and wetland water depth.

4. Monitoring protocol - control and monitoring phase with four surveys each year.
    a. 2 ha surveys and call-playback. 50 - 60 sites
    b. Camera traps. ~30 units. 10 units at 3 acoustic sites each survey
    c. Acoustic sensors. ~10 units. 10 days of continuous recording at each site (yearly acoustic data collected = 9600 hours)
    d. Roadside slashing surveys. Ongoing following training of machine operators.

Long-nosed Potoroo

A nationally significant population of Long-nosed Potoroo population are found on French Island (Figure 21). The absence of red foxes (*Vulpes vulpes*) and presence of long unburnt vegetation have been nominated as factors that have contributed to the security of this population (Frankham *et al.,* 2011). The University of Melbourne conducted studies of the Long-nosed Potoroo population on French Island between 2007 - 2011 that investigated a variety of ecological questions including distribution across the island, influence of fire history and reproductive patterns. Findings indicate that the French Island population has a low density but stable population (Frankham *et al.,* 2011). Potoroos are able to breed throughout the year but recruitment into the population is likely to limited by predation by cats and native predators, such as snakes and raptors. Resource limitations include clearing of vegetation that acts to create 'islands', preferred vegetation age and structure as well as food. Critically, drought, fire and vegetation clearing will act to influence population recovery. Potoroos prefer densely vegetated areas and contribute to soil and forest health through the excavation and consumption of hypogeal fungi (*ibid*). Several techniques were used to monitor for presence of potoroos with each requiring considerable labour inputs (K. Handasyde, pers. comm.). Trapping was conducted at seven sites with potoroos captured reliably at four of these although catch per unit effort was low (R. Reed, unpub. data). Hair snares were used but again detection of potoroos by these devices was low as they were monopolised by rodents. Counts of potoroo digs along 5 x 250 m transects were also undertaken on a seasonal basis through areas of known habitat. Copies of the method used by Reed have been accessed.

Figure 21. Long-nosed potoroo. (French Island Landcare Group)

Due to the requirement for significant labour investment in a dedicated potoroo monitoring program, it is recommended that a lower intensity method is used. An index of incidental captures is used to monitor population change over the project that this simply involves collating all trap and photographic captures and reporting these on an annual basis. There is also merit in re-establishing the foraging dig survey grids adjacent to the Parks Victoria depot as this appears to be the most productive site known on the island and provide a point of comparison against earlier data. The entrance to these transects should be monitored by cameras to determine whether they are used by cats.
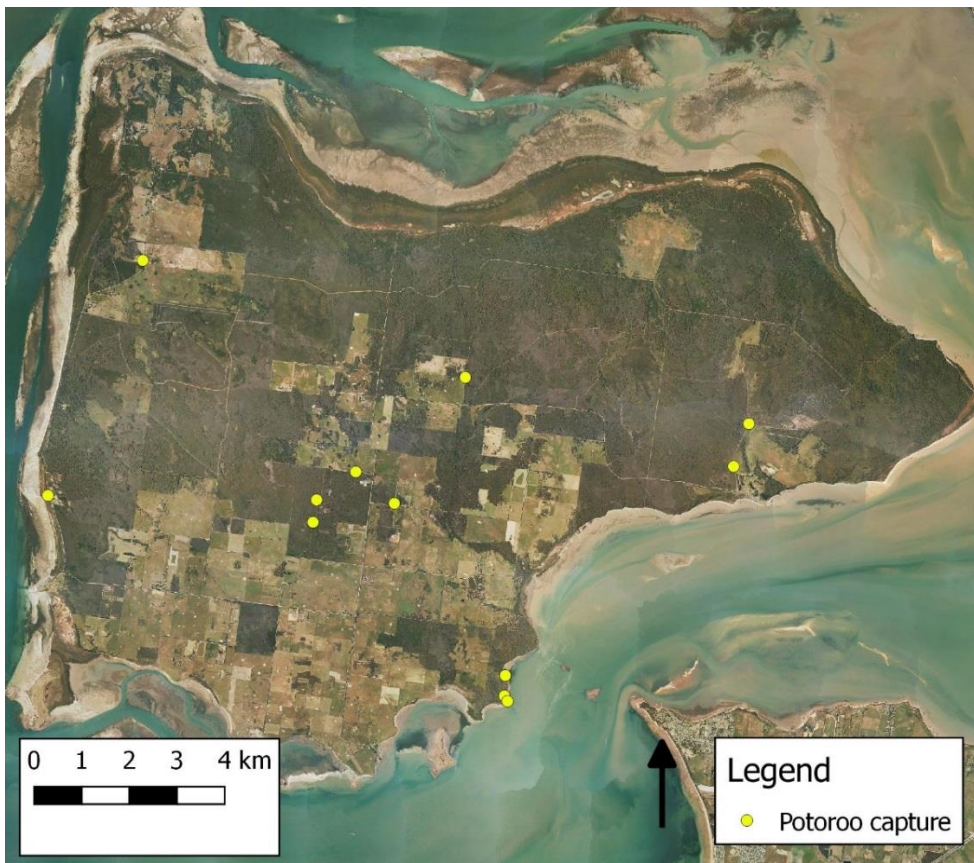

Fig. 22. Location of capture of Long-nosed Potoroo 2010-2016 during cat trapping operations.

Herpetofauna

The Victorian Biodiversity Atlas reports 10 skink, 2 snakes, 1 dragon and 7 amphibian species (see Appendix 2) inhabit French Island, of which the Growling Grass Frog (*Litoria raniformis*), Swamp Skink (*Egernia coventryi*) and Glossy grass skink (*Pseudomoia rawlinsoni*) are recognised as threatened species.

A series of pitfall trapping / drift fences and / or Elliott traps situated across the island in representative habitats, including on Tortoise Head, would provide a worthwhile dataset that could document the response of these species during the project. Alternative techniques such as use of cameras and active searches are considered less suitable for this project given that mark / recapture studies are not possible or that there are complexities associated with the field logistics.

Opportunity exists to undertake a dedicated herpetofauna monitoring component as part of this project. This would necessary be scaled to cover the island in order to accurately report the status of this guild. The most cost-effective method to achieve this is a student project such as a PhD study but may be conducted at a smaller scale by project crew.

Overall Recommendations

Species removal programs on islands require a dedication by all stakeholders involved to commit to the project objective. Scientifically robust monitoring techniques are necessary to document the progress towards the objective and ultimately demonstrate that eradication has been achieved. This report recommends that multiple techniques are utilised to monitor populations of invasive and native species in order to have confidence in the observations. The monitoring of wildlife species is necessary to document the achievement of the project, i.e. this is why the work is being undertaken. The focus of the project should remain on the recovery of wildlife species rather than simply on the 'body-count' of cats removed. Wildlife monitoring is frequently overlooked during species eradications on islands. French Island has an opportunity to undertake this work comprehensively and this should be initiated over the summer 2017/18 season in the expectation that the other elements of the project will develop into 2018.

Techniques to monitor the cat population should include island-wide surveys using cameras, scat searches and DNA- based tools as the minimum, along with accurate reporting of capture and observation data. The project would also benefit from undertaking additional techniques such as radio-collaring of individual cats prior to baiting and fitting owned cats with GPS devices. Engagement with primary producers will be advantaged by recording changes in rabbit abundance and determining whether cats are impacting upon their livestock enterprise.

Results from all facets of the project should be published in the scientific literature and relevant databases, such as the Victorian Biodiversity Atlas.

Acknowledgements

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Appendix 1. Sample data fields for French Island cat management program

Agency   PV   /   FILC

Trapper name _____   Trap open / closed

Date	Trap ID	GPS location	Species caught	Released	Cat						
					Database ID	Sex	Pregnant, Lactating	Weight	DNA	Photo	Comment
28/06/2017	TH1	349383 5748920	Silver Gull	Y							
28/06/2017	TH2	349248 5748464	Cat	N	PV1	F	P	3.4	Y	Y	
28/06/2017	TH3	349044 5748146	Cat (Domestic)	Y	LC17						Owner Name.

There may be other data fields that should be added to the template to record other samples collected such as whiskers, parasites, blood, muscle tissue etc. All cats should be allocated an individual identification number that should be copied across to labels on all sample vials. Cats removed via other means should also be recorded with the comment section indicating how the cat was killed.

Along with the above data set, I would suggest that a photo of both sides of the cat should be taken and stored in the database. A whiteboard can be used to record basic data such that the photo captures all the necessary information (see below). Currently, the EXIF data is used as the reference point but I would encourage the 'whiteboard-in-photo' approach to prevent data loss in cases where the EXIF data is not correctly recorded or transcribed between different software packages. The cat should be arranged such that diagnostic fur patterns are visible in the photo.

Example photographic record of cat.

Appendix 2. Victorian Biodiversity Atlas

Record of Species on French Island (February 2018).

Birds

Pomatostomus temporalis temporalis	Grey-crowned Babbler
Hirundo neoxena	Welcome Swallow
Petrochelidon ariel	Fairy Martin
Petrochelidon nigricans	Tree Martin
Zosterops lateralis	Silvereye
Rhipidura rufifrons	Rufous Fantail
Rhipidura leucophrys	Willie Wagtail
Myiagra rubecula	Leaden Flycatcher
Grallina cyanoleuca	Magpie-lark
Myiagra inquieta	Restless Flycatcher
Rhipidura albiscapa	Grey Fantail
Myiagra cyanoleuca	Satin Flycatcher
Pachycephala rufiventris	Rufous Whistler
Falcunculus frontatus	Crested Shrike-tit
Pachycephala olivacea	Olive Whistler
Colluricincla harmonica	Grey Shrike-thrush
Pachycephala pectoralis	Golden Whistler
Anthus novaeseelandiae	Australasian Pipit
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Coracina tenuirostris	Common Cicadabird
Lalage sueurii	White-winged Triller
Alauda arvensis	European Skylark
Mirafra javanica	Horsfield's Bushlark
Cormobates leucophaeus	White-throated Treecreeper
Acridotheres tristis	Common Myna
Sturnus vulgaris	Common Starling
Daphoenositta chrysoptera	Varied Sittella
Turdus merula	Common Blackbird
Zoothera lunulata	Bassian Thrush
Cinclosoma punctatum	Spotted Quail-thrush
Oriolus sagittatus	Olive-backed Oriole
Acanthiza lineata	Striated Thornbill
Acanthiza reguloides	Buff-rumped Thornbill
Sericornis frontalis	White-browed Scrubwren
Pardalotus striatus	Striated Pardalote
Calamanthus pyrrhopygius	Chestnut-rumped Heathwren
Acanthiza pusilla	Brown Thornbill
Calamanthus fuliginosus	Striated Fieldwren
Acanthiza nana	Yellow Thornbill
Acanthiza chrysorrhoa	Yellow-rumped Thornbill
Pardalotus punctatus punctatus	Spotted Pardalote
Petroica boodang	Scarlet Robin

Petroica rosea	Rose Robin
Melanodryas cucullata cucullata	Hooded Robin
Eopsaltria australis	Eastern Yellow Robin
Petroica phoenicea	Flame Robin
Petroica rodinogaster	Pink Robin
Microeca fascinans	Jacky Winter
Dicaeum hirundinaceum	Mistletoebird
Threskiornis spinicollis	Straw-necked Ibis
Platalea flavipes	Yellow-billed Spoonbill
Platalea regia	Royal Spoonbill
Threskiornis molucca	Australian White Ibis
Pelecanus conspicillatus	Australian Pelican
Egretta garzetta nigripes	Little Egret
Ardea pacifica	White-necked Heron
Ardea ibis	Cattle Egret
Nycticorax caledonicus hillii	Nankeen Night Heron
Ardea modesta	Eastern Great Egret
Egretta novaehollandiae	White-faced Heron
Botaurus poiciloptilus	Australasian Bittern
Cereopsis novaehollandiae	Cape Barren Goose
Chenonetta jubata	Australian Wood Duck
Tadorna tadornoides	Australian Shelduck
Anas superciliosa	Pacific Black Duck
Anas castanea	Chestnut Teal
Malacorhynchus membranaceus	Pink-eared Duck
Cygnus atratus	Black Swan
Anas gracilis	Grey Teal
Anas rhynchotis	Australasian Shoveler
Oxyura australis	Blue-billed Duck
Stictonetta naevosa	Freckled Duck
Biziura lobata	Musk Duck
Cygnus olor	Mute Swan
Aythya australis	Hardhead
Anser anser	Domestic Goose
Anas platyrhynchos	Northern Mallard
Thalassarche cauta	Shy Albatross
Thalassarche melanophris melanophris	Black-browed Albatross
Macronectes giganteus	Southern Giant-Petrel
Puffinus gavia	Fluttering Shearwater
Puffinus grisea	Sooty Shearwater
Fulmarus glacialoides	Southern Fulmar
Pterodroma lessonii	White-headed Petrel
Pelecanoides urinatrix	Common Diving-Petrel
Macronectes sp.	Giant-Petrel species
Puffinus tenuirostris	Short-tailed Shearwater
Pachyptila turtur	Fairy Prion

Halobaena caerulea	Blue Petrel
Phalacrocorax varius	Pied Cormorant
Microcarbo melanoleucos	Little Pied Cormorant
Phalacrocorax sulcirostris	Little Black Cormorant
Phalacrocorax carbo	Great Cormorant
Phalacrocorax fuscescens	Black-faced Cormorant
Morus serrator	Australasian Gannet
Chlidonias hybridus javanicus	Whiskered Tern
Sterna striata	White-fronted Tern
Sternula nereis nereis	Fairy Tern
Chroicocephalus novaehollandiae	Silver Gull
Stercorarius parasiticus	Arctic Jaeger
Larus pacificus pacificus	Pacific Gull
Sterna hirundo	Common Tern
Larus dominicanus	Kelp Gull
Hydroprogne caspia	Caspian Tern
Gelochelidon nilotica macrotarsa	Gull-billed Tern
Sternula albifrons sinensis	Little Tern
Thalasseus bergii	Crested Tern
Haematopus longirostris	Pied Oystercatcher
Haematopus fuliginosus	Sooty Oystercatcher
Vanellus tricolor	Banded Lapwing
Pluvialis squatarola	Grey Plover
Pluvialis fulva	Pacific Golden Plover
Charadrius bicinctus	Double-banded Plover
Charadrius leschenaultii	Greater Sand Plover
Vanellus miles	Masked Lapwing
Charadrius ruficapillus	Red-capped Plover
Elseyornis melanops	Black-fronted Dotterel
Charadrius mongolus	Lesser Sand Plover
Erythrogonys cinctus	Red-kneed Dotterel
Thinornis rubricollis rubricollis	Hooded Plover
Recurvirostra novaehollandiae	Red-necked Avocet
Himantopus himantopus	Black-winged Stilt
Cladorhynchus leucocephalus	Banded Stilt
Turnix varia	Painted Button-quail
Turnix velox	Little Button-quail
Burhinus grallarius	Bush Stone-curlew
Numenius phaeopus	Whimbrel
Limosa lapponica	Bar-tailed Godwit
Tringa glareola	Wood Sandpiper
Tringa brevipes	Grey-tailed Tattler
Calidris tenuirostris	Great Knot
Calidris alba	Sanderling
Gallinago hardwickii	Latham's Snipe
Arenaria interpres	Ruddy Turnstone

Philomachus pugnax	Ruff
Tringa nebularia	Common Greenshank
Calidris canutus	Red Knot
Calidris ferruginea	Curlew Sandpiper
Calidris acuminata	Sharp-tailed Sandpiper
Numenius madagascariensis	Eastern Curlew
Xenus cinereus	Terek Sandpiper
Actitis hypoleucos	Common Sandpiper
Calidris ruficollis	Red-necked Stint
Limosa limosa	Black-tailed Godwit
Coturnix ypsilophora australis	Brown Quail
Coturnix chinensis victoriae	King Quail
Pavo cristatus	Indian Peafowl
Coturnix pectoralis	Stubble Quail
Phaps chalcoptera	Common Bronzewing
Columba livia	Rock Dove
Streptopelia chinensis	Spotted Turtle-Dove
Phaps elegans	Brush Bronzewing
Gallirallus philippensis	Buff-banded Rail
Porzana pusilla palustris	Baillon's Crake
Tribonyx ventralis	Black-tailed Native-hen
Gallinula tenebrosa	Dusky Moorhen
Fulica atra	Eurasian Coot
Porzana fluminea	Australian Spotted Crake
Porphyrio porphyrio	Purple Swamphen
Porzana tabuensis	Spotless Crake
Lewinia pectoralis pectoralis	Lewin's Rail
Porzana sp.	Unidentified Crake
Cincloramphus cruralis	Brown Songlark
Acrocephalus stentoreus	Clamorous Reed Warbler
Cisticola exilis	Golden-headed Cisticola
Megalurus gramineus	Little Grassbird
Stipiturus malachurus	Southern Emu-wren
Malurus cyaneus	Superb Fairy-wren
Myzomela sanguinolenta	Scarlet Honeyeater
Acanthorhynchus tenuirostris	Eastern Spinebill
Phylidonyris melanops	Tawny-crowned Honeyeater
Phylidonyris novaehollandiae	New Holland Honeyeater
Manorina melanocephala	Noisy Miner
Acanthagenys rufogularis	Spiny-cheeked Honeyeater
Anthochaera carunculata	Red Wattlebird
Lichenostomus penicillatus	White-plumed Honeyeater
Epthianura albifrons	White-fronted Chat
Lichenostomus leucotis	White-eared Honeyeater
Anthochaera chrysoptera	Little Wattlebird
Phylidonyris pyrrhoptera	Crescent Honeyeater

Lichenostomus virescens	Singing Honeyeater
Lichenostomus chrysops	Yellow-faced Honeyeater
Falco berigora	Brown Falcon
Falco cenchroides	Nankeen Kestrel
Falco subniger	Black Falcon
Falco longipennis	Australian Hobby
Falco peregrinus	Peregrine Falcon
Accipiter novaehollandiae novaehollandiae	Grey Goshawk
Accipiter fasciatus	Brown Goshawk
Accipiter cirrhocephalus	Collared Sparrowhawk
Aquila audax	Wedge-tailed Eagle
Haliaeetus leucogaster	White-bellied Sea-Eagle
Milvus migrans	Black Kite
Elanus axillaris	Black-shouldered Kite
Elanus scriptus	Letter-winged Kite
Haliastur sphenurus	Whistling Kite
Hieraaetus morphnoides	Little Eagle
Circus approximans	Swamp Harrier
Trichoglossus haematodus	Rainbow Lorikeet
Glossopsitta concinna	Musk Lorikeet
Alisterus scapularis	Australian King-Parrot
Neophema chrysostoma	Blue-winged Parrot
Lathamus discolor	Swift Parrot
Platycercus eximius	Eastern Rosella
Platycercus elegans	Crimson Rosella
Barnardius zonarius zonarius	Australian Ringneck
Neophema chrysogaster	Orange-bellied Parrot
Cacatua galerita	Sulphur-crested Cockatoo
Cacatua sanguinea	Little Corella
Eolophus roseicapillus	Galah
Nymphicus hollandicus	Cockatiel
Callocephalon fimbriatum	Gang-gang Cockatoo
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo
Aegotheles cristatus	Australian Owlet-nightjar
Merops ornatus	Rainbow Bee-eater
Eurostopodus mystacalis	White-throated Nightjar
Melithreptus brevirostris	Brown-headed Honeyeater
Melithreptus lunatus	White-naped Honeyeater
Cracticus torquatus	Grey Butcherbird
Strepera graculina	Pied Currawong
Artamus personatus	Masked Woodswallow
Artamus cyanopterus	Dusky Woodswallow
Cracticus tibicen	Australian Magpie
Artamus superciliosus	White-browed Woodswallow
Strepera versicolor	Grey Currawong
Corvus mellori	Little Raven

Corvus coronoides	Australian Raven
Carduelis carduelis	European Goldfinch
Chloris chloris	European Greenfinch
Neochmia temporalis	Red-browed Finch
Passer domesticus	House Sparrow
Passer montanus	Eurasian Tree Sparrow
Hirundapus caudacutus	White-throated Needletail
Podiceps cristatus	Great Crested Grebe
Poliocephalus poliocephalus	Hoary-headed Grebe
Tachybaptus novaehollandiae	Australasian Grebe
Tyto longimembris	Eastern Grass Owl
Tyto javanica	Pacific Barn Owl
Ninox novaeseelandiae	Southern Boobook
Cacomantis variolosus	Brush Cuckoo
Cacomantis flabelliformis	Fan-tailed Cuckoo
Cacomantis pallidus	Pallid Cuckoo
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo
Chrysococcyx lucidus	Shining Bronze-Cuckoo
Alcedo azurea	Azure Kingfisher
Dacelo novaeguineae	Laughing Kookaburra
Todiramphus sanctus	Sacred Kingfisher
Dromaius novaehollandiae	Emu

Mammals

Vespadelus darlingtoni	Large Forest Bat
Chalinolobus morio	Chocolate Wattled Bat
Nyctophilus geoffroyi	Lesser Long-eared Bat
Chalinolobus gouldii	Gould's Wattled Bat
Vespadelus vulturnus	Little Forest Bat
Rattus fuscipes	Bush Rat
Rattus lutreolus	Swamp Rat
Hydromys chrysogaster	Water Rat
Mus musculus	House Mouse
Oryctolagus cuniculus	European Rabbit
Capra hircus	Goat (feral)
Ovis aries	Sheep (feral)
Potorous tridactylus tridactylus	Long-nosed Potoroo
Mustela furo	Ferret
Tachyglossus aculeatus	Short-beaked Echidna
Pteropus poliocephalus	Grey-headed Flying-fox
Canis lupus	Dingo & Dog (feral)
Sus scrofa	Pig (feral)
Cervus unicolor	Sambar
Phascolarctos cinereus	Koala
Felis catus	Cat

Herpetofauna

Pseudophryne semimarmorata	Southern Toadlet
Crinia signifera	Common Froglet
Limnodynastes dumerilii	Southern Bullfrog (ssp. unknown)
Paracrinia haswelli	Haswell's Froglet
Limnodynastes dumerilii insularis	Pobblebonk Frog
Litoria raniformis	Growling Grass Frog
Litoria ewingii	Southern Brown Tree Frog
Notechis scutatus	Tiger Snake
Austrelaps superbus	Lowland Copperhead
Amphibolurus muricatus	Tree Dragon
Liopholis whitii GROUP	White's Skink
Eulamprus tympanum tympanum	Southern Water Skink
Niveoscincus metallicus	Metallic Skink
Pseudemoia entrecasteauxii	Southern Grass Skink
Lissolepis coventryi	Swamp Skink
Saproscincus mustelinus	Weasel Skink
Tiliqua nigrolutea	Blotched Blue-tongued Lizard
Pseudemoia rawlinsoni	Glossy Grass Skink
Lampropholis guichenoti	Garden Skink
Acritoscincus duperreyi	Eastern Three-lined Skink