The Ecological Society of Australia Ltd (ESA, www.ecolsoc.org.au) is the peak group of ecologists in Australia, with over 1200 members from all states and territories. Our members work in universities and other research institutions, government departments, NGOs, private industry and consultancies. We are a national not-for-profit organisation formed in 1959.

Submission To:

Standing Committee On The Environment And Energy "Inquiry Into The Problem Of Feral And Domestic Cats In Australia" 23 July 2020

SUMMARY

The Ecological Society of Australia (ESA) is the peak body of ecological scientists in Australia.

The ESA welcomes the opportunity to comment on the problem of feral and domestic cats in Australia, to manage the increasing threat posed by cats to native biodiversity, as informed by the best science available. Australia is a world leader in the fields of monitoring invasive predators, modelling and quantifying invasive predator impacts on native wildlife and their habitats, and evaluating the ways in which nature recovers after invasive predators have been removed from an ecosystem. We draw upon this substantial scientific legacy to provide an overview of the science that is applicable to this Inquiry.

Based on the expertise of our membership, we pay particular attention to current evidence about biodiversity monitoring, invasive predator control and flora and fauna recovery, and stress the following critical messages related to the efficacy and cost-effectiveness of feral and domestic cat control measures for protecting and recovering native wildlife and habitats:

1. **Feral cats are among the most damaging invasive species worldwide**, and are implicated in many extinctions, especially in Australia. Each year in Australia, feral and domestic cats are estimated to kill approximately 647 million reptiles and 377 million birds (Woinarski et al. 2017, 2018). Many of the native species that cats prey upon are listed as threatened, and hence, understanding and reducing their impacts is a national and global conservation priority.
2. **Cats can cause significant and unsustainable losses of Australian biodiversity,** and the population suppression or elimination of cats from areas of biodiversity value is necessary for recovering some native species, particularly small- and medium-sized native mammals, reptiles and some birds. The evidence base supporting this includes experimental manipulations (including pest control trials), reintroductions, correlative studies and natural experiments, and historical research.
3. **The most urgent priority is to prevent the imminent extinction of native species** most imperilled by feral cat predation. Examples include the Critically Endangered woylie *Bettongia penicillata*, mountain pygmy possum *Burramys parvus*, Kangaroo Island dunnart *Sminthopsis aitkeni*, central rock rat *Zyzomys pedunculatus*, and western ground parrot *Pezoporus flaviventris* (Woinarski et al. 2014). Captive breeding

programs, translocations to safe havens (feral cat exclosures or islands) or intense lethal control of feral cats may be necessary interventions.

4. **The effectiveness of cat management approaches can be improved** through centralised and cross-jurisdictional coordination of legislation and management. The best scientific evidence is essential to inform management approaches. Scientific approaches to inform management include prioritisation of eradication efforts (Helmstedt et al. 2016), optimisation of the order in which multiple invasive species are removed (Bode et al. 2015), refining monitoring protocols and designs (Geyle et al. 2020), and determination of optimal fence locations (Bode et al. 2012) and arrangements (Helmstedt et al. 2014). The longer-term aim of re-establishing populations in unfenced mainland areas relies on new management approaches to reduce predation risk from feral cats and foxes sufficiently, and includes efforts directed towards preserving habitat complexity through careful management of fire regimes and grazing pressure (livestock, feral herbivores and some overabundant populations of kangaroos and wallabies) and reducing land clearing (Doherty et al. 2015b; Hradsky et al. 2020; Stobo-Wilson et al. 2020).
5. **Research and management priorities** are to: prevent feral cats from driving threatened species to extinction; assess the efficacy of new management tools trial options for mitigating cat impacts via ecosystem management (e.g. controlling their introduced prey (rabbits) and providing shelter for native species); and increase the potential for native fauna to coexist with feral cats (see Miritis et al. 2020). Managing interactions between processes such as fire and grazing of critical habitat is key to successful management of feral cats.
6. **Lack of strategic, long-term, coordinated and standardised monitoring programs evaluating management and policy effectiveness creates significant knowledge gaps** and undermines the capacity for informed and effective environmental decisions and actions to manage the impacts of feral and domestic cats in Australia.

RESPONSES TO TERMS OF REFERENCE A, B, D, E AND G

TOR A: the prevalence of feral and domestic cats in Australia

The first and most comprehensive collation of 91 site-based feral cat density estimates in Australia determined that the population size of feral cats in natural environments fluctuates between 1.4 and 5.6 million, depending on rainfall (Legge et al. 2017). The lower estimate of 1.4 million (95% confidence interval: 1.0–2.3 million) is expected after continent-wide droughts, and the upper estimate 5.6 million (95% CI: 2.5–11 million) after extensive wet periods. The same study (Legge et al. 2017) estimated a further 0.7 million feral cats (i.e. unowned, non-domestic cats) occur in Australia's highly modified environments (urban areas, rubbish dumps, intensive farms). Feral cat

densities are higher on small islands than the mainland, but similar inside and outside conservation land (Legge et al. 2017).

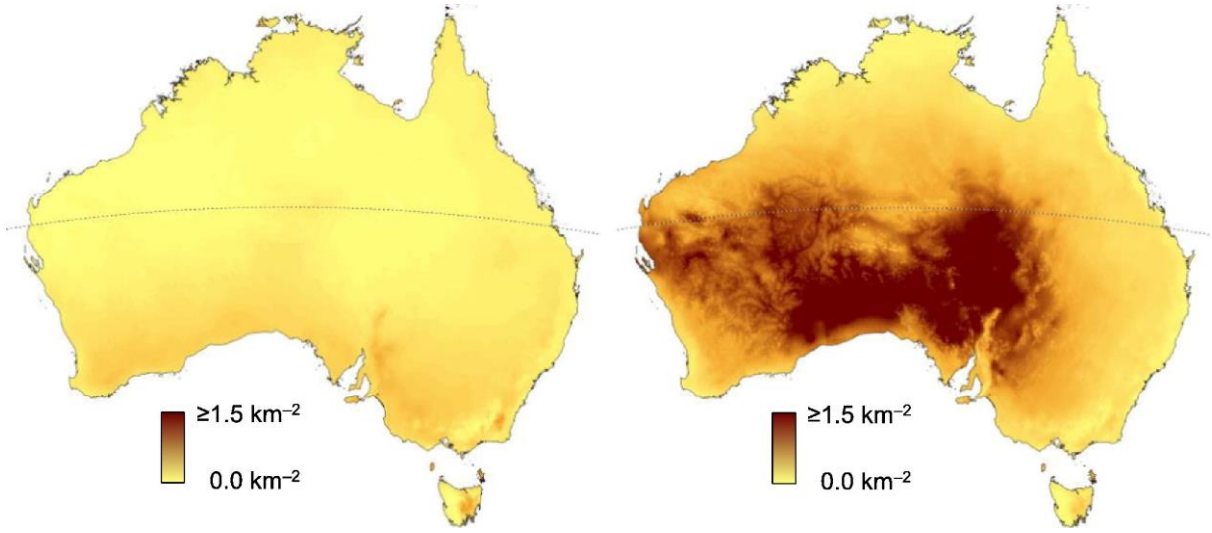

Figure 1. Predictions of cat density in natural environments across Australia during dry-average rainfall conditions (on the left) and after extensive rainfall events (on the right), from Legge et al. (2017).

Unlike feral cats, there has been no scientific review of the prevalence of domestic cats in Australia. However, based on a 2019 survey of pet ownership, it is estimated that 27% of households in Australia own cats (Animal Medicines Australia 2019). This translates to an estimated 3.3 million domestic (owned) cats in Australia (Animal Medicines Australia 2019).

TOR B: the impact of feral and domestic cats including on native wildlife and habitats

Feral cats are among the most damaging invasive species worldwide. Feral cats are implicated in species extinctions in Australia, New Zealand and other islands. In Australia, the most well understood and significant impact of feral cats is predation on threatened mammals (Doherty et al. 2015a). Other documented impacts include predation on other animals, resource competition, disease transmission, and compounding of the impacts from other threats such as changed fire regimes and pastoralism (Denny and Dickman 2010, Doherty et al. 2015b, Doherty et al. 2017):

- **Species extinctions**

  Although the causes of some historic extinctions are difficult to elucidate, scientific evidence from multiple sources suggests cats as the principal causes of extinction for more than 20 Australian species. Evidence comes from dietary and predation studies, comparative analyses of correlates of declines, spatial and temporal analyses of declines, and predator manipulation experiments.

Ecological monitoring and surveys have documented cases across Australia where mammals (e.g. Burbidge and McKenzie 1989, Smith and Quin 1996) and, in some cases, birds (Whitlock 1923) have declined rapidly following feral cat arrival or increases in local abundance. Based on historical evidence of cat arrival times and native species population declines, Dickman et al. (1993) concluded that feral cats were the sole or primary cause of extinction of 10 species of small (<220 g) mammals in western New South Wales in the early 1800s.

Feral cats are considered to have been a major cause of the extinction of 22 Australian endemic mammals, including the lesser bilby *Macrotis leucura* and five species of hopping mouse *Notomys* species (Woinarski et al. 2015). Feral cats threaten a further 75 threatened or near-threatened mammals (Woinarski et al. 2015).

Feral cats were also the principal cause of extinction of at least one Australian bird subspecies (Macquarie Island red-fronted parakeet *Cyanoramphus novaezelandiae erythrotis*), and potentially threaten 40 bird, 21 reptile and four frog species at risk of extinction, including the western ground parrot *Pezoporus flaviventris* and the great desert skink *Liopholis kintorei* (Doherty et al. 2017).

- **Predation on mammals**

  Feral cats are known to consume at least 400 vertebrate species and many invertebrates in Australia (Doherty et al. 2015a) with certain native animals preferentially eaten by cats. For example, Spencer et al. (2014) showed that long-haired rats *Rattus villosissimus* and central short-tailed mice *Leggadina forresti* were selectively preyed upon by feral cats, even when these native rodents were at very low population densities. At Dryandra Woodland, feral cats were responsible for 65% of predator kills in two rapidly declining populations of the threatened woylie *Bettongia penicillata* (Marlow et al. 2015).

  Multiple experimental studies controlling feral cats and monitoring the responses of native mammals have shown improvements in native mammal populations when cats are effectively removed (Box 1). These results are mirrored in fenced predator-free reserves. When declining mammal populations have been protected by fencing areas off and excluding feral cats and foxes, the abundance of threatened native mammals such as the pale field rats *Rattus tunneyi*, golden bandicoot *Isoodon auratus* and greater bilby *Macrotis lagotis* has stabilised and, in many cases, increased (Doherty et al. 2017, Moseby et al. 2011). At the same time, native mammals outside these cat-proof exclosures have declined (Frank et al. 2014, Tuft et al. 2014, Moseby et al. 2011). A review of translocation successes and failures in Australia showed that the single biggest influence on translocation success of native mammals in Australia is the presence or absence of cats and foxes at release sites (Clayton et al. 2014).

Box 1: Experimental Evidence for the Negative Impacts of Feral Cats on Native Mammals

Experimental studies show that when feral cats are removed from the landscape, native mammal numbers increase. For example, in the Simpson Desert in western Queensland, live trap capture rates of the sandy inland mouse *Pseudomys hermannsburgensis* increased by 42% following the removal of feral cats and foxes, whereas capture rates declined by 63% on experimental control plots where the predators remained (Mahon 1999). At Heirisson Prong in Western Australia, live trap capture rates of small mammals declined by 80% in a low fox and high cat density treatment, whereas they doubled in population when fox and cat populations were both kept low, and were intermediate in a control area with moderate densities of cats and foxes (Risbey et al. 2000). At Arid Recovery, the abundance of native rodents in a fenced reserve with no feral cats, foxes, or rabbits was 15 times higher than outside the reserve (Moseby et al. 2009).

The most striking evidence for the impacts of feral cats on Australian native mammals comes from Australia's Threatened Mammal Index (https://tsx.org.au/visualising-the-index/2019-tmx/; Figure 1), a project funded by the Australian Government National Environmental Science Program's Threatened Species Hub. In 2019, the Threatened Mammal Index team calculated trends for 57 mammal taxa at 1,186 monitoring sites between 1995 and 2016, and found that, at a continental scale, mammals declined 60% on average at sites without conservation management. In contrast, mammals in feral cat-free havens (islands and fenced reserves) increased fivefold over the same period (Figure 2).

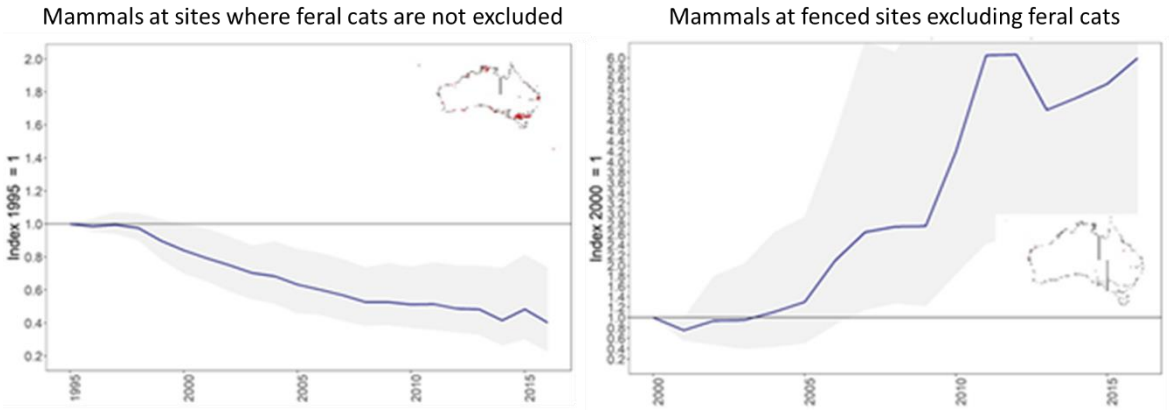

Figure 2. Trends in threatened mammal abundances across Australia in locations where feral cats have not been excluded (left) compared with where feral cats were excluded (either islands or cat-free exclosures)

- **Predation on other animals (e.g. birds, reptiles)**

  Cats are reported to predate at least 258 Australian reptile species (about one-quarter of described species), including 11 threatened species (Woinarski et al. 2018). Additionally, feral cats tend to have significantly higher proportion of birds in their diet compared to other main mammalian predators such as foxes.

Recent studies modelled and mapped the number of birds and reptiles killed by feral cats in Australia using data from 93 Australian studies of cat diet (collectively>10 000 samples) and previous ecological studies estimating the feral cat population size in different locations (Woinarski et al. 2017, Woinarski et al. 2018). They found that each feral cat in the Australian bush kills about 740 vertebrate animals per year on average, including birds, mammals and reptiles (Woinarski et al. 2019). Meanwhile, each domesticated cat kills about 75 animals annually, on average (Woinarski et al. 2019).

In total, it is estimated that all the feral cats in Australia's natural environments consume an average of 466 million reptiles and 272 million birds each year (Woinarski et al. 2017, Woinarski et al. 2018). The number of reptiles and birds killed by cats is highest in hot, arid regions. However, cat predation rates on native animals substantially vary between years, depending on changes in the cat populations that are driven by rainfall conditions. After wet periods they kill even more native animals - up to 1006 million reptiles and 757 million birds (Woinarski et al. 2017, Woinarski et al. 2018). After dry periods, the number of birds killed per year averages 161 million because cat densities decrease (Woinarski et al. 2017). When averaged across the whole continent, feral cats kill 61 reptiles and 35.6 birds per square kilometre per year (Woinarski et al. 2017). An individual feral cat kills 225 reptiles and 129 birds each year, 99% of which are native (Woinarski et al. 2017, Woinarski et al. 2018).

Combining predation rates by both feral and domestic cats leads to a total of 649 million reptiles and 377 million birds killed each year. This is equivalent to over 1.75 million reptiles and over 1 million birds killed per day. The annual estimates include approximately 130 million reptiles and 44 million birds killed by feral cats in highly modified places like cities, and 53 million reptiles and 61 million birds killed by domestic cats (Woinarski et al. 2017, Woinarski et al. 2018).

Cats on islands have an even greater impact on native wildlife. The average rates of predation by cats on birds on islands are about 10 times higher than for comparable mainland areas (Woinarski et al. 2017).

For domestic cats, pet owners reported an average of 8.0 birds observed to be taken home as prey per cat per year in a sample of 700 cats from mainly around Adelaide (Paton 1990, 1991, 1993), 2.3 in Canberra from a sample of 138 cats (Barratt 1997), and 3.3 in Hobart from a sample of 166 cats (Trueman 1991) – i.e. an average of 4.53 birds per year across these studies.

- **Resource competition**
  Scientific studies have shown that the diets and home ranges of feral cats overlap with native mammal and bird predators, which likely leads to competition between feral cats and native animals for resources. Impacted native animals include quolls *Dasyurus* species, Tasmanian devils *Sarcophilus harrisii*, raptors such as letter-winged kites *Elanus scriptus*,

and *Varanus* reptiles (Glen and Dickman 2008, Glen et al. 2011, Pavey et al. 2008). However, no studies have experimentally investigated the extent, or the potential impacts, of resource competition.

- **Disease transmission**
  Thirty-six pathogens or diseases have been recorded from Australian feral cats (Henderson 2009). The parasite *Toxoplasma gondii* is the most significant and well-studied, due to its potentially harmful effects on humans, wildlife and livestock. Infection with *Toxoplasma gondii* can cause death in some marsupials (e.g. Bettiol et al. 2000), but the prevalence and clinical effects of *Toxoplasma gondii* infection in native species are poorly understood (Hillman et al. 2016). *Toxoplasma gondii* infection may also increase predation risk in infected mammals, either by altering their behaviour or decreasing their fitness. More research is needed to better understand the biological and ecological contexts in which native species are susceptible to, and adversely affected by, *Toxoplasma* infection (Hillman et al. 2016).

- **Interacting and indirect impacts on wildlife and habitats**
  Feral cat impacts vary over time and space depending on the extent of other threats to biodiversity such as frequent fire or intense pastoralism (Doherty et al. 2015b, Hradsky et al. 2020; Stobo-Wilson et al. 2020). Evidence from comparative scientific studies of native mammals in habitats differently affected by these threats and cats suggests that cat impacts are greatest in habitats with less vegetative ground cover (Burbidge and McKenzie 1989, Burbidge and Manly 2002, Fisher et al. 2014, Lawes et al. 2015).

  The impacts of feral cats on native animals may be particularly high in recently burnt areas (Geary et al. 2020, Hradsky et al. 2017). In Australian tropical savannas, feral cats preferentially hunt in recently burnt and heavily grazed areas (McGregor et al. 2014). Their hunting success is higher in these relatively open areas (McGregor et al. 2015) with predation rates on rodents being greater in burnt areas than in unburnt areas (Leahy et al. 2016).

  By causing or contributing to the extinction of many native mammal species, feral cats have indirectly affected multiple ecological processes. Many extinct mammal species in Australia dug prolifically to forage or construct burrows (Fleming et al. 2014). Reduced disturbance to litter and topsoil following the loss of digging mammals has led to landscapes with reduced organic matter accumulation, water retention, fungal diversity, seed germination and seedling establishment (reviewed by Fleming et al. 2014).
  In some circumstances, feral cats reduce impacts from other threats, for instance, by controlling introduced rodents and rabbits (Dickman 2009).

TOR C: the effectiveness of current legislative and regulatory approaches

There is a lack of scientific evidence supporting the effectiveness of current legislative and regulatory approaches due to (a) inconsistent regulation and management of feral cats within and across jurisdictions, (b) a lack of long-term ecological monitoring comparing places with and without feral cat regulation, and (c) recency of state, territory and local strategies and policies, which have not had enough time to take effect and be effectively evaluated.

(a) inconsistent regulation and management of feral cats within and across jurisdictions, inconsistent management across jurisdictions

Predation by feral cats was listed as a key threatening process under Australian legislation in July 2000. Feral cat management is coordinated broadly through a *Threat Abatement Plan* developed by the Department of Agriculture, Water and the Environment. Responsibility for managing feral cats therefore lies with the Commonwealth (Australian) Government as well as with individual States and Territories under their jurisdictional environmental laws. However, controlling feral cats is challenging, and eradication from mainland Australia is currently impossible (Denny and Dickman 2010).

Current legislative and regulatory approaches for controlling feral and domestic cats vary depending on the jurisdiction. At the State and Territory level, feral cats are declared as pests in some jurisdictions but not others (Woinarski et al. 2019). This variable declaration status likely affects the effectiveness of legislative and management approaches to reduce cat impacts on native wildlife and habitats. In the Australian Capital Territory, revisions to the *Domestic Animals Act 2000* include cat containment regulations in a number of Canberra's suburbs. However, in New South Wales, the *Companion Animals Act 1998* does not enforce state-wide cat confinement, and cats from NSW can easily move in and out of the ACT, potentially reducing the effectiveness of the ACT's *Domestic Animals Act 2000* cat confinement regulation.

Even within jurisdictions there are inconsistencies in policies that impede the effectiveness of feral cat management strategies. In Western Australia, for example, the *Animal Welfare Act 2002* provides a defence against a charge of animal cruelty for killing pest animals (defined as an animal declared as such in sections 12 or 22 of the *Biosecurity and Agriculture Management Act 2007*). However, the WA *Biosecurity and Agriculture Management Act 2007* does not list feral cats as pests, meaning that landowners and land managers who lethally control feral cats could be prosecuted under the *Animal Welfare Act 2002*.

Most Australian States and Territories have recently developed, or are in the process of developing, comprehensive cat management strategies, but like jurisdictional legislation, these are not coordinated across jurisdictions and have inconsistencies that could reduce their effectiveness. The 2017 Tasmanian Cat Management Plan is a good example of a comprehensive management strategy (Biosecurity Tasmania 2017). It includes many positive steps towards minimising feral cat impacts, such as proposing legislative changes that mandate compulsory desexing and microchipping of all cats, and fewer constraints on land managers killing cats. However, it does not include recommendation for legislative change to enforce containment for pet cats.

(b) a lack of long-term ecological monitoring comparing places with and without feral cat regulation

Successive national State of the Environment reports have noted the absence of suitable environmental data to appropriately assess the state and trends of Australian wildlife and habitats. The inadequacy of current biodiversity monitoring and data collation in Australia (Legge et al. 2018a) means that it is difficult to know if feral and domestic cat regulations are achieving their goals. Current regulations at all levels of government (including the *Environment Protection and Biodiversity Conservation Act 1999*) do not require mandatory monitoring in relation to threatened species and key threatening process management. Mandatory monitoring would place Australia's legislation in line with endangered species legislation in other developed nations.

Increased investment and legislation mandating monitoring of biodiversity is required to effectively assess regulation and legislation related to feral and domestic cats. Coordination of monitoring should be through an independent national environmental authority, in cooperation with State and Territory environmental management agencies (Ecosystem Science Council 2019).

(c) recency of state, territory and local strategies and policies, which have not had enough time to take effect and be effectively evaluated

At the local level, there is an increasing trend for more councils imposing more regulations on domestic cats, such as cat confinement legislation that may include enforced desexing, limitations of cat numbers per household, nocturnal curfews, an obligation to register pet cats, and exclusion of cats from public areas of high conservation value (Grayson and Calver 2004, Algar et al. 2004). However, regulations are implemented with varying levels of enforcement and success (Grayson and Calver 2004). There has been little monitoring of these policies, so it is difficult to ascertain their effectiveness. In one Victorian council (Sherbrooke), following implementation of cat curfews, there was some decrease in the incidence of injured wildlife brought into local vets and a reported decrease in injuries to pet cats (Pergl 1994).

Most councils have local regulations preventing the abandonment of cats. These laws may constrain the trial and implementation of Trap-Neuter-Return programs that are predicated on the return of unowned cats to their capture site after they have been neutered (Woinarski et al. 2019). Until continual long-term monitoring of these policies come into effect, it is difficult to evaluate their effectiveness on protecting biodiversity while reducing cat impacts.

TOR D: the effectiveness of Commonwealth action and cooperation with states and territories on this issue, including progress made under the Threat Abatement Plan, national framework and national declaration relating to feral and domestic cats in Australia

See our response to TOR C.

TOR E: the efficacy (in terms of reducing the impact of cats), cost effectiveness and use of current and emerging methods and tools for controlling feral cats, including baiting, the establishment of feral cat-free areas using conservation fencing, gene drive technology.

Despite the variety of control options available for managing feral and domestic cat impacts, in most of Australia there is no management of cats (Garrard et al. 2017). Current methods of cat control kill an estimated ~210,000 per year (Garrard et al. 2017) – this represents less than 10% of the total feral cat population (Legge et al. 2017). This level of cat control is unlikely to confer benefits to predator-susceptible populations of native species unless carried out in a coordinated and consistent manner (Garrard et al. 2020).

(a) Feral cat-free areas on islands and in fenced exclosures

Cat exclusion through the establishment of feral cat-free areas, either on islands or in exclosures of conservation fencing (known as "safe havens"), has been shown to recover native mammal populations (see Figure 2). Relative to other protection measures, "safe havens" are the most effective option for protecting native species sensitive to predation by cats (Legge et al. 2018a). Currently, nine mainland mammal taxa are now known to only persist within mainland fenced areas and/or on offshore islands where cats have been removed or excluded (Woinarski et al. 2014, Legge et al. 2018b). However, these "island arks" are risky. They can be prone to resource depletion and competition between recovering animals. They impede movement of large wildlife (e.g. kangaroos and emus), and create cat "naïve" prey, that are not adapted to living in the presence of invasive predators (Miritis et al. 2020, Jolly et al. 2018).

Cat-free exclosures are also immensely expensive. They require considerable initial investment in fencing, the removal of cats inside the exclosure, plus ongoing maintenance of fencing and management of cat incursions if fences fail. Exclosure fencing requires an upfront cost typically around $15,000/km for fence materials, while additional costs for site preparation and labour may add up to $40,000/km or more (Clapperton and Day 2001, Bode and Wintle 2010, Bode et al. 2012, Hayward et al. 2014, Helmstedt et al. 2014). Then there is the cost of feral cat eradication which range from $1,500-$2,500 per km^2 (Clapperton and Day 2001, Helmstedt et al. 2014). Taken together, a fenced area of $1km^2$ would cost about $120,000 to establish. The costs of eradicating cats even on islands without fencing requirements can range from $600/$km^2$ (for Faure Island, Algar et al. 2010) up to $26,000/$km^2$ (for Macquarie Island in 2009, Campbell et al. 2011). These costs increase with island area, accessibility and distance from the servicing airport (Martins et al. 2006).

The current distribution and species representativeness of cat-free exclusion areas (fenced reserves or islands) is sub-optimal (Ringma et al. 2018, 2019), mainly due to the decentralised expansion of these areas and lack of coordination across organisations and jurisdictions. Some species are not represented "safe haven" networks. Of the 66 threatened mammal taxa that are highly susceptible to predation by cats and/or foxes, 38 are represented across 103 islands (that's a total of 2,188 km^2 free of feral predators) and 15 mainland exclosures (324 km^2) (Legge et al.

2018b, Woinarski et al. 2014). Thus, nearly half of the species and subspecies needing a haven do not have one (Ringma et al. 2018, 2019).

There are many opportunities to increase the use of cat-free islands to recover native wildlife populations that have declined due to cat impacts on the mainland (Woinarski et al. 2019). Of the 592 Australian islands known to be cat free, only 101 are known to currently support populations of mammal species vulnerable to predation by cats (Legge et al. 2018b). Many of the remaining islands are suitable for translocation of cat-sensitive species. A more coordinated, centralised approach to designating cat-free exclusion areas at a national scale is necessary.

(b) Lethal control in unfenced areas

In unfenced areas of Australia, aerial poison baiting can provide landscape-scale control of feral cats (e.g. over an area of 2,350 km^2; Algar et al. 2013). In arid and semi-arid Australia, the efficacy of feral cat baiting is highest when prey availability is lowest (Christensen et al. 2013). Baiting operations may fail if high rainfall before baiting elevates prey populations (Johnston et al. 2012, Tulloch et al. 2020).

Use of poison baits is constrained in some parts of Australia due to risks to non-target species. In Tasmania, there is the risk that already threatened Tasmanian devils might eat and be killed by poison baits. Additionally, feral foxes and dingoes/dogs often consume baits more readily than feral cats (Algar and Burrows 2004), meaning that baiting could actually have the unwanted effect of increasing feral cat numbers if dingoes/dogs and foxes that suppressed them are removed from the landscape (Risbey et al. 2000, Brook et al. 2012, Wang and Fisher 2013, Marlow et al. 2015, Wysong et al. 2020).

Feral cat baiting operations must use integrated, multi-species approaches to avoid perverse effects, such as increased cat populations (Doherty et al. 2017). Baiting will only be effective if timed to avoid the negative impacts of weather (Tulloch et al. 2020), and if carried out strategically to accomplish large and consistent reductions in feral cat densities. Otherwise, rapid immigration of cats in neighbouring areas will replace the killed individuals (Lazenby et al. 2014, Lieury et al. 2015). Toxin resistance can also build up in baited cat populations, further reducing its effectiveness (e.g. Twigg et al. 2002).

(c) Gene drive technology

Although in its infancy, gene drive technology also may be able to induce sex bias or toxin sensitivity in target species through genetic modification (Strive and Sheppard 2015). A major challenge in developing new biocontrols is the need to reduce risks of infection for pet cats and felids in other parts of the world. Investment in biocontrol research may facilitate the development of an effective, long-term control tool.

(d) Other developing options for controlling cats

Recent innovative research efforts have led to important advances in techniques available for controlling feral cats. These include guardian dogs, more judicious management of habitat structure, fire and grazing (McGregor et al. 2014), re-wilding of the landscape with dingoes (Wallach et al. 2010, Allen and Fleming 2012, Glen 2012, Dickman et al. 2014a), 'training' of

threatened native mammals to make them more wary of cats as predators (Atkins et al. 2016, West et al. 2018), and coordinated management efforts that integrate feral predator management with management of other pests impacts by those predators, such as rabbits (Bergstrom et al. 2009a, Pedler et al. 2016, Dowding et al. 2009).

Guardian dogs are bred and trained to accompany livestock and protect them from predators. In Australia, guardian dogs effectively prevent predation on livestock by wild canids (van Bommel 2010). Applications of guardian dogs to wildlife conservation have not been explored in Australia, except for two cases in which Maremma sheepdogs eliminated predation by foxes on breeding colonies of little penguins *Eudyptula minor* and gannets *Morus serrator* in south-west Victoria (van Bommel 2010). It is not known whether guardian dogs may likewise reduce the impacts of feral cats, nor whether the model can be extended from colonial seabird species to wider ranging, solitary, and nocturnal mammal species.

Habitat structure modifies species' vulnerability to predation (Burbidge and McKenzie 1989, Fisher et al. 2014, Lawes et al. 2015). Reduction in ground or understorey vegetation cover by fire and grazing can make prey species more vulnerable to predators (McGregor et al. 2014, 2015, Hradsky 2016, Leahy et al. 2016). Appropriately managing grazing and fire should increase the ability of at least some species to coexist with predators (Doherty et al. 2015b). Experiments with landscape-scale fire and grazing in northern Australia show that management of these two habitat modifiers can boost native mammal populations even without feral cat control (Kutt and Woinarski 2007, Legge et al. 2011), probably by reducing the impacts of cats (McGregor et al. 2014, 2015, Leahy et al. 2016) and by increasing resource availability.

As for legislative responses to the cat problem, the efficacy of new management initiatives to reduce cat impacts is uncertain due to their recency and a lack of coordinated investment in monitoring and evaluation of Australian wildlife responses to management. Longer-term monitoring of these policies is critical in determining their effectiveness.

TOR G: public awareness and education in relation to the feral and domestic cat problem

In Australia, studies have shown that there is a relatively high public awareness of, and concern about, the impacts of cats on native wildlife(Zito et al. 2015, Hall et al. 2016a). Surveys have shown that most Australians recognise that feral and domestic cats have significant undesirable impacts on wildlife (62% of cat owners and 95% of non-owners agree that they are a serious problem), and that most Australians support lethal management (Hall et al. 2016a, Travaglia and Miller 2018). Australians also show more support for legislation constraining pet cats than respondents in other countries (Hall et al. 2016a), and for the establishment of cat-free areas in and around sites of importance for native wildlife.

Despite the awareness of the feral and domestic cat problem in Australia, a review of management options for pet cats in the ACT (Eyles and Mulvaney 2014) found that more public education is needed. This includes education relating to responsibilities of owners of pet cats and those people feeding stray cats, biodiversity impacts of pet cats, and enforcement of existing legislation. Public awareness measures in cities and towns are especially important given that the

impacts of domestic cats are considered by the public to be of lower magnitude than those of feral cats (Travaglia and Miller 2018). This is despite the fact that each domesticated cat kills about 75 animals annually in and around urban areas, which are also hotspots of native wildlife (Woinarski et al. 2017, 2018, 2019).

TOR H: the interaction between domestic cat ownership and the feral cat problem, and best practice approaches to the keeping of domestic cats in this regard.

Around settled areas, populations of feral cats are supported by provision of food sources and recruitment from pet and stray cats; and pet and stray cats cause at least localised biodiversity impacts. However, there is no coherent management of pet and stray cats across local and state/territory governments, and many cat owners have little awareness of these impacts, or of the extent of the conservation problem imposed by feral cats more broadly. There is likely to be little community support for programs aimed at the extensive management of feral cats unless that awareness is increased. Research into understanding human perceptions of cat control and protection of biodiversity, and how best to communicate feral and domestic cat management are critical in gaining community support.

The Royal Society for the Prevention of Cruelty to Animals (RSPCA) recognises that "a coordinated approach to the management of feral and domestic cats is essential to ensure that laws and strategies are complementary, not opposing" (RSPCA 2018).

FOR FURTHER INFORMATION

The ESA welcomes the opportunity to provide further information to this Parliamentary Inquiry or to discuss our submission in more detail. We may be contacted using the details below:

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