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Department of the Environment

Background document for the threat abatement plan for predation by feral cats



2015



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1 Introduction

This is the background document to the *Threat abatement plan for predation by feral cats* (Department of the Environment 2015). Predation by feral cats was identified as a key threatening process under earlier legislation and listed as a key threatening process in 1999 with the assent of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This document aims to provide information to underpin the threat abatement plan. It provides information on:

- feral cat characteristics, biology and distribution
- impacts on environmental, social and cultural values
- current management practices and measures.

The threat abatement plan (TAP) establishes a national framework to guide and coordinate Australia's response to the effects of predation by feral cats on biodiversity. It identifies the research, management and other actions needed to ensure the long-term survival of native species and ecological communities affected by feral cats. It replaces the *Threat abatement plan for predation by feral cats* published in 2008 (Department of the Environment, Water, Heritage and the Arts 2008).

1.1 Categories of cats

Cats (*Felis catus*) are an important domestic companion animal as well as being a significant threat to native fauna. It is important for public debate that it is recognised that all cats are the same species and the categorisation of domestic, stray and feral are labels of convenience. The categories and definitions used here are outlined in the threat abatement plan and below:

- **Feral cats** are those that live and reproduce in the wild (e.g. forests, woodlands, grasslands, wetlands) 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.
- **Domestic cats** are those owned by an individual, a household, a business or corporation; most 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.

Feral cats

The impact caused by self-sustaining feral cats is the focus of the threat abatement plan. Threatened species impacted by feral cat predation tend to be located in areas away from domestic and stray cats. However, stray and domestic cats can also cause impacts on threatened species, especially when they move into another category (e.g. get lost or are abandoned). Feral cats occur on Commonwealth land, such as Commonwealth managed national parks and Department of Defence properties. On a national scale, however, management of feral cats on Commonwealth land, as required by the EPBC Act via the obligation to implement the threat abatement plan, is only a small part of the larger picture of conserving threatened species affected by feral cat predation. State and territory conservation agencies have a long history of practical on-ground management of feral cats, and it is largely through their efforts, sometimes supported by Australian Government programs, that major technical and strategic advances have been made. Private sector and community initiatives have also contributed significantly to feral cat control activities and research.

Stray cats

Irresponsible cat owners and people who feed stray cats play a major role in maintaining populations of stray cats in urban and rural areas. Engendering changes in the behaviour of these people will reduce the numbers of free-ranging stray cats where they are causing damage to native wildlife. Campaigns such as the “Who’s for cats” (Australian Animal Welfare Strategy n.d.) promote the solutions to stray cats, including responsible ownership, and governments and animal welfare groups support these.

Capturing, sterilising and releasing (otherwise known as trap, neuter, release/return or TNR) programs are seen as an effective approach to managing colonies of stray cats in urban areas elsewhere in the world and are promoted in Australia. This approach should be considered unacceptable in Australia as there are no benefits to wildlife and it does not improve the welfare of the individual animals concerned (RSPCA 2011). It is also not considered to be effective where the population can be supplemented through immigration of fertile cats, as is the case for, at least, mainland Australia and Tasmania.

Domestic cats

Concern about the predation on wildlife by domestic cats has been an issue for a long time. Published studies in Australia and New Zealand (Morgan et al. 2009) have linked domestic cats to predation on wildlife.

Dickman and Newsome (2014) surveyed owners of domestic cats in the eastern suburbs of Sydney, 44 per cent of which had potential access to bushland reserves within the city. Over half of the cats returned to the owners with prey that ranged from small birds (most common) to large birds, lizards and snakes, rats, frogs, and possums. While these species may currently be non-threatened, adaptable species, it illustrates the potential for impact of predation particularly when domestic cat densities are high.

Although the responsibility for managing domestic cats ultimately rests with their owners, consideration must be given to the mechanisms to limit the impact of domestic cats on native fauna. State, territory and local governments already support some initiatives aimed at encouraging responsible pet ownership, including the development and enforcement of appropriate legislation, and education and awareness programs. Some governments or councils have confinement regulations including night curfews and 24-hour curfews, particularly in locations where there are nearby nature reserves that have high potential for predation of native species by roaming domestic cats. Extension of confinement regulations for other identified areas close to important reserves, wildlife corridors, important wetlands and other areas may assist in reducing predation by domestic cats.

1.2 Feral cat distribution and abundance

Cats (*Felis catus*) have a history of association with humankind dating back thousands of years. They accompanied seafarers for vermin control, companionship and food (Jones 1989; Dickman 1996), and in this way the species has spread to all inhabited parts of the globe and many uninhabited islands. *Felis catus* is now the most widely distributed of all the world’s felids.

Feral cats became established in Australia after European settlement with multiple introductions around the continent. Historical records used by Abbott (2008) to model feral cat spread across Australia suggests feral cat establishment around Sydney by the 1820s and the entire continent by the 1890s. In Tasmania the first domestic cats are recorded in Hobart in 1804. The introduction and subsequent success of the European rabbit lead to widespread release of cats into the wild for rabbit control in the 1850s. At other times, cats were released to

combat plagues of long-haired rats (*Rattus villosissimus*) and mice (*Mus musculus*). Offshore islands may have become inhabited through European colonisation or through shipwrecks (Abbott 2008).

Feral cats are now found in all of mainland Australia, Tasmania and many offshore islands (Figure 1). Feral cats have been eradicated from 21 offshore islands and from within fenced mainland reserves. These offshore islands are listed in Appendix B.



Source: IA CRC and NLWRA (2007)

Figure 1: Occurrence of feral cats, *Felis catus*

The abundance of feral cats is highly variable across Australia according to prey resources and other basic requirements of cats. Feral cats tend to be mainly solitary animals, with the exception of queens with their kittens, but the areas occupied (home ranges) of cats of opposite sex will overlap. Home ranges of feral cats of the same sex tend to show little overlap. Table 1 below provides some measured home ranges of feral cats across Australia, which range from 50 hectares up to 2210 hectares. Note that these numbers cannot be converted to abundance rates. Denny and Dickman (2010) provide a table of density estimates for feral cats from Australian studies between 1990 and 2005. The estimates are highly variable and range from 0.03 cats per square kilometre to 4.7 cats per square kilometre. The estimates should be interpreted according to the environment, season (including rainfall), prey availability and other factors the study authors highlight, and are not appropriate to scale across the continent.

Location	Home range	Home range (males)	Home range (females)	Reference
Victorian mallee (semi-arid NW Victoria)		330 – 990 ha (mean 620 ha)	70 – 270 ha (mean 170 ha)	Jones & Coman 1982
Central-western NSW agricultural land	248 ± 34.9 ha. No sex difference but larger cats had bigger home ranges.			Molsher et al. 2005
Central Australia semi-arid woodland		2210.5 ha (24 hr mean was 249.7 ha but the cats periodically shifted their 24hr home ranges)		Edwards et al. 2008

Location	Home range	Home range (males)	Home range (females)	Reference
Arid South Australia	50 – 1320 ha. No sex difference.			Moseby et al. 2009
Far East Gippsland forest		455 ± 126 ha	105 ± 28 ha	Buckmaster 2011

Table 1: Measured home ranges of feral cats across Australia.

Feral cat numbers also fluctuate in response to prey resources. Hone et al. (2010) estimated that at least 57 per cent (range of 24 – 93 per cent) of the population needs to be removed to cause a decline in the overall population. For example when there are plagues of rats or mice, feral cat numbers will also build in response to the additional food available. Individual feral cats may specialize in particular prey species and cause a greater impact on those species in an area, or may rapidly switch between prey species when resources become scarce. In particular, the switching to different prey can cause significant problems for threatened species if they are targeted. Importantly, for any given area of Australia, the impact of feral cats in that area is more relevant to management than the actual number of feral cats.

1.3 Impact of feral cats

Feral cats have been implicated as a threat to 142 species and sub-species, comprising 40 mammal species and sub-species (Woinarski et al. 2014), 40 birds, 21 reptiles and four amphibians (Department of the Environment 2015b). However, there are fewer species where there is a confirmed predation. Doherty et al. (2015) collated data from feral cat diet studies across Australia and identified 27 species consumed or killed by feral cats that are listed under the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. Seventeen of the species identified by Doherty et al. (2015) are also listed under the EPBC Act. The other 115 species in Appendix A of the threat abatement plan are listed under the EPBC Act as potentially threatened by feral cats based on their size or habits. However, absence of published evidence does not mean there is no threat as predation by feral cats will be impacting on at least some of these species.

As outlined in the introduction to the threat abatement plan, feral cats have impacts on native species through predation, competition and disease transmission. Predation is the dominant threat but the other two threats may be significant for those species affected.

Predation

Species being preyed on have been the subject of many studies. Doherty et al. (2015) cite 49 data sets and determined from these that feral cats are opportunistic, generalist carnivores that consume a diverse suite of prey; but that rabbits are preferentially fed upon when available. Where rabbits occurred in diets less frequently, there were higher frequencies of small dasyurids (<500 grams mean adult body weight) and rodents. Dickman and Newsome (2014) found at Ethabuka, an arid desert site, and Kellerberrin, in the Western Australian wheat belt, that rabbits were >50 per cent of the feral cat diet except when rabbit control or drought severely reduced their numbers. Monitoring of feral cat and rabbit numbers in the 1990s in South Australia demonstrated a strong link between these two species with populations of both rabbits and feral cats crashing with the release of rabbit haemorrhagic disease virus (Read & Bowen 2001; Holden & Mutze 2002). Feral cat scats showed the remainder of their diet to be broad with small mammals (<3 kilograms), ground-dwelling or near-ground birds, reptiles, invertebrates, frogs and even fish. In tropical regions the lack of rabbits meant that the proportion of small dasyurids and rodents in the mammal portion of the feral cat's diet is much higher (Doherty et al. 2015).

The type of mammal taken as prey by feral cats varies with what mammals are abundant in the area. Medium-sized mammals, including possums and bandicoots, are frequently in feral cat diets in south-eastern Australia

(Doherty et al. 2015). This is likely to be due to the greater abundance of these species relative to other areas. In Kutt's (2012) study of the feral cat diet in north-central Queensland, there was a strong selection for mammals <100 grams in size and this was dominated by dunnarts and planigales. Spencer et al. (2014) compared prey items between feral cats, European red foxes and dingoes in 2011–12. Feral cats had the greatest consumption of small mammals and positive correlations for long-haired rats (*Rattus villosissimus*) and Forrest's mouse (*Leggadina forresti*). Yip et al. (2014) studied the diet of feral cats in semi-arid grassland habitats in Queensland and found that, during an irruption of long-haired rats, they occurred in 60 per cent of samples and comprised more than 50 per cent of all prey by volume. Also contained within the diets of the feral cats in this area were fish, frogs and freshwater crustaceans.

Reptiles are consumed in greater portion where they are more abundant, in central Australia and north-east and north-west Australia (Doherty et al. 2015), but the rainfall-driven fluctuations that drive explosions of small mammals mean the feral cats switch prey resources from reptiles to small mammals at those times. In the savannah region of north-central Queensland (Kutt 2011) reptiles from the families gekkonidae (geckos) and agamidae (dragons) dominate the feral cat diet. At Roxby Downs, South Australia, analysis of cat consumption has indicated about 700 reptiles per square kilometre per year are eaten (Read & Bowen 2001).

Invertebrate (including spiders, scorpions, centipedes, millipedes and insects) consumption is poorly known across all of Australia, except that they are not a preferred food source. They only become important in times of prey scarcity (Doherty et al. 2015). However, Kutt (2011) determined from north-central Queensland that invertebrates and mammals had the highest portion of relative importance in the diet of 169 feral cats. In particular, grasshoppers and centipedes were highly ranked. Invertebrates and amphibians were more important in the wet months than in the dry season (Kutt 2011). Koch et al. (Unpub.) analysed cat diets over two seasons in the semi-arid rangelands of Western Australia (Karara-Lochada pastoral leases and Mt Gibson) and found that grasshoppers and centipedes were also important food sources with grasshoppers comprising 46 per cent of the total number of species in the diet in spring and centipedes comprising 16 per cent in winter.

Ground dwelling or low dwelling birds are an important component of diet for feral cats in the southern rangelands of Western Australia. They comprise 26 per cent of the total number of species in winter and 31 per cent in summer Koch et al. (Unpub.). Birds and invertebrates were important, after irrupting long-haired rats, to feral cat diets in the semi-arid grasslands of Queensland (Yip et al. 2014).

Nesting seabirds form a major component of feral cat diets in coastal and island areas, especially when there are few mammal species available on the island (Doherty et al. 2015).

As Doherty et al. (2015) note, the interplay between feral cat diet and prey species diversity is complex and land managers need to understand these interactions at their property or regional scale in order to effectively know how best to control feral cats for biodiversity outcomes.

Competition

Feral cats compete with other carnivores and omnivores for food resources. A number of studies have been undertaken that investigated dietary overlap, to determine the degree of competition from these species. In particular, European red foxes, quolls and other dasyurids, dingoes/wild dogs, raptors, varanids, owls, and snakes all have some dietary overlap with feral cats.

Dingoes, wild dogs and their hybrids may influence the abundance and habits of feral cats. The interactions between the various introduced and native predators are still a subject of research across Australia (see section 3.3). Understanding this part of this complex ecosystem is difficult and the findings are likely to vary in space and time across different landscapes in Australia. Section 3.3 provides further discussion on the interactions with dingoes, wild dogs and their hybrids.

Diets of feral cats and European red foxes overlap (e.g. Catling 1988) and there is evidence of competition between the two species, with European red foxes competitively excluding feral cats from food resources, and of

direct predation of European red foxes upon feral cats (Robley et al. 2004; Buckmaster 2011). The interaction between European red foxes and feral cats is made more complex in areas where dingoes/wild dogs are also present as all three species interact with each other.

Glen and Dickman (2011) hypothesised that the competition overlap between spotted-tailed quolls (*Dasyurus maculatus*) and feral cats is lower than for European red foxes, possibly due to feral cats consuming smaller prey on average and may not be as dominant in aggressive encounters between the two species.

In Tasmania, a study by Fancourt et al. (2015) of Tasmanian devils (*Sarcophilus harrisi*) found they appear to influence cat activity times but did not suppress cat abundance.

Varanids and feral cats have some dietary overlap (Sutherland et al. 2011). However, other species that are more willing to consume carrion (e.g. European red fox, Tasmanian devil) have a greater dietary overlap and higher potential for competition. Rowles (2008) as cited in Sutherland et al. (2011) found increases in sand monitors (*Varanus gouldii*) after cats were eradicated from Faure Island in Shark Bay, Western Australia. Read and Scoleri (2014) reported an increase in *V. gouldii* after cats and European red foxes were excluded from the Arid Recovery Reserve. But others such as Edwards et al. (2002) as cited in Sutherland et al. (2011) did not find any change in monitor abundance following cat control in central Australia.

Birds of prey have some dietary overlap with feral cats. In particular, wedge-tailed eagles (*Aquila audax*), little eagle (*Hieraaetus morphnoides*), black-breasted buzzard (*Hamirostra melanosternon*), brown goshawk (*Accipiter fasciatus*), grey goshawk (*Accipiter novaehollandae*) and spotted harrier (*Circus assimilis*) take rabbits as prey so are likely to have an overlap with feral cats (Debus 2012). However, competition with feral cats or other mammalian predators is not identified as a threat to these birds.

Disease

While disease and parasite transmission from feral cats is not recognised under the key threatening process, it has been identified as an important impact of feral cats in some parts of Australia (see Henderson 2009 for examples). Native species may be deleteriously affected through parasites and diseases transmitted from cats. As the threat abatement plan notes, Australian feral cats are hosts to three viruses, >40 bacteria, >17 fungi, 21 protozoa species, 26 helminth species, and 19 arthropod species. A list of pathogens is provided in Henderson (2009). Some of these can be transmitted to other animals, including livestock and people.

Toxoplasma gondii, causing toxoplasmosis, is a well-known protozoa that uses the cat as a definitive host and is particularly concerning for native Australian animals, and immunocompromised people and pregnant women. *T. gondii* can infect virtually all warm-blooded animals including humans. It has also been found in marine mammals including Indo-Pacific humpbacked dolphins (*Sousa chinensis*) (Bowater et al. 2003) and dugong (*Dugong dugong*) (Owen et al. 2012). Measures et al. (2004) state that the discovery of *T. gondii* in marine mammals may indicate natural infections unknown because of lack of study or might indicate recent contamination of the marine environment from the terrestrial environment by natural or anthropogenic activities. *T. gondii* affects neural and muscular tissues and this can cause the animals to have obscured vision, difficulty in walking and calcification of the heart (Adams 2003). It has also been implicated in increasing the susceptibility of the animal to predation (Berdy et al. 2000; Webster 1994a and Webster et al. 1994: all as cited in Adams 2003). Infection with *T. gondii* in sheep and goats (and people) can cause early embryonic or fetal death, abortion or stillbirth (Dubey 2009).

Fancourt (2014) observed an abrupt decline in Tasmanian bettongs that coincided with the first appearance of cats at the site. Fancourt (2014) suggested that feral cat predation and exposure to toxoplasmosis may have contributed to the bettongs' disappearance. In Tasmania, 84 per cent of feral cats are carriers of *T. gondii* (Fancourt and Jackson 2014). However, studies (see Henderson 2009 for examples) have indicated that some

Australian native marsupials appear to be particularly susceptible to acute infection and Bettiol et al. (2000) have demonstrated eastern barred bandicoots (*Perameles gunni*) die from infection within 15–17 days.

The degree of impact to native animals from toxoplasmosis across all of Australia is not obvious because there has been no exclusion of feral cats and the protozoa would have been in the environment for a long time. Adams (2003) measured *T. gondii* levels in Western Australia and found infections in 4.9 per cent of feral cats and 6.5 per cent of native mammals. Parameswaran et al. (2009) found that marsupials in the Perth metropolitan area had a 15.5 per cent prevalence of *T. gondii*. It is probable that these animals have a higher exposure to cats through the presence of domestic, stray and feral cats than areas further from human habitation.

Sarcosporidiosis is a cyst forming organism that can infect mammals, with feral cats being a host. Where infection rates are high, such as on Kangaroo Island, this can impact on primary production through carcass rejection or trimming of affected meat. While this does not impact on biodiversity, it does impact on the livelihood of some farmers who may also participate in biodiversity conservation or contribute to the control of feral cats.

1.4 Cat biology

Feral cats have a body form, musculature, nervous coordination and senses that are highly specialised for stalking and capturing prey. They hunt using audio and visual clues, and adopt two different techniques. Firstly, active hunting involving the seeking out of prey and then stalking using available cover, and secondly, a 'sit-and-wait' approach where the cat expects prey to appear. The prey is then ambushed from the cover spot. This second approach is often used near rabbit burrows (Dickman & Newsome 2014).

Feral cats have a basic metabolic requirement that Hilmer (2010, cited in Buckmaster 2011) determined for a 3.7 kilogram cat in winter to be 800 kilojoules per day. This equates to approximately 160 grams of wet food and may necessitate several kills per day.

The diet must be high in protein, moderate in fat and low in carbohydrates – that is found in vertebrate prey – as cats lack a metabolic enzyme that restricts their diet (Zoran 2002, cited in Buckmaster 2011).

Adult feral cats vary in size, but are typically 3–5 kilograms (Denny & Dickman 2010).

2 Controlling feral cats

Control techniques for feral cats are generally expensive and labour intensive, require continuing management effort and can be effective only in limited areas.

A model code of practice for the humane control of cats is available (Sharp and Saunders 2012). The aim of this code of practice is to provide information and recommendations to vertebrate pest managers responsible for the control of feral cats. It includes advice on how to choose the most humane, target specific, cost effective and efficacious technique for reducing the negative impact of feral cats. This code of practice is a guide only; it does not replace or override the legislation that applies in the relevant state or territory jurisdiction. The code of practice should only be used subject to the applicable legal requirements (including health and safety) operating in the relevant jurisdiction.

2.1 Eradication

Eradication of feral cats is an attractive option because, once achieved, it requires no further commitment of resources other than for monitoring. Bomford and O'Brien (1995) argue that the following three conditions must apply to achieve eradication:

- The rate of removal exceeds the rate of increase at all population densities
- There is no immigration
- All reproductive animals are at risk (e.g. all females in the population are able to be eliminated).

There are three further conditions that will provide an indication that eradication is the best option to be pursuing:

- All animals can be detected at low densities
- Discounted cost-benefit analysis favours eradication
- There is a suitable socio-political environment.

These conditions cannot be met for mainland Australia or Tasmania at present. The eradication of feral cats is well beyond the capacity of available techniques and resources. Because feral cats are so well established across the whole continent, it is not possible to meet the rate of removal requirement. In addition, feral cats can reproduce quickly when conditions are favourable so the requirement that the females in the population are all removed also cannot be met. See section 2.4 for a discussion on localised eradication from mainland fenced areas.

However, the potential for feral cats to be eradicated from offshore islands around Australia is excellent. Feral cats have been eradicated from a number of islands including Macquarie Island (Tas.), Montobello Islands (WA), Faure Island (WA), and Tasman Island (Tas.) (see Appendix B for a full list). In 2015, eradication programs were underway on Christmas Island, Dirk Hartog Island (WA) and West Island in the Sir Edward Pellew Islands (NT).

The eradication of feral cats from offshore islands is an important element in the recovery of species threatened by predation by feral cats. Eradication provides immediate benefits for the fauna on the island and in some situations will provide an important refuge for mainland species. If habitat and other factors are suitable, translocation of critically endangered or endangered species to cat-free islands may prevent the extinction of the species or allow population recovery.

2.2 Shooting

As a control technique, shooting is most appropriate if applied for an extended period or timed for critical periods. Ongoing shooting is appropriate in areas where there is a continual immigration of feral cats from surrounding areas and the species being protected from predation is vulnerable all of the time. Critical periods of shooting can be undertaken in locations where either there is a rapid increase in feral cat numbers, such as in response to a prey irruption, or at a time in the threatened species life cycle, such as during breeding, when the population of the threatened species is at a higher risk.

Recreational hunters also kill feral cats, but the magnitude of the impact of recreational hunting on feral cat or prey populations is unknown.

Shooting is considered to be humane if the shooters are experienced, skilled and responsible, the feral cat can be clearly seen and is within range, and the correct firearm, ammunition and shot placement is used. A standard operating procedure is available as a guide for ground shooting of feral cats (Sharp 2012a). Shooting is usually done at night from a vehicle with the aid of a spotlight, but can also be conducted during the day.

Shooting is expensive, labour intensive, time consuming and can only be done on a relatively small scale because of the resource requirements and high cost.

2.3 Trapping

Acceptable trapping of feral cats comprises cage traps and padded jaw leg-hold traps, although acceptable methods may vary in each state or territory.

Cage trapping is considered to be an ineffective tool for large areas, but it may be useful in urban/residential areas where domestic cats are present, or where populations have already been reduced and individual cats need to be targeted. In urban/residential areas cage traps are preferred as fewer injuries are sustained, non-target animals can be released unharmed and trapped feral cats can be transported away from the area for euthanasia. Cage traps must be set so that they provide shelter for the trapped animal, must be checked frequently (dependent on conditions but at least daily) and trapped feral cats must be killed quickly and humanely.

Padded-jaw traps are useful for sites where the feral cat can be destroyed by shooting while still held in the trap. They may also be more effective than cage traps for hard-to-catch feral cats that have had minimal exposure to humans. Padded-jaw traps should be set carefully to minimise non-target species catches and, if possible, provide shelter for the trapped animal. These traps must also be set and checked appropriately.

Standard operating procedures are available as guides for trapping of feral cats using cage traps (Sharp 2012b) and trapping of feral cats using padded-jaw traps (Sharp 2012c). With both techniques of trapping, skilled operators are required to set the traps and lures to attract the feral cats. Trapping is expensive, labour intensive and time consuming; and is only recommended on a small scale or where eradication is the objective.

2.4 Exclusion fencing

Exclusion fencing is an effective technique for native fauna vulnerable to terrestrial predators, such as feral cats. It is considered to be the most humane non-lethal feral cat control method, but the cost of establishing fences can be prohibitive. Maintenance costs must also be considered as these are essential to excluding predators who will continually challenge any weakness. Their use is increasing but tends to be limited to the management of highly valued threatened species that can live in relatively small areas from which feral cats can be eradicated.

A number of different types of fences are used; but they typically comprise a high vertical section with some sort of overhang or cap to prevent climbing over and mesh apron at the base to prevent digging under. Some may incorporate electric wires (Moseby & Read 2006; Robley et al. 2006).

If breached, fences may increase the vulnerability of threatened species by preventing their escape from predators. Fencing also affects the movement of other wildlife, and may prevent their dispersal and interbreeding with other populations. Fences may also concentrate predators outside the fence boundary to the detriment of other native species (Long & Robley 2004). Exclusion fences are often erected for the purpose of excluding more than one type of vertebrate pest, typically wild dog, European red fox, feral cat and rabbit.

To minimize the risk of breaches, fencing should be combined with an integrated baiting and trapping program in the surrounding area to reduce the frequency of challenge to the fence by incoming predators (Hayward et al. 2014). The combination of fencing with a baiting and trapping program is a high cost option, which has proven very effective in recovering high value threatened species.

2.5 Baiting

Baiting can be the cheapest and most effective broadscale technique for controlling the numbers of animals. Baiting techniques for feral cats tend to be much less effective than techniques for baiting wild dogs and European red foxes. Feral cats prefer live prey and will only take carrion (i.e. baits) when hungry. To be successful in baiting feral cats enough baits must be spread across the areas where the cats are so that they will be encountered at the time when the cat is hungry – otherwise they will be ignored. Feral cats, unlike wild dogs and European red foxes, will not exhume baits so the baits must be laid on the surface.

The timing of a baiting program is a critical element in successful baiting of feral cats (Algar et al. 2007). There are usually times during the year, typically winter in southern Australia and at the end of the dry season in northern Australia, when cats are most food stressed and more likely to take baits. Other factors such as large rain events with subsequent irruptions in rodents can change the food availability (Johnston et al. 2012) reducing the effectiveness of bait. Consideration also needs to be given to effective baiting programs potentially becoming less effective if the prey items (e.g. threatened species) respond by increasing in their abundance.

The Western Australian Department of Parks and Wildlife has developed the Eradicat® bait which is registered for use in Western Australia. This bait is a small kangaroo and chicken chipolata sausage containing the toxin 1080 (sodium monofluoroacetate) (Algar et al. 2013). The baits can be surface laid in Western Australia with minimal risk to native animals that may consume the baits. These species have a degree of tolerance to the toxin because some plants in Western Australia naturally contain the chemical. This is not the case for the rest of Australia. Algar et al. (2013) describe a baiting program using Eradicat® at Lorna Glen (Matuwa) Conservation Reserve over seven years, confirming that when prey availability is low baiting can effectively control feral cat numbers.

The Australian Government, in partnership with the Victorian and Western Australian governments has developed a bait for use in southern and central Australia, with the exception of Tasmania. The Curiosity® bait is very similar to the Eradicat® bait but uses a different toxin, para-aminopropiophenone (PAPP), that feral cats are highly susceptible to. In addition, the Curiosity® bait also encapsulates the toxin in a hard plastic pellet to reduce the risk to non-target species. Native species, such as bandicoots, will reject the hard plastic pellet while eating the bait (Department of the Environment 2015a). The mode of action of the toxin PAPP means that there can be no secondary poisoning of any other animals from consuming a carcass of a feral cat that ate a Curiosity® bait. The toxin PAPP does have an antidote in methylene blue; however, the antidote must be administered very rapidly. As at July 2015, the antidote is not registered for use in Australia as a veterinary chemical. The Invasive Animals Cooperative Research Centre is conducting research and development into the antidote for use with accidental poisoning of working and pet dogs.

The Australian Government is also developing (again in partnership with the Victorian and Western Australian governments) a bait for use in northern Australia and Tasmania, called Hisstory, that is similar to the Curiosity® bait but has the toxin 1080 encapsulated in the hard plastic pellet. This will provide non-target protection to the same species as the Curiosity® bait, and can be laid in areas where reptiles and Tasmanian devils are active.

However, baiting can pose risks to other species that may eat a bait. Baits are designed to contain the least amount of toxin required, which reduces the risk to species that have some tolerance (e.g. goanna species that are tolerant to a cat-sized dose of 1080 toxin). Placement of baits can also reduce risks, as can the timing of baiting (e.g. when reptiles are less active). Finally, designs such as with the Curiosity® bait make the bait as species-specific as possible.

A bait that is sufficiently attractive for a cat to consume will also be attractive to European red foxes, wild dogs and dingoes. Generally, a cat-sized dose of toxin is not a lethal dose for a European red fox, wild dog or dingo. However, the lay rate of cat baits in the environment is higher so it is possible that a European red fox, wild dog or dingo may take multiple cat baits and die. This should be considered in designing a feral cat control program using toxic baiting.

It is acknowledged that the toxin 1080, through its complex modes of action, typically manifested in the central nervous system in most animals, causes symptoms that appear to be inhumane. McLeod and Saunders (2013) provide a summary for cats with death from 1080 typically taking 4–24 hours, from either depression of the respiratory centre or ventricular fibrillation. However, 1080 is also considered to be more humane than other slower acting toxins (AWMS, no date) and remains a critical tool for the effective control of feral cats and other vertebrate pests in Australia.

2.6 Other uses of toxins

Research and development is underway to explore other devices that can deliver toxins to feral cats but minimise the risk to non-target species through species identification prior to toxin delivery. Grooming traps that spray toxins onto the fur of the feral cats triggering a grooming response by the animal have had successful proof-of-concept trials (Read et al. 2014). These devices have potential to be useful at sites where the area is restricted in size or feral cats predominantly use landscape features such as tracks or watercourses from which they can be lured to the device.

2.7 Lures

Feral cats' hunting skills rely on audio and visual stimuli rather than an acute sense of smell. There are a variety of lures available and being tested to draw feral cats to monitoring points and control sites. They include visual lures of feathers, tinsel and the like, and scents including faeces, urine and food. Typically a combination of a visual and scent lure is used and may be changed during the duration of the program to provide a novel item in the landscape to attract attention by the feral cats.

A study by Read et al. (2015) compared a visual, auditory and scent lure for feral cats, European red foxes, and wild dogs/dingoes in semi-arid South Australia. They found that although some individual feral cats may be attracted to or remain near some lures for longer; none of the lures tested offered consistent and significant benefits for feral cat control.

A plant (*Acalypha indica*) from Christmas Island is under investigation to look at two chemical compounds that provoke a behavioural response in cats, with the intention of incorporation into baits and lures (Algar et al. 2013).

2.8 Other controls

Feral cats get predated on, either for consumption or the killing of competition, by wild dogs, dingoes and European red foxes. The role that these larger predators may have in controlling feral cats is being studied and exploited.

The role of dingoes in suppressing feral cats is being studied to determine the extent to which this can help with the recovery of threatened species and other native species being predated on by feral cats. As mentioned earlier (and in section 3.3), the interaction of dingoes, wild dogs, feral cats and other species including European red foxes are complex and appears to vary across the continent.

Maremma dogs have been bred as guardian dogs to protect livestock. They are being actively used in Australia to protect native species (e.g. little penguins on Middle Island, Victoria (Warrnambool City Council 2015)). There is potential to use Maremma dogs to protect native species from feral cat predation, such as eastern barred bandicoots in Victoria (Zoos Victoria 2015).

2.9 Biological control

The use of a biological control, such as a cat-specific virus, has appeal as a broadscale control tool for feral cats. However, for Australia, a study by Moodie (1995) found it unlikely that any felid-specific pathogen may be suitable as a sufficiently virulent and humane biological control agent from which domestic cats can be protected. It may be appropriate to re-examine potential pathogens as described in Action 1.8 in the threat abatement plan, noting the specific conditions of humaneness and protection for domestic cats which would still need to apply.

2.10 Fertility control

Fertility control is an attractive form of pest animal management, being more humane than using lethal control measure to reduce pest population numbers. If an immunocontraceptive vaccine were developed for cats, its broadscale use would depend on the development of a suitable delivery mechanism for the vaccine and appropriate approvals to release the vaccine into the wild. The development of immunocontraceptive vaccines is both high cost and high risk, and no effective fertility control agents are currently available for broadscale use against any carnivore in the world (Saunders & McLeod 2007). In addition, consideration would also need to be given to protection for domestic cats, and the potential for the fertility control agent to get to another country that has native felids – posing a threat to them. Therefore, fertility control is not a feasible option for cat control at this time.

Another option for fertility control could be via the use of genetic technology. Novel gene drive technology is an emerging technology that has potential for use in feral animal control programs by genetically altering entire populations. RNA-guided gene drives can be designed to edit any gene with extremely high precision in order to alter a trait of an individual. The gene drive then can cause the gene-editing event to re-occur in each individual that inherits one copy of the gene drive. This way any trait can be spread through entire populations over time through natural breeding.

Suggested RNA-guided gene drive strategies for pest animal control include (but are not limited to) population suppression by altering sex bias of new animals that will eventually lead to a population crash, and sensitizing specific species to a particular toxin and thereby rendering them susceptible to it (Esvelt et al. 2014).

RNA-guided gene drives are a rapidly expanding new research field, however the technology is in its infancy for applications in vertebrates and there should not be an expectation that a gene drive based management tool for feral cats will be rapidly available. Consideration will also need to be given to the risk of movement (legal or illegal) of the gene-drive modified populations internationally to countries where *Felis catus* is a native or desired species. In addition, there will need to be public acceptance in Australia of both the technology and the specific application to feral cats prior to any release.

2.11 Habitat management

Feral cats will take advantage of elements of their habitat and studies have been undertaken to determine if it is possible to manipulate or exploit any of these elements in the control of feral cats.

Consideration of home range size – that is the area in which individual feral cats live – will determine the density at which control devices need to be deployed. As mentioned earlier the home range size is highly variable across Australia. However, Bengsen et al. (2012) have determined that, for their Kangaroo Island site, devices should be deployed at no less than 1.7 devices per square kilometre.

McGregor et al. (2014) determined that in the Kimberley the feral cats preferentially used the more open habitats of grazed areas and fire scars to hunt. They suggest that consideration should be given to the vegetation structure when planning burns and grazing areas to provide greater cover for small mammals.

Paltridge et al. (1997) observed that watering points were used as daytime shelter for feral cats as a consequence of the taller vegetation behind fenced-off bores. The authors also noted that many species of birds taken by feral cats in central Australia were those that regularly required free water, and that during drought feral cats consumed carrion from dingo kills near watering points.

2.12 Financial incentives

Reviews of the history of pest management conclude that, in general, subsidies and bounties have rarely been effective in reducing damage by pest animals (e.g. Braysher 1993). As a general policy, it is not cost-effective to seek to raise the level of recreational or professional hunting or trapping of feral cats on a broad scale by payment of bounties, subsidies or other similar artificial market incentives.

Where private land adjoins or contains important wildlife habitat, assistance or encouragement of landowners and the development of incentives to promote feral cat control on private land may be appropriate, especially if the property forms part of a buffer zone to protect threatened species. There may also be instances where hunters can be utilised as part of a specific control program and incentives may assist in reaching the desired goal.

The removal of financial barriers may be beneficial in helping to address issues of predation by feral cats. Examples of how these barriers can be removed include the subsidisation or loan of cage traps for community groups seeking to undertake feral cat control, and on islands seeking to remove all cats from the island assistance for community members to de-sex their domestic cats. An example of the latter is on Christmas Island where all domestic cats in the community were de-sexed, microchipped and vaccinated as part of the eradication program (Algar et al. 2011). These domestic cats will be allowed to remain on the island but no new domestic cats are permitted.

3 Factors affecting feral cat control

3.1 Understanding the extent and nature of the threat

Predation is a feature of virtually all ecological systems. Raw estimates of the total number of prey animals taken by cats are of limited value in determining the ecological impact of predation. Cat predation becomes a significant threat to native species only when the level of predation and other causes of mortality exceed the capacity of individual populations to replace themselves.

Australia's pre-European fauna included a suite of native predators, including large reptiles, raptorial birds, quolls and dingoes. The degree of threat posed by cat predation is associated with:

- Behavioural, morphological and physiological characteristics of cats that make them more efficient predators than native predators
- Factors that make cats more abundant or persistent than native predators
- The small size and isolation of populations of some threatened species

- The vulnerability of native prey to cat predation.

From a wildlife management point of view, the key question is whether the removal, or reduction, of feral cats will result in significant increases in the population or distribution of particular native species. A significant impediment to answering this question is the technical difficulty in measuring and manipulating the numbers of feral cats and monitoring of the native species at risk. Sampling a portion of the population using GPS tracking systems is providing some answers and other sampling methods such as camera traps, spotlighting and track counts may give an indication on population changes.

3.2 Interactions with other introduced species

As mentioned in section 1.3, in areas where rabbits occur, they tend to be the main prey item for feral cats. Dickman and Newsome (2014) found that during periods when drought or rabbit control reduced the number of rabbits; the proportion of native prey in the feral cat diet increased. This is also mentioned by Williams et al. (1995) in that feral cat numbers have been observed to rise and fall with fluctuations in rabbit numbers. As mentioned earlier, Read & Bowen (2001) and Mutze & Holden (2002) found feral cat numbers decreased in response to the rabbit haemorrhagic disease virus killing large numbers of rabbits in the Flinders Ranges.

Introduced rats and mice also form part of feral cat diets (Robley et al. 2004; Johnston et al. 2012).

European red fox

There are interactions between European red foxes and feral cats in the form of competition for prey, competitive exclusion and direct predation. Diets and distributions of European red foxes and feral cats overlap (e.g. Catling 1988; May & Norton 1996; Read & Bowen 2001). Robley et al. (2004) found evidence for interspecific competition, with European red foxes competitively excluding feral cats from food resources, and of direct predation of European red foxes upon feral cats. Marlow et al. (2015) found that feral cats preyed on more woylies (*Bettongia penicillata*) than European red foxes and were more abundant in areas that had been toxic baited for European red foxes. Smith and Quin (1996) found a degree of overlap but also segregation in rodent prey with small, <35g, rodents in greatest decline where feral cats were abundant and all rodents only where foxes absent. Greenville et al. (2014) found a slight positive interaction between European red foxes and feral cats instead of the reverse; but this was in desert country during a resource boom.

3.3 Interactions with dingoes

There have been many studies into dingoes, wild dogs, dingo-dog hybrids and their relationships with feral cats in different Australian environments and this section does not attempt to comprehensively cover the debate.

Humans aside, dingoes are considered to be the apex predator in most Australian environments (noting that dingoes (*Canus dingo*) are absent from Tasmania). As such they have the potential to influence or regulate the ecological system in which they are in. Dingoes, especially when they form stable pack structures that allow effective cooperative hunting, are able to prey on most animals up to the size of large macropods (Dickman et al. 2014). There is some dietary overlap between dingoes and feral cats, but feral cats tend to consume smaller prey items and unlike dingoes they avoid carrion (e.g. Spencer et al. 2014).

Dingoes influence the behaviour and possibly the densities of smaller predators, both native and introduced, within the ecological systems. Dingoes and wild dogs may impact smaller predators in an ecological system by preying on them, or by competing with them for resources. The predation can be killing and eating events (intraguild predation) where the dingo/wild dog consumes the predator, or killing with no further purpose other than to remove a competitor (intraguild killing) (Glen 2014). The risk of predation can alter behaviour of these mesopredators too; they may avoid the areas used by dingoes/wild dogs, and/or they may avoid being active

when dingoes/wild dogs are active. Below are some studies that have had a focus on dingoes and feral cats, and provide examples of where intraguild predation, intraguild killing, spatial avoidance and temporal avoidance have been observed.

Intraguild predation

While stomach and scat records from studies have shown dingoes will eat feral cats, Allen et al (2014a) looked at 31,000 dingo diet records in the literature and determined that only 0.63 per cent contained any evidence of cat consumption. Allen et al (2014a) are careful to point out that this does not preclude intraguild killing.

Intraguild killing

Moseby et al. (2009) conducted an experiment in a 37 km² fenced area where predators could get in but not out. Two dingoes, European red foxes and six cats were introduced and observed using tracking collars. Moseby et al. (2009) were able to confirm three of the six cats were killed by the dingoes but not eaten. The cause of death of the other three was unable to be determined due to carcass degradation.

The Australian Wildlife Conservancy's work in the Kimberley has shown that dingoes killed approximately one third of the feral cats with tracking collars (Australian Wildlife Conservancy 2014).

Spatial avoidance

Buckmaster (2011) noticed that some of the home ranges of feral cats being tracked in Far East Gippsland forests had areas that were not used even though the resources appeared to be the same. It was hypothesised that the feral cats may be avoiding wild dogs and European red foxes using those areas.

A study of the response of feral cats to the control of dingoes was conducted at several sites in the Northern Territory and Kimberley by Kennedy et al. (2012). Monitoring prior to the implementation of control showed a negative correlation between feral cat and dingo activity with either fewer feral cats or feral cats avoiding the sites visited by dingoes. Poison baiting reduced dingo activity by 55 per cent within four weeks of baiting but there was no compensatory increase in feral cat activity. This suggests that feral cat density (rather than simply feral cat activity) was lower where dingo activity was high (Kennedy et al. 2012).

Temporal avoidance

Wang and Fisher (2012) used camera traps to look at spatial and temporal overlaps of dingoes and feral cats in central Queensland. They found no evidence of spatial exclusion from areas of high prey activity by the dingoes but, during the wet months of the year, a separation of activity times.

Greenville et al. (2014) gathered two years of camera trap data over a major rain event and subsequent boom period in central Australia. These data demonstrated a consistently negative relationship between dingoes and feral cats and that there was a two hour offset in peak activity times. Greenville et al (2014) suggest that this could be a function of preferred prey activity times rather than avoidance by feral cats of the dingoes. The rodent activity peaked at the same time as feral cat activity, whereas the dingo activity was also high around the early hours of daylight when larger macropods are easier to hunt. In contrast, Brook et al. (2012) found that feral cats shifted their peak activity time in response to the presence of dingoes, and suggested that this shift resulted in reduced feral cat-predation of small native mammals.

Gordon et al. (2015) explored the concept that, for small prey that is less attractive to dingoes (in this case *Notomys fuscus*), it is better for them to be in a site where dingoes are suppressing feral cat activity. Camera traps demonstrated dingo activity negatively correlating with feral cat activity and that the *Notomys fuscus* altered its behaviour more in the presence of feral cats than the dingoes.

The examples above are from studies that have directly measured dingo and feral cat activity. It is also acknowledged that there are also a suite of studies that have considered indirect evidence such as comparing mammal communities in the presence and absence of dingoes which are not addressed here.

There are also interactions with the European red fox with both the dingo/wild dogs and feral cat that need to be considered. The European red fox, being larger than the feral cat, is likely to have similar influences on feral cats as dingoes. Where European red foxes, wild dogs and/or dingoes and feral cats co-exist, the interactions and influences described above may be more complex or modified.

3.4 Animal welfare concerns

Most animal welfare organisations accept that there is a need to control feral cats to protect environmental values and wildlife (RSPCA 2003). However, this must be done using control methods that are humane.

As mentioned above the *Model code of practice for the humane control of feral cats* (Sharp and Saunders 2012) provides information and recommendations to feral cat managers, including advice on how to choose the most humane, target-specific, cost-effective and efficacious control techniques. Standard operating procedures (Sharp 2012a; Sharp 2012b) provide information about the appropriate application of the method, animal welfare considerations, health and safety considerations, equipment required and procedures to guide managers.

3.5 Cultural value of cats

The cultural value placed on feral cats varies according to the observer's own value system. Australia's unique fauna is widely valued by society, and many perceive feral cats to be a threat to native fauna. Nevertheless, there are concerns that domestic cats may be threatened by management actions taken to control the impacts of feral cats.

Indigenous people also have a range of views about feral cats. Some see the problem of predation by feral cats on native fauna, some recognise introduced animals as part of the landscape and see them as newcomers rather than feral, and others have feral cats as part of their Dreaming.

In remote communities the interactions between people and animals is complex, and for companion animals such as domestic cats, there may be difficulty in defining the differences between domestic, stray and feral cats. However, organisations such as AMRRIC (Animal Management in Rural and Remote Indigenous Communities) have demonstrated how it is possible to work with communities to provide education on the threat to biodiversity posed by cats and support for their management.

Consideration of the differing cultural values attached to domestic and feral cats is an important component of any control program.

4 Developing a national approach to feral cat management

This section looks at the different aspects involved in developing a national approach to feral cat management. It covers planning, including strategies for allocating resources and identifying priority areas for action. It is consistent with the principles outlined in the Australian Pest Animal Strategy (NRMMC, 2007).

4.1 Strategies for allocating resources to feral cat management

Abating the threat posed by feral cats and securing threatened species is a long-term process requiring careful planning, research, frequent reviews of programs, the adoption of new knowledge and an adaptive management framework. As has been stated previously, the total eradication of feral cats throughout Australia is impossible with the current control techniques. This plan must ensure that the limited resources available are strategically allocated to give the best outcome for threatened species conservation.

There are two main approaches that can be taken, with current techniques, to reduce feral cat impacts. The first is to eradicate or suppress feral cats in manageable areas of high conservation value, while the second approach is preventative:

- (i) ensure that feral cats do not become established on islands of high conservation value where they do not presently occur; and
- (ii) prevent the transition of cats from domestic to stray to feral using education, and domestic and stray cat control techniques.

Development of more effective and humane techniques to control feral cats must be actively encouraged and supported.

As a strategy, local eradication of feral cats is applicable only to small islands or small mainland sites that are surrounded by predator exclusion fences. Maintaining an area free from feral cats requires a sustained control operation to prevent reinvasion from surrounding areas. Buffer zones may be a necessary component of managing small areas, to reduce the threat from continual reinvasion by feral cats from surrounding areas. Development of such buffer zones will require the active participation of surrounding land managers and a clear identification of the benefits to be obtained by all participants. Significant benefits can be obtained through cooperative implementation of plans across different land tenures.

Where local eradication is not possible, two broad strategies can be used for localised management:

- (i) sustained management, where control is implemented on a continuing, regular basis; or
- (ii) intermittent management, where control is applied at critical periods of the year when damage is greatest and short-term control will reduce impacts to acceptable levels.

Sustained management is generally necessary for protecting habitats of threatened species or reintroduction sites. Intermittent management may be effective as a temporary seasonal measure to protect areas such as nesting or resting sites of migratory bird species. It may also be useful when transient feral cats are moving into an area where threatened species have been reintroduced, and during periods of drought, prey shortage, disease or other stress when the feral cat population is vulnerable and more likely to crash.

Recovery plans for some threatened species identify feral cats as a perceived threat. Where it has been confirmed that feral cats are a key threat for the species, control activities for feral cats are well justified. For other species, to ensure efficient and effective use of resources, an experimental approach must be used to determine the significance of feral cat predation in the decline of these species. By approaching feral cat control on an experimental basis, the true significance of predation by feral cats will be better understood. If the hypothesis that feral cats are a significant threat is confirmed, the control of feral cats in sites where the species occurs is justified. However if cat control is shown to be irrelevant to the recovery of the species, efforts can be redirected to other threat abatement.

Programs to control feral cats must be integrated with other pest control activities whenever possible. The pest species management series published by the Bureau of Rural Sciences (now Australian Bureau of Agricultural and Resource Economics and Sciences - ABARES) provides guidelines for the application of an integrated approach to pest management (Williams et al. 1995; Saunders et al. 1995; Braysher & Saunders 2003). The steps used by Braysher (1993) for planning and evaluating integrated pest management programs are as follows:

- Define the problem, including a measure of the deleterious impact
- Develop well-defined objectives, performance criteria and criteria for failure
- Identify and evaluate management options
- Implement the plan
- Monitor and evaluate the plan against its objectives.

A focus on integrated pest management and local action will provide a good mechanism for integrating feral cat control with other biodiversity conservation actions.

High priority must be given to monitoring the outcomes of feral cat control in terms of conservation benefits derived, not simply the feral cat kill rate. Ineffective control may result in high body counts but little reduction in predation if feral cats maintain a sustainably high reproductive rate, are bait-shy and trap-shy, or if populations are maintained through immigration. Even worse, Lazenby et al. (2015) found that at some of their study sites ad hoc low level culling of feral cats showed an increase the relative abundance and activity of feral cats, possibly due to the immigration of feral cats from surrounding areas.

When monitoring feral cat activity or abundances within a control program the information collected should be reported at a national level. A site such as the Atlas of Living Australia may be a suitable repository of these data. Collation of these data will allow a national picture to be developed of what action is being undertaken and the effectiveness of that action.

4.2 Identifying priority areas for action

It is important to identify native species and populations, particularly threatened ones that will benefit from feral cat control. Determining areas of high priority for these species or populations will maximise the conservation benefits derived from expenditure on feral cat control.

In addition, once areas are identified for control, the planning of the control program must optimise resources put into the program by knowing the optimal point where the benefits are maximised and also when management actions should cease (Parkes 1993). The level of variation in the system must also be known, to enable the effects of management action to be separated from the effects of environmental changes.

Figure 2 shows the density of mammal, reptile and bird species identified as threatened by predation by feral cats. The species shown on the figure are listed as threatened under the *Environment Protection and Biodiversity Conservation Act* (1999). This figure demonstrates how it is possible to use information on threatened species to identify areas to focus feral cat control effort. This map does not summarise all of the impacts of predation by feral cats because the threat from predation by feral cats is also dependent on other factors such as vegetation structure and fire regimes. As such, other data should be included in a prioritisation of locations.

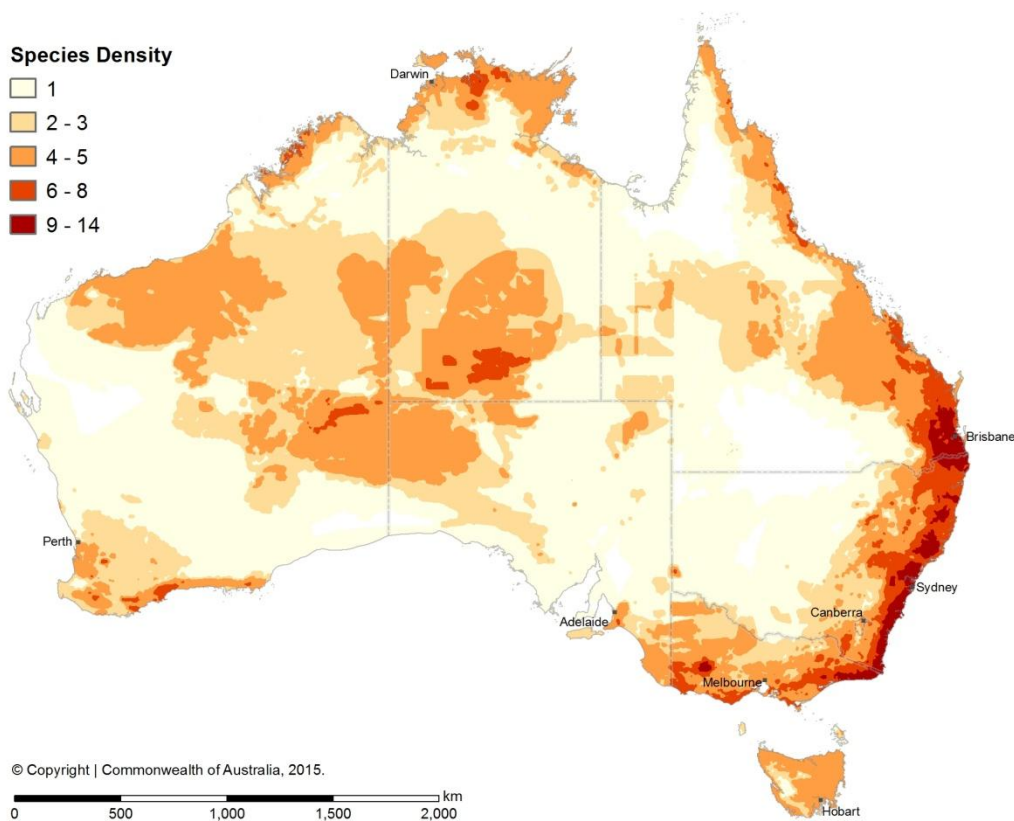


Figure 2 Map of EPBC Act threatened mammals, reptiles and birds threatened by cat predation.

Dickman et al. (2010) developed a more complex interactive decision-making tree to prioritise sites across Australia for the implementation of cat control programs. This decision-making tree is based on characteristics of prey species to provide a relative measure of probable feral cat impacts between sites on the Australian mainland and offshore islands. Scores are provided by geographical (Interim Bioregionalisation of Australia – IBRA) regions, specific mainland sites and offshore islands; and can be compared to allocate resources to sites for feral cat control. This prioritisation used the threatened species listed in the 2008 Threat abatement plan (Department of the Environment, Water, Heritage and the Arts 2008) against species lists for IBRA regions or, for smaller specific sites such as islands, data provided by land managers or in literature. It would be appropriate to repeat the assessment to reflect the changes since this time; including sites where additional threatened species have been identified and where feral cat control programs have been implemented. The decision-making tree could also be adapted to draw upon other datasets related to site values that were not available in 2010.

Regardless of the methodology used to develop national priority areas, some state or territory conservation agencies will necessarily identify higher priority sites in their jurisdictions based on their own threatened species lists or other priority species. These priority sites must also evolve with new information and experience to ensure an efficient national approach to the management of feral cats.

4.3 Implementation

Implementation of the Threat abatement plan for predation by feral cats and feral cat control more broadly within the national priority areas will need to be undertaken by everyone: the Australian Government, other governments, non-government organisations, researchers, industry, community groups and individuals within their particular sphere of expertise, capability or jurisdiction.

An element of implementation by the Australian Government will be through the establishment of a Feral Cat Taskforce in the Office of the Threatened Species Commissioner. The Taskforce will bring together government officials and key stakeholders to ensure effective implementation, monitoring and reporting on progress towards the goals of the threat abatement plan and targets related to feral cat predation. A key consideration of the Feral Cat Taskforce will be working with stakeholders to ensure that the management of other invasive species, such as European red foxes, rats and rabbits, is considered in areas where feral cat control is undertaken.

Included in the implementation of the threat abatement plan must be the implementation of recovery plans for threatened species affected by predation by feral cats. These plans lay out species specific actions related to feral cats that should directly lead to the recovery of the species. In combination, the implementation of these recovery plans should assist native fauna more broadly.

The tasks ahead for effective threat abatement from predation (and competition and disease transmission) by feral cats are to greatly increase our knowledge of feral cat impacts on wildlife and to develop better tactical methods for reducing those impacts. It is a long-term process, and the threat abatement plan offers a framework for undertaking these tasks.

Glossary

Biodiversity	Variability among living organisms from all sources (including terrestrial, marine and other ecosystems and ecological complexes of which they are part), which includes diversity within species and between species and diversity of ecosystems (Beeton et al. 2006).
Biodiversity conservation	The protection, maintenance, management, sustainable use, restoration and enhancement of the natural environment (Beeton et al. 2006).
Eradication	Application of measures to eliminate an invasive alien species from a defined area.
Exclosure / exclusion (fencing)	An area that is fenced to protect the native species within and to prevent the entry of introduced predators.
Felid	A member of the cat family.
Feral	An introduced animal, formerly in domestication, with an established, self-sustaining population in the wild.
Immunocontraception	The stimulation of the immune responses (antibody production and cell-mediated immunity) in the target animal against its own reproductive hormones, gamete proteins or another protein essential to reproduction, to induce sterility (Saunders and McLeod 2007).
Key threatening process	Under the EPBC Act, a process that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.
Recovery plan	Under the EPBC Act, a document setting out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities.
Threatened species	Refers to the Australian Government list of threatened native species divided into the following categories as per the EPBC Act: critically endangered, endangered, vulnerable, conservation dependent.

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Appendix A Threat abatement plans and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Extracts from the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and EPBC Regulations 2000 relating to the requirements for threat abatement plans.

Environment Protection and Biodiversity Conservation Act 1999

Section 271 Content of threat abatement plans

- (1) A threat abatement plan must provide for the research, management and other actions necessary to reduce the key threatening process concerned to an acceptable level in order to maximise the chances of the longterm survival in nature of native species and ecological communities affected by the process.
- (2) In particular, a threat abatement plan must:
 - (a) state the objectives to be achieved; and
 - (b) state the criteria against which achievement of the objectives is to be measured; and
 - (c) specify the actions needed to achieve the objectives; and
 - (g) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).
- (3) In making a threat abatement plan, regard must be had to:
 - (a) the objects of this Act; and
 - (b) the most efficient and effective use of resources that are allocated for the conservation of species and ecological communities; and
 - (c) minimising any significant adverse social and economic impacts consistently with the principles of ecologically sustainable development; and
 - (d) meeting Australia's obligations under international agreements between Australia and one or more countries relevant to the species or ecological community threatened by the key threatening process that is the subject of the plan; and
 - (e) the role and interests of indigenous people in the conservation of Australia's biodiversity.
- (4) A threat abatement plan may:
 - (a) state the estimated duration and cost of the threat abatement process; and
 - (b) identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan; and
 - (c) specify any major ecological matters (other than the species or communities threatened by the key threatening process that is the subject of the plan) that will be affected by the plan's implementation.
- (5) Subsection (4) does not limit the matters that a threat abatement plan may include.

Section 274 Scientific Committee to advise on plans

- (1) The Minister must obtain and consider the advice of the Scientific Committee on:
 - (a) the content of recovery and threat abatement plans; and
 - (b) the times within which, and the order in which, such plans should be made.

- (2) In giving advice about a recovery plan, the Scientific Committee must take into account the following matters:
 - (a) the degree of threat to the survival in nature of the species or ecological community in question;
 - (b) the potential for the species or community to recover;
 - (c) the genetic distinctiveness of the species or community;
 - (d) the importance of the species or community to the ecosystem;
 - (e) the value to humanity of the species or community;
 - (f) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.
- (3) In giving advice about a threat abatement plan, the Scientific Committee must take into account the following matters:
 - (a) the degree of threat that the key threatening process in question poses to the survival in nature of species and ecological communities;
 - (b) the potential of species and ecological communities so threatened to recover;
 - (c) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

Section 279 Variation of plans by the Minister

- (1) The Minister may, at any time, review a recovery plan or threat abatement plan that has been made or adopted under this Subdivision and consider whether a variation of it is necessary.
- (2) Each plan must be reviewed by the Minister at intervals not longer than 5 years.
- (3) If the Minister considers that a variation of a plan is necessary, the Minister may, subject to subsections (4), (5), (6) and (7), vary the plan.
- (4) The Minister must not vary a plan, unless the plan, as so varied, continues to meet the requirements of section 270 or 271, as the case requires.
- (5) Before varying a plan, the Minister must obtain and consider advice from the Scientific Committee on the content of the variation.
- (6) If the Minister has made a plan jointly with, or adopted a plan that has been made by, a State or self-governing Territory, or an agency of a State or self-governing Territory, the Minister must seek the co-operation of that State or Territory, or that agency, with a view to varying the plan.
- (7) Sections 275, 276 and 278 apply to the variation of a plan in the same way that those sections apply to the making of a recovery plan or threat abatement plan.

Environment Protection and Biodiversity Conservation Regulations 2000

Regulation 7.12 Content of threat abatement plans

For paragraph 271 (2) (g) of the Act, a threat abatement plan must state:

- (a) any of the following that may be adversely affected by the key threatening process concerned:
 - (i) listed threatened species or listed threatened ecological communities;
 - (ii) areas of habitat listed in the register of critical habitat kept under section 207A of the Act;

- (iii) any other native species or ecological community that is likely to become threatened if the process continues; and
- (b) in what areas the actions specified in the plan most need to be taken for threat abatement.

Appendix B Islands where feral cats have been eradicated

Islands where feral cats have been eradicated

ISLAND NAME	ISLAND GROUP	STATE
Lord Howe Island		NSW
Muttonbird Island		NSW
Althorpe Islands	Althorpe Islands	SA
Reevesby Island	Sir Joseph Banks Group	SA
Troubridge Island		SA
Little Green Island	Furneaux Group	Tas.
Macquarie Island		Tas.
Tasman Island		Tas.
Boatswain Island	Mud Islands	Vic.
Cliffy Island	Seal Islands	Vic.
Churchill Island		Vic.
Gabo Island		Vic.
Sunday Island		Vic.
Angel Island	Dampier Archipelago	WA
Dolphin Island	Dampier Archipelago	WA
Gidley Island	Dampier Archipelago	WA
Legendre Island	Dampier Archipelago	WA
Hermite Island	Montebello Islands	WA
Faure Island		WA
Rottneest Island		WA
Serrurier Island		WA

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