CENTRE FOR
INVASIVE SPECIES SOLUTIONS

Committee Secretary
Standing Committee on the Environment and Energy
PO Box 6100
Parliament House
Canberra ACT 2600

30 July 2020

Dear Committee Secretary

Thank you for the opportunity to provide a submission to the Standing Committee on the Environment and Energy's inquiry into *the problem of feral and domestic cats in Australia.*

About the Centre

The Centre for Invasive Species Solutions (CISS) is one of the world's largest pest animal RD&E collaborations. Our current collaboration involves 17 government, industry and research provider partners. Our first vertebrate pest focused RD&E portfolio was launched in September 2018, and we have scoped a 10-year weeds RD&E investment plan. Information on the Centre and its Strategy is available at www.invasives.com.au.

CISS plays a leadership and enabling role in relevant National Biosecurity System collaborative RD&E initiatives and develops new knowledge, tools and practices to continually improve best practice invasive species management. We currently facilitate 40 collaborative projects involving environmental, community and agriculturally based invasive species issues across the entire invasion curve. CISS is maintaining the knowledge and innovation momentum gained through the national collaborative research pursued through the Invasive Animals Cooperative Research Centre and its participants.

Relevant to this submission, CISS, and its predecessor, the Invasive Animals Cooperative Research Centre has been a significant facilitator of large-scale collaborative feral cat research and research into the drivers of behaviour in domestic cat owners. We facilitated the national feral cat workshops in 2008, 2010 and 2015. Apart from cat specific research, our non-species-specific research is also relevant to cat management issues under the purview of your Committee's inquiry. A copy of the proceedings of the 2015 workshop is attached for the information of the committee.

CISS research collaborations have been instrumental for the conceptualisation, development and release of a range of new tools that have reduced the impact of invasive species in Australia and

internationally. These tools range between digital platforms to facilitate community engagement and participation in cooperative regional management programs, including feral cats, to biological control agents for rabbits - Australia's most costly invasive species – and carp, and new toxins and baits delivery systems for managing foxes, wild dogs and feral pigs to minimise the impact of these species on agriculture and the environment.

General Comments

CISS is a strong advocate for best practice strategic management of invasive species at a scale that is appropriate to best mitigate their impact. For most invasive species, including feral cats, management action needs to be undertaken at the landscape scale to have measurable sustained impact. Similarly, best practice requires that the focus of any management intervention be on minimising the impact of the invasive species rather than, simplistically, on reducing the number of pest species present. This outcome-based approach allows an effective, integrated, landscape scale approach to invasive species management resulting in a greater reduction of impact across all environmental, agricultural and community sectors. CISS is active is developing and enhancing best practice management for invasive species and maintains an openly accessible best practice management toolkit available through www.PestSmart.org.au .

Background

There has been a complex and changing relationship between humans and felids during the past 10 000 years. Nearly 40% of all felid species have been tamed by humans over the millennia however only one species has been domesticated and there is evidence that this domestication may have taken place on multiple occasions in separate locations. By the time of the ancient Egyptians, there is evidence of domestic cats being bred and raised as part of households. The domestic cat subsequently spread across Europe with the expanding Roman empire some 2 000 years ago. Subsequent movements of humans and their associated domestic animals have spread the cat around the globe. By the time of the industrial revolution, owners were selectively breeding their cats to form new breeds of the domestic cat.

There are many hypotheses as to how the cat arrived in Australia. These range from arriving with indigenous people as much as 50 000 years ago to Macassan trepangers, or as the result of European ships being shipwrecked on the barren coasts of western and northern Australia. There is little evidence to support any of these claims. It is highly likely that the domestic cat did not arrive in Australia until European settlement with it spreading across the landscape as European settlement progressed inland. Through a succession of intentional and unintentional releases, the cat now occupies all areas of the Australian mainland, Tasmania, and many offshore islands.

Feral cats have extensive negative impacts on both the agricultural and environmental sectors in Australia. Cats are the definitive host of parasites that cause the diseases of toxoplasmosis and sarcocystis. Toxoplasmosis in particular impacts the agricultural sector through loss of productivity in

sheep herds due to disease induced abortions and loss of fitness. Toxoplasmosis also has the potential to negatively impact on human health. Sarcocystis infection requires the trimming of valuable muscle mass from sheep carcasses following slaughter. These diseases also cause negative impacts to Australian native species populations.

Feral cats have been implicated in the decline and extinction of a number of Australian native species and predation by feral cats is recognised as a major threatening process to the majority of threatened native mammals and birds. Domestic cats also depredate on native species and their impact can be greater than that of feral cats as they are a subsidised predator.

Despite this, the cat occupies a unique position in society in being both a loved family pet and a loathed invasive predator. Feral cats are often perceived within the community as a significant threat to native wildlife and most community surveys show a high level of support for managing feral and urban cat populations [1], there are other attitudes that can disrupt or impair attempts to manage cats such as the incorrect perception that feral and domestic cats are two separate species or through misplaced affection for feral cats.

While CISS, and its predecessors, the Invasive Animals Cooperative Research Centre, has undertaken collaborative research into both feral and domestic cats in Australia, our submission to the Inquiry will focus primarily on feral cats.

Invitation

The Centre for Invasive Species Solutions would be available to attend the Inquiry either in person or via video link to provide expert advice and commentary to the inquiry and to answer questions from Senators.

Recommendations

1. **Legislation and policy should not form an impediment to the formation of national collaborative approaches to the management of feral and domestic cats.**
2. **Feral cats should be managed as part of a landscape scale integrated predator management approach to ensure that unintended consequences from single species management are avoided.**
3. **Indirect management of feral cats through the continued use of rabbit biocontrol should be considered an essential component of integrated predator management programs where rabbits are prevalent.**
4. **There should be continued support to take forward work on strategic planning for a genetic biocontrol for feral cats as part of a broader vertebrate pest genetic biocontrol research and innovation program.**

5. **All applications to import hybrid and/or high-risk cat species undergo a risk assessment conducted by a suitably qualified and independent assessor to determine if they pose a risk to Australian native species.**
6. **That the effectiveness of domestic cat legislation in minimising the rate of cats dumped in the environment and contributing to the stray and feral cat population be assessed.**

CISS provides the following more detailed comments to the Terms of Reference for the inquiry appended to this covering letter.

Yours faithfully

Andreas Glanznig
Chief Executive

CENTRE FOR
INVASIVE SPECIES SOLUTIONS

Detailed Response Addressing Terms of Reference

The Centre for Invasive Species Solutions response to the terms of reference for the Inquiry into *the problem of feral and domestic cats in Australia.*

a. The prevalence of feral and domestic cats in Australia

The domestic and feral cat populations are not discrete and separate populations and there is a continuum between wholly domestic and wholly feral. Cats can, and do, move in both directions along that continuum.

It is possible that single or small groups of cats arrived at various times in Australia as a result of shipwrecks or coastal landings of European traders prior to European settlement [2]. However, it is most likely that the domestic cat did not arrive in Australia in sufficient numbers to form breeding populations until after European settlement. After European settlement, cats arrived at multiple points around the coastline as new settlements were established between 1824 and 1886 [3]. They then moved inland and travelled across Australia with expanding European settlements.

The successful introduction of the rabbit into Australia in 1859 and their rapid growth to plague proportions is likely to have unwittingly accelerated the spread of the cat across Australia. Rabbits provided a readily available source of food for feral cats and, additionally, domestic cats were bred, advertised, sold, and released in their hundreds in inland Australia as a measure to combat the growing rabbit plagues [4]. A combination of intentional and accidental releases of domestic cats into the wild has resulted in feral cats being widespread across mainland Australia, Tasmania and many offshore islands [3, 5].

Many differing definitions have been formulated to describe the various states of cats with respect to their interactions with the environment and with humans. Categories used by one author or organisation often overlap with categories used by another author or organisation. As an example, the terms “free living”, “stray”, and ‘semi-feral” have all be used to describe the same class of cat. Generally, however, there are three categories of cats used:

Domestic cat: Those cats that are owned and live in close connection with human who assume most, if not all, of the responsibility for providing the cat with food and shelter.

Stray cat: Those cats that live in proximity to humans but are not wholly dependent on humans for food and shelter. These can include unowned cats found in towns, garbage dumps and dockyards. Also included in this category are cats described as “farm cats” there they live on a farm and allowed to remain there primarily for rodent control.

Feral cat: Those cats that are free living and do not rely on humans for any portion of their food and shelter needs, either directly or indirectly, and have formed self-sustaining populations.

It must be noted that individual cats may move between classes on several occasions throughout their lives. A feral cat may become a domestic cat and *vice versa*. Additionally, there are no sharp divides along the continuum between being wholly domestic and wholly feral. The category boundaries are blurred and based on the circumstances of the individual cat at any given time [6].

There were many figures used to define the prevalence of feral cats in Australia. Values of "between 5.6 and 18.4 million" were regularly quoted by media and other organisations and this was later increased to 20 million. In 2014, the validity of these figures was questioned and it was suggested that they had no basis in fact [7]. It was subsequently discovered that most of these figures arose from a single incautious extrapolation in 1990 that had not been fact-checked before being accepted, reported, and extensively promoted by the media and other organisations [8].

A subsequent meta-analysis of feral cat studies across Australia showed that the population of feral cats varies depending on climatic conditions. During periods of continent-wide drought there are as few as 1.4 million but increasing to 5.6 million following extensive periods of good rainfall. An estimated additional 0.7 million stray cats are found in places like rubbish tips making a total of between 2.1 and 6.3 million feral cats found over 99.8% of Australia [9].

The Centre has not undertaken research into the numbers of owned domestic cats in Australia. However, Animal Medicines Australia undertook research indicating that in 2019 there were 3.77 million owned domestic cats in Australia with 27% of households having one or more cats as a pet [10]. A similar report on pet ownership worldwide indicated that approximately 29% of Australian households owned a cat. CISS has no reason to doubt or challenge that figure.

b. The impact of feral and domestic cats including on native wildlife and habitats

Impacts of cats on agriculture.

A study by the University of Adelaide indicated that toxoplasmosis costs the South Australian sheep industry an estimated $70 million per year due to lost production and replacement costs.

Feral and domestic cats have a larger impact on agricultural production, especially lamb and beef production than is commonly realised. Feral cats are the definitive hosts for the protozoa that cause toxoplasmosis (*Toxoplasma gondii*) and sarcocystis (*Sarcocystis gigantea*). Both are generally contracted by sheep and cattle through consuming contaminated grass or stock feed containing spores or oocysts deposited in cat faeces. Insects are also able to carry the oocysts on their feet and

mouthparts and can transmit the parasite to animals either consuming the insect directly or feed that the insect has walked over.

Toxoplasmosis is relatively common in sheep and goats and the parasite can be transferred across the placenta and primarily causes abortions or foetal re-absorption in infected animals. Foetuses that survive are generally still born or born weakened with low rates of survival. Ewes and does then generally develop an effective immune response which limits further infection and impact. Toxoplasmosis infections are generally more prevalent in the cooler southern parts of Australia than in the warmer central and northern regions [6]. A national baseline survey of lambs and sheep in 2007 -2008 gave a national estimate of the sero-prevalence of *Toxoplasma gondii* as 16.4% in lambs and 31.9% in adult sheep [11]. This difference is because of a greater likelihood of exposure for adult sheep than for lambs.

There are limited data available on the economic costs of toxoplasmosis to the agricultural industry. There are very few formally published studies worldwide and those that are published only cover two countries (Great Britain and Uruguay). According to a 2017 ABC news article, a study undertaken by the University of Adelaide indicated that toxoplasmosis costs the South Australian sheep industry an estimated $70 million per year due to lost production and replacement costs [12]. This study has not been published and accordingly the accuracy of these estimates cannot be checked and verified.

The *Sarcocystis* parasite does not impact the health of the animals it infects; however, it forms white cysts in the intestines and muscles of infected animals, predominantly sheep. These cysts can take between one month and one year to develop from the time of infection [13]. This infected meat is classified as not suitable for human consumption and must be trimmed from the carcase at the abattoir. Extensive infestations can result in the entire carcase being classed at not suitable for consumption and condemned.

Sarcocystis is more prevalent in southern Australia with the highest rates found in Tasmania and Kangaroo Island. It is estimated that approximately 14.3% of Tasmanian sheep slaughtered at abattoirs in Tasmania, Victoria and South Australia were infected so some degree with *Sarcocystis* with a greater prevalence in adult sheep than in lambs [13]. Carcasses with light to moderate infection require on average 5.6 kg of meat to be trimmed. This is required on approximately 0.3% of adult sheep carcasses. Approximately 0.01% of adult sheep carcasses have heavy infections and are condemned. This results in an economic cost of approximately $0.9 million [14].

Impacts of feral cats on native wildlife.

A single feral cat was responsible for the failure of two attempts at reintroducing the rufous hare--wallaby (*Lagorchestes hirsutus*) into the Tanami desert.

The dominant impact that cats have on wildlife is through depredation. Cats are obligate carnivores and require a diet high in protein and fat with minimal carbohydrates. In the wild this can be satisfied only by a diet that consist largely of vertebrate prey. An average feral cat of 3.7 kg has a basal metabolic requirement of about 800 kJ per day which equates to a minimum of 160 g of food per day. As cats generally prefer to hunt animals smaller than themselves, this can mean several kills per day to fulfil metabolic requirements. Cats are excellent predators and have developed optimal hunting strategies for their prey species [15].

While marsupial predators do exist, Australian native animals did not co-evolve with placental carnivores such as cats. Prey species that co-evolve with predators possess predator recognition and avoidance strategies that naïve prey species lack. The lack of predator avoidance can lead to introduced predators such as the cat having substantial negative impacts on naïve prey species.

Feral cats have been implicated in the decline and extinction of a number of native Australian species [16]. They are directly implicated as a threat to 142 EPBC listed species [17] and are also listed as a threat to 117 native species in New South Wales [18]. There is a positive correlation between the presence of feral cats on islands and the extinction of ground dwelling native fauna on those islands [19]. Feral cats have negative impacts on attempts to reintroduce native fauna such as the brush-tailed phascogale, rufous hare wallaby, and the burrowing bettong, back into ranges that they used to occupy. A single cat was responsible for the failure of two attempts at reintroducing the rufous hare-wallaby into the Tanami desert [20, 21]. This demonstrates that there is no simple rule of thumb for estimating what reduction in feral cat density is needed to mitigate their impact on native species and that the level of reduction required may vary significantly depending on the situation and environment that recovery actions are taking place in.

A meta-analysis of Australian studies found 400 vertebrate species in the diets of feral cats, of which 28 were IUCN listed species [22]. More recently, these studies have also been used to make estimations as to the number of mammals, birds, and reptiles that feral cats consume on an annual basis [for examples see 23, 24, 25]. While these estimated numbers can appear very large, they must be treated with caution. The simple presence of an animal in the diet of feral cats does not mean that the cats are having a negative impact on those species at a population level. For cats to have an impact, they must remove animals at a faster rate than the animal can reproduce. In many cases, these studies fail to show that feral cats are having a negative impact on the species they list. For some species, it is likely that the cats are simply consuming the doomed surplus (i.e. the proportion of the prey population what would have perished anyway even in the absence of the cat). In other cases, cats are likely having a negative impact at a population level. Rather than conflating the two situations, there must be a differentiation between a species simply appearing in the diet of a cat and cats having a negative impact on that species population

Australian native species are also impacted by diseases and pathogens carried by cats. *Spirometra erinacie* is a large tapeworm that uses cats as a definitive host. Native animals infected with *S. erinacie* often produce no obvious clinical symptoms however soft tissue damage and muscle damage can be caused leading to the death of the infected animal. Toxoplasmosis has been found in many native Australian species including dasyurids, bandicoots, macropods, dugongs, and some bird species [26]. The pathway to infection is the same as for livestock. Toxoplasmosis generally results in the abortion of foetuses but can also cause cellular damage to the brain, heart, lungs and/or liver. The extent of toxoplasmosis morbidity and mortality in Australian native species is unknown.

The impacts of feral cats on native can be exacerbated by other factors such as habitat loss, competition for food with introduced species and climatic events such as droughts, fires, and floods.

Impacts of domestic cats on native wildlife.

> "The cat is relatively easy to house, feed and handle, but despite the process of domestication, it has retained a behavioural repertoire which makes it very successful in the feral state, that is, living wild without deliberate provisioning by man." [27]

While cats have been domesticated for many centuries, they still have the complete range of hunting skills they had before domestication [27]. Domestic cats also have an impact on native species, again predominantly through predation. The main difference is that domestic cats are subsidised predators as most of their nutritional requirement are not met through hunting [28]. Their owners provide all their food requirements, so hunting is a form of play for them rather than a survival necessity. Being nutritionally subsidised, they can continue to hunt and catch animals in areas where the low prey abundance would have forced feral cats to abandon those areas in search of higher prey abundance. This can result in a greater detrimental impact on native species by domestic cats than would occur if the area was being hunted by feral cats.

Studies around Canberra in 1997 showed that domestic cats caught an estimated 380 000 – 630 000 animals annually. The majority of these were introduced species of mammal and bird with only a small proportion of native animals [29]. This low proportion is likely due to the reduced number of native species in the area due to urbanisation. Radio tracking of those cats showed that cats on the suburban / rural interface roamed up to 900 metres into the surrounding areas. Forays into the areas of more than 200 metres only happened at night.

There are scant data on the impacts of domestic and stray cats on specific species of Australian native animals. There are two well documented cases where this has occurred. The range of the eastern barred bandicoot (*Parameles gunnii*) had constricted to a small area around Hamilton, Victoria by 1970. In 1982-83 the population comprised some 1 750 animals however by 1989 the population had crashed to 300 animals or less. The high rate of juvenile mortality was identified as the

leading cause of the decline and that more than 42% of the juvenile deaths were caused by cat predation [30]. Similarly, the population of the superb lyrebird (*Manura novaehollandiae*) in Sherbrooke forest, Victoria had fallen to approximately 60 birds by 1988. Predation by cats as well as foxes and domestic dogs was identified as the major cause of the populations decline [31, 32].

c. The effectiveness of current legislative and regulatory approaches

As an RD&E organisation, the Centre for Invasive Species Solutions does not specifically comment on current state, Commonwealth and national laws and policy regarding feral and domestic cats in Australia. The continent-wide distribution of feral and domestic cats requires a coordinated and consistent national, landscape scale, nil-tenure approach to their management to minimise the impacts of these species on the environment, agriculture and community values. CISS advocates that any state or national laws and policy should not form an impediment to the creation of national collaborations for the effective management of these species nor should there be any legislative or policy barrier to the implementation of best practice management actions.

Recommendation.

1. **Legislation and policy should not form an impediment to the formation of national collaborative approaches to the management of feral and domestic cats.**

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

There is considerable evidence of cooperation between the Commonwealth and the states and territories for the management of feral cats under the Threatened Species Strategy. This includes cooperation for the eradication of feral cats from islands and through the formation of the Feral Cat Taskforce, chaired by the Threatened Species Commissioner and involving all states, territories and many NGO and stakeholder groups including CISS.

Cooperative feral cat management innovation between the Commonwealth and the States is exemplified by the current and on-going CISS project to enable national registration of the Eradicat® feral cat bait. Currently Eradicat® is only registered for use in Western Australia, with other States seeking to add this toxic bait to their feral cat management toolkits. This CISS project is being led by Primary Industries and Regions South Australia (PIRSA) and has project participants from many states and territories all working for the common goal of having an additional feral cat management

option in the toolkit. The Commonwealth Department of Agriculture, Water and the Environment is providing core financial support for this project.

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

The Centre is a strong proponent of landscape scale integrated management, particularly for predators. CISS, its predecessor the Invasive Animals CRC, and the NSW Department of Primary Industries have demonstrated the effectiveness of integrated landscape scale predator management through projects running in the New England region of New South Wales.

Single species predator management can result in perverse and unintended outcomes. As an example, following extensive landscape scale management of foxes in Western Australia, the woylie (*Bettongia penicillata*) was removed from the state's threatened species list in 1996. By 2000, however, the populations had declined sharply and by 2002 were back to pre-fox baiting levels in some areas [33]. The woylie was re-listed by the Western Australian government and were also listed as 'Endangered' under the EPBC Act by the Commonwealth. Research, funded in part by the IA CRC, to determine the cause of the decline demonstrated that 65% of the monitored woylies were killed by feral cats between 2006 and 2009. This rate was three times greater than those killed by foxes over the same period [33].

Indirect feral cat management

Management of introduced invasive feral cat prey species – namely the rabbit – is also an effective indirect tool for feral cat management. The release of the rabbit biocontrol, RHDV, into the Australian environment in 1996 resulted in a sudden and precipitous decline in the introduced European rabbit. The European rabbit is the preferred prey item for feral cats [22]. Studies in the Flinders Ranges in South Australia showed that while cats are able to switch prey when their primary prey has declined, the rapid decline in the rabbit population resulted in a substantial reduction in both feral cat and fox number in the 6-10 months following the release of RHDV [34]. While the proportion of native species in the feral cats' diet increased during this time, it was offset by the reduction in feral cat numbers and the net level of predation on native species had decreased.

There was extensive recovery of threatened arid zone mammals following with release of RHDV. The dusky hopping-mouse (*Notomys fuscus*), spinifex hopping mouse (*Notomys alexis*), plains mouse (*Pseudomys australis*) and marsupial micro-predator the crest-tailed mulgara or ampurta (*Dasycercus cristicauda*), all increased their extent of occurrence by an unprecedented up to 365%. The recovery

of all these native animals is linked to the above described recovery in their habitat and food resources, but they would also have greatly benefitted from declines in red fox and feral cat numbers from the loss of their primary prey item, the rabbit [35, 36].

There is emerging evidence that wild dog and fox management may also assist in indirectly managing feral cats. The fate of dried meat baits for wild dogs was investigated in Western Australia to determine if non-target bait take would impact on the effectiveness of wild dog management actions. Feral cats took approximately 5% of the dried meat baits where the fate of those baits could be determined [37]. Additionally, aerial baiting for wild dogs in the New England region resulted in the death of a significant proportion of radio-collared feral cats. The proportion of collared feral cats killed during the subsequent round of aerial baiting for wild dogs was less than during the initial round. This shows that cats can be killed as by-product of wild dog and fox management. New South Wales DPI is continuing investigations to determine what level of feral cat management occurs during these programs. A feral cat has also been recorded excavating and carrying off a buried wet meat bait during a fox baiting program as part of the Malleefowl Recovery Program in the central mallee region of New South Wales (T Buckmaster - unpublished data).

Direct feral cat management.

There is little or no evidence that supports the use of TNR as an effective technique for population level management of feral cats, particularly while there is continued recruitment into the population through deliberate dumping of unwanted pet cats. There is, however, a large volume of scientific literature that refutes the claims that TNR is an effective management strategy.

There are limited direct techniques available for the management of feral cats in Australia. At present there are only four techniques that can be used and only one of these is suitable for use at a landscape level. Indirect techniques, particularly rabbit biocontrol, also need to be considered.

In order of common use, these are

1. **Trapping**, either using padded jaw traps or cage traps, is the most used method for the capture of feral cats. The use of steel jaw traps is banned in all Australian jurisdictions due to welfare and ethical considerations. Trapping is labour and time intensive with traps needing to be checked at least once every day and is only able to be deployed across a small area.
2. **Ground based shooting** generally undertaken at night using competent qualified shooters with the aid of a spotlight. It is both labour and time expensive and is not able to be used at a landscape level, nor it is an option for management of feral or stray cats in urbanised areas.
3. **Poison baiting** is less commonly used but is effective at landscape level management of feral cats. Extensive development efforts have resulted in the development of two feral cat baits with a third still in development. The Eradicat® feral cat bait consists of a chipolata

sausage style bait matrix into which the toxin 1080 is directly injected. This bait is currently only registered for use in Western Australia however the Centre has developed a collaborative project, led by South Australia, to facilitate the national registration of the bait through the APVMA.

The Curiosity® feral cat bait consists of the same chipolata style bait matrix however the toxin, para aminopropiophenone (PAPP), is encapsulated with an acid soluble hard-shelled delivery vehicle (HSDV) concealed within the bait matrix. The HSDV increases the target specificity of the bait as most native carnivores eating the bait will detect the HSDV and spit it out thinking it a rock or piece of bone. Feral cats lack grinding premolars so do not have teeth that are suitable for chewing. This results in them swallowing larger bites and so swallow the HSDV without detecting it. Once in the stomach, the stomach acid dissolves the HSDV releasing the toxin. The Curiosity bait is registered for use nationally.

The Hisstory® bait is similar to the Curiosity bait however uses encapsulated 1080 rather than PAPP as the toxin. This bait is not currently registered for use in Australia.

4. **Predator exclusion fencing** is used to provide secure areas for native animals and to prevent reinvasion of areas that have been cleared of predators using other techniques mentioned above. Exclusion fencing is expensive to erect and must be maintained continuously to ensure its effectiveness. Predator exclusion fencing has been used successfully by the Arid Recovery Project in South Australia and at a number of Australian Wildlife Conservancy reserves across Australia.

There are increasing calls from within the community advocating for the trapping, sterilisation, and re-releasing of feral cats into the environment as a management technique (Trap Neuter & Release or TNR). TNR programs are extensively used in North America and are advocated by cat welfare groups on the pretext of managing feral cat populations based on the assumption that it is more humane than euthanasia. Neutered feral cats released back into the environment still prey on and negatively impact native animals.

There is little or no evidence that supports the use of TNR as an effective technique for population level management of feral cats, particularly while there is continued recruitment into the population through deliberate dumping of unwanted pet cats with people believing that the cat will be cared for as part of a TNR program [38]. There is, however, a large volume of scientific literature that refutes the claims that TNR is an effective management strategy [for examples see 39, 40, 41].

Potential of genetic technology for strategic feral cat management: CISS genetic biocontrol planning project

Genetic technologies have potential as a strategic vertebrate pest tool, if technical feasibility, cost, social acceptance, and other risk issues can be resolved. Research on the viability of the technology to mammals is at an early stage.

To foster a strategic and collaborative research and innovation approach, the Centre through a CSIRO led project is developing a priority framework to underpin a proposed long-term research and innovation program that can cost-effectively assess and demonstrate the viability of genetic technologies (genetic biocontrol) for vertebrate pest management. The major project objective is to build a framework to assess the knowledge gaps that currently exist, the feasibility and a means to prioritise genetic technologies in our efforts to control vertebrate pest animals. This includes proposing a potential sequence/s of vertebrate pest priorities starting with mice as a mammal model species. Stakeholders have highlighted that feral cats should be considered within this framework and sequence. Details of this project can be found at https://invasives.com.au/research/genetic-technologies-for-pest-animal-control/

Recommendations

2. **Feral cats should be managed as part of a landscape scale integrated predator management approach to ensure that unintended consequences from single species management are avoided.**
3. **Indirect management of feral cats through the continued use of rabbit biocontrol should be considered an essential component of integrated predator management programs where rabbits are prevalent.**
4. **There should be continued support to take forward work on strategic planning for a genetic biocontrol for feral cats as part of a broader vertebrate pest genetic biocontrol research and innovation program.**

f. the efficacy of import controls for high risk domestic cat varieties to prevent the impacts of feral and domestic cats, including on native wildlife and habitats

A recent assessment has determined that 93% of Australia's threatened Australian mammal species would likely face the risk of predation from the Savannah Cat had it been permitted to enter Australia.

The introduction of new cat genetics carries a risk that if/when new cat varieties interbreed with feral cats, new genes that improve their predation efficacy will be introduced into the feral cat population. The proposed importation of Savannah Cats is a case in point. In 2008 the importation of the

Savannah Cat into Australia was banned. The then Minister for the Environment determined that the risk to Australian native fauna when the Savannah Cat entered the feral cat population was too great. A recent assessment has determined that 93% of Australia's threatened Australian mammal species would likely face the risk of predation from the Savannah Cat had it been permitted to enter Australia [42].

The Invasive Animals CRC – the predecessor to CISS – provided evidence in its submission on the then draft risk assessment for importation of Savannah Cats to strongly oppose their importation. A key point from the IA CRC submission was that:

> New genes can 'supercharge' a feral population. There are numerous examples where new genetic lines have led to feral populations taking off, most likely through hybrid vigour and/or by generating advantageous phenotypes outside the previous range [43].

This point is also relevant for any imports of any new high-risk cat varieties that could potentially lead to new genes being incorporated into feral cat populations that would confer biological advantages.

The Centre for Invasive Species Solutions supports the use of appropriate risk assessment protocols for determining if the importation of hybrid and/or high-risk domestic cat varieties as domestic pets poses a risk to native Australian fauna. These risk assessment protocols already exist [44].

It is also recognised that there is a black-market trade in prohibited pets in Australia and that there is the potential for hybrid cats to enter Australia illegally. The Centre is actively involved in developing approaches to detect and combat trade in illegal non-native species through a collaborative project involving the University of Adelaide, CSIRO, the Arthur Rylah Institute, and the Australian Museum.

Recommendation

5. **All applications to import hybrid and/or high-risk cat species undergo a risk assessment conducted by a suitably qualified and independent assessor to determine if they pose a risk to Australian native species.**

g. public awareness and education in relation to the feral and domestic cat problem

CISS believes that in most cases, public awareness and education is preferable to enforcement action in the first instance. Collaborative research projects undertaken by CISS and its predecessor, the Invasive Animals CRC, have shown that appropriately framed public awareness messages and education is able to elicit a positive behavioural response from the public that receive the message. In relation to domestic cats, our research demonstrated that public awareness messages regarding the negative welfare impacts of free roaming domestic cats on native wildlife resulted in an increased intention and adoption by cat owners to prevent their cats from roaming outside [45].

Cat management, particularly domestic cat management, is a complex social issue. CISS' research projects have shown that there is no single intervention or message that will result in all owners adopting appropriate cat containment behaviours. The drivers and barriers to adopting appropriate domestic cat management practices need to be determined and should form the basis of public awareness and education campaigns. This should be evidence based, and the CISS predecessor – the IA CRC - describes an integrative framework based on the behavioural literature to design better, equitable and ethically acceptable interventions for free-roaming cat management [46].

To strengthen community engagement in feral cat management, CISS has developed a citizen science feral cat reporting and mapping tool that contributes to the DAWE assessment of national effort towards feral cat control, and is also producing a feral cat best practice management glovebox guide as part of our popular CISS glovebox guide series.

FeralCat Scan has been developed in conjunction with the NSW Department of Primary Industries with funding support from the Threatened Species Commissioner's office developed (https://www.feralscan.org.au/feralcatscan/default.aspx). This smart device App and on-line reporting tool allows the community to take an active role in the management of feral cats through enabling them up upload sightings of feral cats, the damage that feral cats have done and the location of any control actions being taken. Since inception, there have been nearly 7,300 records uploaded to the database. Database entries of feral cat locations are available to be viewed by members of the public. The location of control actions is not available to be viewed by the public to remove the potential for interference by people or groups who would wish to interfere with those control measures.

The CISS feral cat glovebox guide will provide stakeholders and land managers with information on best practice feral cat management, and is designed to complement our on-line PestSmart feral cat best practice management toolkit at www.pestsmart.org.au. The Guide is being produced with the financial support of the Commonwealth Department of Agriculture, Water and the Environment and will complement the PestSmart guides developed for the best practice management of wild dogs, foxes, rabbits and feral pigs (which are available on the PestSmart web site.

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

The domestic and feral cat populations are not discrete and separate populations and there is a continuum between wholly domestic and wholly feral. Cats can, and do, move in both directions along that continuum. There is extensive evidence to show that domestic cats contribute to the feral cat population however there is limited evidence as to the rate at which this occurs. It is likely that the rate varies depending on a range of factors including food availability, climatic conditions and location of release.

Domestic cats that are intentionally and unintentionally released into environment by their owners are likely to survive given that they still have all the hunting and behaviour instincts of their predecessors before the species became domesticated. In areas with abundant native or introduced wildlife, the released cat is likely to find sufficient food to survive.

While most states have legislation requiring the microchipping and registering of domestic cats, and the desexing of domestic cats except in limited circumstances, there is scant data to indicate if this has been successful or not.

Recommendation

6. **That the effectiveness of domestic cat legislation in minimising the rate of cats dumped in the environment and contributing to the stray and feral cat population be assessed.**

References

1. Johnston, M.J. and Marks, C. (1997) Attitudinal survey on vertebrate pest management in Victoria. Report Series 3. Frankston.

2. Burbidge, A.A., Johnson, K.A., Fuller, P.J. and Southgate, R.I. (1988) Aboriginal knowledge of the mammals of the central deserts of Australia. Wildlife Research 15(1): 9-39. doi: doi:10.1071/WR9880009.

3. Abbott, I. (2002) Origin and spread of the cat, *Felis catus*, on mainland Australia, with a discussion of the magnitude of its early impacts on native fauna. Wildlife Research 29: 51-74.

4. Rolls, E.C. (1969) They all Ran Wild. Angus & Robertson, Sydney.

5. Burbidge, A., Williams, M. and Abbott, I. (1997) Mammals of Australian islands: factors influencing species richness. Journal of Biogeography 24(6): 703-15.

6. Dickman, C.R. (1996) Overview of the Impacts of Feral Cats on Australian Native Fauna. Canberra.

7. Hone, J. and Buckmaster, T. (2014) How many are there? The use and misuse of continental-scale wildlife abundance estimates. Wildlife Research 41(6): 473-9. doi: http://dx.doi.org/10.1071/WR14059.

8. Buckmaster, T. and Hone, J. (2015) Quantifying cats: How many are there and do we need to know? In: Tracey, J., Lane, C., Fleming, P., Dickman, C., Quinn, J., Buckmaster, T. and McMahon, S., editors. 2015 National Feral Cat Management Workshop; Canberra, ACT. Invasive Animals Cooperative Research Centre, Canberra. p. 45-55.

9. Legge, S., Murphy, B.P., McGregor, H., Woinarski, J.C.Z., Augusteyn, J., Ballard, G., Baseler, M., Buckmaster, T., Dickman, C.R., Doherty, T., Edwards, G., Eyre, T., Fancourt, B.A., Ferguson, D., Forsyth, D.M., Geary, W.L., Gentle, M., Gillespie, G., Greenwood, L., Hohnen, R., Hume, S., Johnson, C.N., Maxwell, M., McDonald, P.J., Morris, K., Moseby, K., Newsome, T., Nimmo, D., Paltridge, R., Ramsey, D., Read, J., Rendall, A., Rich, M., Ritchie, E., Rowland, J., Short, J., Stokeld, D., Sutherland, D.R., Wayne, A.F., Woodford, L. and Zewe, F. (2017) Enumerating a continental-scale threat: How many feral cats are in Australia? Biological Conservation 206: 293-303. doi: http://dx.doi.org/10.1016/j.biocon.2016.11.032.

10. Animal Medicines Australia Pty Ltd. (2019) Pets in Australia: A national survey of pets and people. Animal Medicines Australia Pty Ltd, Barton, ACT.

11. Kiermeier, A., Hamilton, D., Smith, G. and SA Research and Development Institute. (2008) National serological baseline survey of *Toxoplasma gondii* in lambs and sheep. Meat and Livestock Australia, North Sydney.

12. Australian Broadcasting Commission. (2017) New study estimates toxoplasmosis costs sheep industry $70 million per year in South Australia [accessed 21 July 2020]. Available from: https://www.abc.net.au/news/rural/2017-02-07/toxoplasmosis-costs-south-australian-sheep-producers/8245676#:~:text=Toxoplasmosis%20is%20estimated%20to%20cost,in%20weakened%20lambs%20post%2Dinfection.

13. Phythian, C.J., Jackson, B., Bell, R., Citer, L., Barwell, R. and PA, W. (2018) Abattoir surveillance of *Sarcocystis spp., Cysticercosus ovis* and *Echinococcus granulosus* in Tasmanian slaughter sheep, 2007 - 2013. Australian Veterinary Journal 96(3): 62- 8.

14. GHD Pty Ltd, Jubb, T., Shephard, R., Webb-Ware, J. and Fordyce, G. (2015) Priority list of endemic diseases for the red meat industries. Meat and Livestock Australia, North Sydney.

15. Buckmaster, T. and Dickman, C. (2012) Feral cats in the tall forests of Far East Gippsland, Australia. In: Timms, R.M., editor. Proceedings of the 25th Vertebrate Pest Conference; Monterey, California. University of California, Davis; California. p. 54-60.

16. Woinarski, J., Burbidge, A.A. and Harrison, P.L. (2014) The Action Plan for Australian Mammals, 2012. CSIRO Publishing, Collingwood, Victoria. 1038 p.

17. Department of the Environment. (2015) Background document for the threat abatement plan for predation by feral cats. Australian Government, Department of the Environment, Canberra, Australia.

18. Coutts-Smith, A.J., Mahon, P.S., Letnic, M. and Downey, P.O. (2007) The threat posed by pest animals to biodiversity in New South Wales. Invasive Animals Cooperative Research Centre, Canberra.

19. Burbidge, A. and Manly, B. (2002) Mammal extinctions on Australian islands: causes and conservation implications. Journal of Biogeography 29: 465-73.

20. Gibson, D.F., Johnson, K.A., Langford, D.G., Cole, J.R., Clarke, D.E. and Willowra Community. (1995) The rufous hare-wallaby *Lagorchestes hirsutus*: a history of experimental reintroduction in the Tanami Desert, Northern Territory. In: Serena, M., editor. Reintroduction Biology of Australian and New Zealand Fauna. Surrey Beatty and Sons Pty Limited, Chipping Norton, NSW. p. 171-6.

21. Gibson, D.F., Lundie-Jenkins, G., Langford, D.G., Cole, J.R., Clarke, J.E. and Johnson, K.A. (1994) Predation by feral cats, *Felis catus*, on the rufous hare-wallaby, *Lagorchestes hirsutus*, in the Tanami Desert. Australian Mammalogy 17: 103-7.

22. Doherty, T.S., Davis, R.A., van Etten, E.J.B., Algar, D., Collier, N., Dickman, C.R., Edwards, G., Masters, P., Palmer, R. and Robinson, S. (2015) A continental-scale analysis of feral cat diet in Australia. Journal of Biogeography 42(5): 964-75. doi: 10.1111/jbi.12469.

23. Murphy, B.P., Woolley, L.-A., Geyle, H.M., Legge, S.M., Palmer, R., Dickman, C.R., Augusteyn, J., Brown, S.C., Comer, S., Doherty, T.S., Eager, C., Edwards, G., Fordham, D.A., Harley, D., McDonald, P.J., McGregor, H., Moseby, K.E., Myers, C., Read, J., Riley, J., Stokeld, D., Trewella, G.J., Turpin, J.M. and Woinarski, J.C.Z. (2019) Introduced cats (Felis catus) eating a continental fauna: The number of mammals killed in Australia. Biological Conservation 237: 28-40. doi: https://doi.org/10.1016/j.biocon.2019.06.013.

24. Woinarski, J.C.Z., Murphy, B.P., Legge, S.M., Garnett, S.T., Lawes, M.J., Comer, S., Dickman, C.R., Doherty, T.S., Edwards, G., Nankivell, A., Paton, D., Palmer, R. and Woolley, L.A. (2017) How many birds are killed by cats in Australia? Biological Conservation 214: 76-87. doi: http://dx.doi.org/10.1016/j.biocon.2017.08.006.

25. Woinarski, J.C.Z., Murphy, B.P., Palmer, R., Legge, S., Dickman, C.R., Doherty, T.S., Edwards, G., Nankivell, A., Read, J.L. and Stokeld, D. (2018) How many reptiles are killed by cats in Australia? Wildlife Research 45(3): 247-66.

26. Wildlife Health Australia. (2019) Toxoplasmosis of Australain Mammals: Fact sheet. Wildlife Health Australia, Sydney.

27. Bradshaw, J.W.S., Goodwin, D., Legrand-Defrétin, V. and Nott, H.M.R. (1996) Food selection by the domestic cat, an obligate carnivore. Comparative Biochemistry and Physiology Part A: Physiology 114(3): 205-9.

28. Soulé, M.E., Bolger, D.T., Alberts, A.C., Wright, J., Sorice, M. and Hill, S. (1988) Reconstructed dynamics of rapid extinctions of Chaparral-requiring birds in urban habitat Islands. Conservation Biology 2(1): 75-92.

29. Barratt, D. (1997) Predation by house cats *Felis catus* (L) in Canberra, Australia. I Prey consumption and preference. Wildlife Research 24: 263-77.

30. Dufty, A. (1994) Population demography of the eastern barred bandicoot (*Perameles gunnii*) at Hamilton, Victoria. Wildlife Research 21(4): 445-57. doi: https://doi.org/10.1071/WR9940445.

31. Maisey, A., White, S., Incoll, J. and Lloyd, J. (2018) A lyrebird tale: Birdlife Australia; [accessed 28th July, 2020]. Available from: https://www.birdlife.org.au/australian-birdlife/detail/a-lyrebird-tale.

32. Larkin, J. (1989) The song of Sherbrooke. Common Ground, June-July: 21-25 [as cited in Dickman, C. (2009). House cats as predators in the Australian environment: impacts and management. Human-Wildlife Conflicts. 3(1): 41-48].

33. Marlow, N.J., Thomas, N.D., Williams, A.A.E., Macmahon, B., Lawson, J., Hitchen, Y., Angus, J. and Berry, O. (2015) Cats (*Felis catus*) are more abundant and are the dominant predator of woylies (*Bettongia penicillata*) after sustained fox (*Vulpes vulpes*) control. Australian Journal of Zoology 63(1): 18-27. doi: https://doi.org/10.1071/ZO14024.

34. Holden, C. and Mutze, G. (2002) Impact of rabbit haemorrhagic disease on introduced predators in the Flinders Ranges, South Australia. Wildlife Research 29: 615-26.

35. Cooke, B.D. and Soriguer, R.C. (2017) Do dingoes protect Australia's small mammal fauna from introduced mesopredators? Time to consider history and recent events. Food Webs 12: 95-106. doi: https://doi.org/10.1016/j.fooweb.2016.04.002.

36. Pedler, R.D., Brandle, R., Read, J.L., Southgate, R., Bird, P. and Moseby, K.E. (2016) Rabbit biocontrol and landscape-scale recovery of threatened desert mammals. Conservation Biology 30(4): 774-82. doi: 10.1111/cobi.12684.

37. Kreplins, T.L., Kennedy, M.S., Adams, P.J., Bateman, P.W., Dundas, S.D. and Fleming, P.A. (2018) Fate of dried meat baits aimed at wild dog (*Canis familiaris*) control. Wildlife Research 45(6): 528-38. doi: https://doi.org/10.1071/WR17182.

38. Winter, L. (2004) Trap-neuter-release programs: the reality and the impacts. Journal of the American Veterinary Medical Association 225(9): 1369-76. doi: doi:10.2460/javma.2004.225.1369.

39. Longcore, T., Rich, C. and Sullivan, L.M. (2009) Critical assessment of claims regarding management of feral cats by trap-neuter-return. Conservation Biology 23(1): 887-894.

40. Lepczyk, C.A., Dauphine, N., Bird, D.M., Conant, S., Cooper, R.J., Duffy, D.C., Hatley, P.J., Marra, P.P., Stone, E. and Temple, S.A. (2010) What conservation biologists can do to counter trap-neuter-return: response to Longcore *et al*. Conservation Biology 24(2): 627-9. doi: 10.1111/j.1523-1739.2009.01426.x.

41. Peterson, M.N., Hartis, B., Rodriguez, S., Green, M. and Lepczyk, C.A. (2012) Opinions from the front lines of cat colony management conflict. PLoS ONE 7(9). doi: ARTN e44616 http://10.1371/journal.pone.0044616. PubMed PMID: ISI:000308458400096.

42. Dickman, C.R., Legge, S.M. and Woinarski, J.C.Z. (2019) Assessing risks to wildlife from free-roaming hybrid cats: the proposed introduction of pet savannah cats to Australia as a case study. Animals 9(10): 795-807. PubMed PMID: doi:10.3390/ani9100795.

43. Invasive Animals Cooperative Research Centre. (2008) Submission to the Independent Review of the EPBC Act 1999. Department of Agriculture, Water and the Environment, Canberra. [accessed 29th July 2020]. Available from: https://www.environment.gov.au/system/files/pages/dacbabf4-0bca-46ee-9271-2fa95ce1b6dc/files/046-invasive-animals-cooperative-research-centre.pdf.

44. Bomford, M. (2008) Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand. Invasive Animals Cooperative Research Centre, Canberra.

45. McLeod, L., Hine, D., Bengsen, A. and Driver, A. (2017) Assessing the impact of different persuasive messages on the intentions and behaviour of cat owners: a randomised control trial. Preventative Veterinary Medicine 146: 136-42. doi: http://dx.doi.org/10.1016/j.prevetmed.2017.08.005.

46. McLeod, L.J., Hine, D.W. and Driver, A.B. (2019) Change the humans first: principles for improving the management of free-roaming cats. Animals 9(8): 555-71. PubMed PMID: doi:10.3390/ani9080555.