THE UNIVERSITY of ADELAIDE

The significance of social factors in the planning and implementation of feral cat management programs

Thesis submitted for the degree of

Doctor of Philosophy

Brooke Patricia Deak

Department of Ecology and Evolutionary Biology

School of Biological Sciences

The University of Adelaide

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Thesis declaration

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Abstract

Feral cat management is the subject of debate in many countries due to conflicting ecological, ethical, economic, and social reasons. Perceptions and attitudes around the various possible feral cat management methods influence socially and politically acceptable management. While most of the recent research conducted on feral cat management has taken technical aspects into account, there is considerably less emphasis on how the social aspects may influence success. This thesis aims to compare global differences in feral cat management approaches, and to improve the understanding of how social factors influence attitudes around different feral cat management methods.

The first objective was to investigate global attitudes towards feral cats by analysing international scientific literature around feral cat management with a focus on social perspectives. The literature review (chapter 2) presents global comparisons by providing insight into how feral cats are perceived by stakeholders in various countries, and what social factors influence these perceptions worldwide.

The second objective of this thesis focused on analysing public attitudes towards feral cats and their management in both a regional and international context and determined the countries and groups that contributed greatly to the social media narrative around feral cats. In this portion of the study, Twitter data was used to distinguish the language used by differing groups in various countries to portray attitudes towards feral cats, as detailed in chapter 3.

The final objective focused on determining the social factors that influence public attitudes and perceptions of methods used in feral cat management, and the social acceptability of these methods. A landholder questionnaire was used to assess the acceptance of several feral cat management methods on properties on Kangaroo Island, South Australia and near to the Grampians National Park region of western Victoria. It was found that gender, land use, previous knowledge of feral cat management methods,

and location influenced the likelihood of participants to accept and use various feral cat management methods on their properties, as covered over chapters 4 and 5.

This study highlights the importance of communication and information sharing in feral cat management, including knowledge about control tools, and demonstrates that education about feral cat impacts can increase support for management. It further suggests that feral cat management in any locality needs to consider the potential for regional differences that might stem from variations in culture and environment=. Feral cat management in any space requires investigation into the demographic and social factors that influence levels of support for particular interventions in an area, and that includes appealing to the public and engaging with the local community by interacting with them directly and educating while spreading awareness.

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Chapter 1

General Introduction

1.1 Introduction:

For centuries, people around the world have associated cats with companionship, pest control, and even worship (Driscoll et al. 2009). Today, cats are perceived differently depending on the beliefs and values of the people in the region they inhabit, and successful cat management in any area is dependent upon these perceptions (Farnworth et al. 2011; Rotherham 2013). In North America and parts of Europe, outdoor cats are often found in or near cat colonies that consist of feral, stray, or outdoor domestic cats that are cared for by humans (Hatley 2003; Hernandez et al. 2018). Though there is some concern regarding the impacts of outdoor cats on native wildlife in these locations, these cats have remained an expected part of the urban landscape, and cat management is not considered an urgent matter by government (Hatley 2003; Natoli 2014). In most cases, cat management in such a context is a responsibility undertaken by animal welfare groups and individuals who are concerned for the wellbeing of all outdoor cats, whether they are considered feral, stray, or outdoor domestic (Hunter and Brisbin 2016).

In Australia and New Zealand, feral cats are considered invasive pests, or animals that are not native and have the potential to cause damage to native ecosystems. Feral cats threaten populations of native wildlife species and need to be managed effectively, and so are addressed as a priority for government (Australian Veterinary Association 2016). Though some cat colonies can be found throughout Australia, the keeping of outdoor domestic or stray cats is often strongly discouraged, if not banned by some regional councils (Australian Government Department of the Environment 2015c; Hollingsworth 2019). While feral cat management in any locality around the world depends heavily on the behavioural ecology of the cats within that landscape and the threat they pose to local native wildlife, it also depends on the level of social license granted by the public within a specific region to implement particular techniques, which is strongly influenced by their perceptions and attitudes towards feral cats and

feral cat management (Estevez et al. 2014; Garcia-Llorente et al. 2008). Without this social licence, invasive species management campaigns including those for feral cats can be delayed or even postponed indefinitely (Nogales et al. 2004).

Much of the debate that occurs around feral cat management focuses on the control methods that are proposed. Use of specific feral cat management methods within a locality depends on the urgency of management in that location as well as the social acceptability of the methods (Garcia-Llorente et al. 2008). For instance, in the United States of America (USA) and in parts of Europe, feral cat management is not seen as an incredibly urgent matter by government. Therefore, it is often handled by animal control officers, animal welfare groups and communities of individuals, with legislation relevant to the species focusing more on ownership than on direct management measures (Hunter and Brisbin 2016). Animal welfare and community members are generally against the use of lethal management methods, instead favouring non-lethal methods such as cage trapping and neutering that seeks the gradual decline of the cat population over time (Hunter and Brisbin 2016; Palmer 2014). Use of certain poisons such as sodium fluoroacetate (1080), which is sometimes used in feral predator management, has been severely restricted in countries such as the USA, further limiting the options for management (Wallace 2014).

In contrast, use of strictly non-lethal methods is not seen as a viable option in countries such as Australia and New Zealand because of the amount of time it would take to remove the cats completely and the immediate threat that feral cats pose to the survival of native wildlife populations (Crawford et al. 2019). Instead, feral cat management campaigns in these countries are focused on depleting cat numbers as quickly as possible using a combination of lethal and nonlethal methods that are strongly supported by the public (Australian Government Department of the Environment 2015c). Within Australia, often the time is limited for management to gauge public attitudes around different management methods and address concerns about methods that may be effective in a technical sense and from a cost-benefit

standpoint but may not be ethically sound according to the public. Therefore, with a range of methods proposed for use and a need for rapid depletion of feral cat populations, social research into the factors that influence attitudes towards feral cat management and how to approach the community based on these factors is necessary prior to planning which methods to implement in a management campaign.

Though evident differences exist between and within locations regarding attitudes towards various feral cat management methods, the social factors and the extent to which they influence these differences have not been greatly explored. The main aim of this thesis is to investigate intercultural attitudes around feral cats and various feral cat management methods to determine why certain methods are preferred and adopted over others from a social standpoint.

1.2 Feral cat management methods

From an ecological perspective, invasive species management methods are often chosen based on the size of the targeted area, the landscape, the density of the cat population in the area, and the cost-effectiveness of each method (Australian Government Department of the Environment 2015c; Baker and Bode 2016). Though some countries such as the USA and parts of Europe tend to implement loosely framed feral cat management programs that involve strictly non-lethal methods to control cat populations, an increase in the interest and sense of urgency in controlling the feral cat population within Australia has lead environmental departments across all levels of government to prioritise the creation and implementation of feral cat management plans that include a combination of methods that aim to be well-suited and effective for their specific region (Australian Government Department of the Environment 2015b). Regardless of the final specific differences in approaches implemented, public acceptance will be essential for the use of any of the common feral cat management methods, including those listed below (Australian Government Department of the Environment 2015c; Larson et al. 2011).

1.2.1 Baiting with poison

In general feral predator management, baiting is a method that involves distributing a small piece of meat or meat based product containing a dose of a toxin throughout areas that the target species is believed to inhabit (Algar et al. 2011). Baiting is usually considered the cheapest, most effective landscape-scale option to control invasive animals. However, baiting can sometimes be less effective on feral cats due to their preference for live prey, and their tendency to only scavenge if there is a low abundance of food in the area (Australian Government Department of the Environment 2015a; Christensen 2012). Therefore successful baiting of feral cats depends heavily on the timing of the intervention, such as during winter in cold climate regions or late in the dry season in arid and semi-arid regions, when prey can become scarce and there is a higher chance that feral cats will have to scavenge to supplement for a lack of hunting opportunities (Algar et al. 2011; Glen et al. 2007).

Though baiting is commonly used in Australia, it is not commonly used in feral cat management in other countries due to the involved use of poison. There are currently two poisons that are used for baiting feral predators in Australia: sodium fluoroacetate, commonly referred to as 1080, and para-aminopropriophenone (PAPP) (Green and Rohan 2012; Johnston et al. 2014). 1080 can be delivered as off-the-shelf manufactured baits (eg. Doggone®; Fox-off® etc) or as semi-dried fresh meat baits. For example, the Eradicat® bait comes in the form of a small chipolata that is primarily made of minced kangaroo meat and chicken fat (Algar et al. 2011).

There are many reservations around using 1080, mainly due to the heightened sensitivity exhibited by certain non-target wildlife species to this compound (Glen et al. 2007). It has even been banned in some countries such as the United States, where it is prohibited except for use in livestock protection-collars against coyote populations (Eisler 1995). In general, there is a greater social acceptance of the use of 1080 to control fox and cat populations in Western Australia (WA) than in other Australian states because most local native species have a strong tolerance of the poison. This

tolerance has been derived from the co-evolution of the animals in WA with plants in the genus *Gastrolobium* which contain 1080 (Glen et al. 2007; National Possum Control Agencies 2020). Some tolerance to 1080, especially when compared to introduced targeted carnivores, has also been demonstrated in wildlife species across the remainder of the Australian continent, but community concerns have been greater in these other regions (Dundas et al. 2014). There is also a general hesitation to use 1080 because it is highly toxic to domestic cats and dogs. The poison acts relatively slowly and in canids, triggers outward symptoms that are noticeable and visibly distressing (Algar et al. 2011; Australian Government Department of the Environment 2015a). For example, Eradicat® cat baits are distributed on the ground either aerially or manually at rates of up to 40 baits per km^2 within Australia, and when consumed, cause the respiratory system of the animal to fail, with symptoms of disorientation and lethargy exhibited prior to death (Algar et al. 2011; Marais 1943). So, while 1080 can be a useful tool to reduce feral cat numbers, its use has been ecologically, ethically and socially problematic.

PAPP is considered by some to be a more humane alternative to 1080 in managing feral cats (Johnston et al. 2014). In the context of Curiosity® baits, the PAPP poison is placed within a capsule that is inserted into a minced-meat bait. Once consumed by the feral cat, the capsule is broken and the poison takes effect at a faster rate than 1080 (Johnston et al. 2014). Once in the system, the poison disrupts the transport of oxygen to the heart and brain of the animal, and results in a quick loss of consciousness. No visible signs of pain or distress are exhibited, leaving this baiting option to be considered a more ethical technique for management (Australian Government Department of the Environment 2015a). However, secondary poisoning of native wildlife after Curiosity® baiting is a primary issue, reflected in the bait's use of encapsulated toxin and its Direction for Use, with goanna and bandicoot species being identified as very vulnerable (Algar et al. 2011; Australian Government Department of the Environment 2015c). Also, because the PAPP is inserted into the bait matrix in a

capsule, research found that some species that try to consume the bait will most likely avoid ingesting the capsule itself (Hetherington et al. 2007; Marks et al. 2006). At the same time, however, it is known that some native Australian species such as goanna species and the southern brown bandicoot have little to no tolerance for PAPP, and are at high risk of poisoning if the baits (Jessop et al. 2013). PAPP is starting to be used in New Zealand for invasive species management, and it is being introduced as a potential feral predator management option for coyotes in the USA, as an alternative to 1080 in livestock protection collars (Pitt et al. 2017).

1.2.2 Grooming traps

Felixer™ grooming traps are a new technology developed for use in feral cat management that integrates the use of traps and poison (Australian Government Department of the Environment 2015b; Read et al. 2019). These devices are specifically designed to target cats by using sound lures to attract the animal to the location, with laser sensors installed in the front of the trap to detect the shape and size of the animal. Once an animal is detected and identified by the algorithm as highly likely to be a cat, the trap is designed to rapidly eject a sticky gel containing poison onto the fur of the cat as it passes by (Read et al. 2019). In a grooming response, the feral cat will lick and clean the patch of fur that has been sprayed and ingest the poison, leading to its death. As a new technology, the grooming trap has so far proved successful in proof-of-concept trials for feral cat control programs throughout Australia, but is not yet registered and has not been introduced to other countries as a potential solution (Read et al. 2019).

1.2.3 Shooting

A method that may be more familiar to the general public is shooting to control populations of cats and other pest predator species around the world. This method is most appropriate if applied for an extended period of time, or if used during critical periods of an eradication program, such as when most of the cats have been removed from an area using other methods (Bomford and O'Brien 1995; Fisher et al. 2015).

Shooting is only effective if the hunters involved are experienced, licensed, and skilled enough to humanely cull an animal. Feral cats in particular are known to be mostly active at night, and so most shooting takes place during this time using a vehicle and spotlight to find the individuals. At the same time, some campaigns include day shooting as well, often while using detector dogs to locate individual cats. The choice of appropriate firearm, ammunition, and shot placement also follows strict requirements in planning and implementation in different regions worldwide (Algar et al. 2010; Australian Government Department of the Environment 2015c). Because of these specifications and the risks involved, shooting is normally considered resource intensive and costly, and is often only employed in management campaigns if there are low numbers of cats in an area, or if the area is small in size (Australian Government Department of the Environment 2015a; Bester et al. 2002). In the UK, shooting is employed in a less formal setting, as feral cats are included on the list of game that recreational hunters are allowed to hunt throughout the year. This hunting can only take place as long as the shooting is done humanely and in accordance with the UK animal welfare legislation that applies the same protections to feral cats as it does to domestic cats that are kept as pets.

Shooting has been used in a number of small-scale feral cat eradication programs that have taken place on islands around Australia. The feral cat eradication campaign on North West Island off the coast of central Queensland in Australia included shooting, as well as trapping and baiting (Domm and Messersmith 1990). It was only after trapping was shown to be not as effective for this campaign that shooting was employed. Shooters went out on six separate trips over the course of one year, and each trip involved one to two shooters using double-barrel and pump-action 12-gauge shotguns(Domm and Messersmith 1990). The trips took place over four days each and included day hunting over the whole island by walking transects or random searching. They also included spotlighting at night along the beach. As a result, 95 of the 105 cats were confirmed killed by shooting, while the others were terminated using traps and

baits (Domm and Messersmith 1990).

Shooting has also been used on islands in the Galapagos, Ecuador, such as on Baltra Island, where a feral cat eradication campaign was set up to help protect different species of the Galapagos Island Iguana (Phillips et al. 2005). In this campaign, baiting was used as the primary technique for initially eliminating cats from the area. After a significant number of cats had been removed from the island using the baits, shooting was employed to remove the remaining individuals (Phillips et al. 2005). Although the landscape contained thorny shrubs and rocky terrain, spotlighting at night using a .243 calibre rifle or a 20-gauge shotgun was shown to be highly effective. For those that were not able to be shot, cage traps were set up and the captured individuals were humanely euthanised (Phillips et al. 2005).

1.2.4 Trapping

Trapping is a method that is often deployed throughout the USA and Australia for use in various feral predator management programs, including for feral cats. It can be used by either wildlife management authorities or by landholders who wish to keep cats off their property. Types of traps often used include cage traps and padded jaw leg-hold traps (Australian Government Department of the Environment 2015c; Bomford and O'Brien 1995). The latter are sometimes used in conjunction with shooting, as it can be easier to shoot and kill a cat that has stepped into a padded jaw leg-hold trap. Padded jaw leg-hold traps are considered to be more effective in catching feral cats, especially if the animals have previously encountered cage traps and are wary of them (Nogales et al. 2004). As a requirement, traps in both the USA and Australia are supposed to be set up so that they provide shelter for the animal, and be checked at least every 24 hours so as not to cause additional stress (Hildreth et al. 2010). Once trapped, it is expected that individuals in urban and peri-urban areas will be scanned for microchips to ensure that they are not domestic cats that are owned. If the cats are found to be feral, they are supposed to be killed quickly either on the spot, or

transported to an animal health facility to be euthanised (Australian Government Department of the Environment 2015a; Bomford and O'Brien 1995).

In some countries such as North America, the UK and of parts of Europe, Trap-Neuter-Return (TNR) programs are used. These programs involve using cage traps to capture individual feral cats, taking them to an animal health care facility to be sterilised, and then returning them to the environment (Longcore et al. 2009). If this approach is used, the animals are supposed to be quickly transported to a designated vet clinic and released back at the capture location once the neutering procedure has been completed (Fisher et al. 2015; Foley et al. 2005; McCarthy et al. 2013). TNR programs and cage trapping in general are considered most useful in urban areas or where individual animals need to be targeted. This is because it is easier to capture individuals without causing them harm, which further aids in gaining acceptance and support from the surrounding communities (Natoli et al. 2006).

To aid in successful trapping of a feral cat, a lure is sometimes used to attract individuals to the trap. Lures can be visual and include tinsel or feathers, or they can be scent-based and smell of faeces, urine or a food item. Few studies have been conducted on the efficacy of using lures for attracting, and hence trapping, cats (Bengsen et al. 2011; Read 2015). The downside to trapping however, is that it tends to be relatively costly, labour intensive and time consuming. Much like shooting, trapping is recommended for small scale campaigns involving low numbers or densities of cats.

1.2.5 Detector dogs

Detector dogs (*Canis domesticus*) are specifically trained to track feral cats or other pests in various types of landscape (Johnston et al. 2017). The dogs are accompanied by their handlers to locate feral cats within a landscape, and to give a signal once the individual has been located. The cat is then normally humanely euthanised. It should be noted that the dogs are not used to catch or kill cats, but only to locate them. These dogs have been deployed in campaigns aimed at eradicating feral predators on islands such Dirk Hartog Island, Western Australia and in certain areas of

New Zealand, where feral cats are considered a major threat to biodiversity (Glen et al.).

1.2.6 Guardian dogs

Guardian dogs are often placed onto properties that host livestock, such as sheep farms, to protect the animals from predators. There are multiple breeds that can be trained as guardian dogs, and although Maremma dogs, for example, are now commonly used to protect stock on modern Australian farms, the method has pre-historic origins in large parts of the globe (Van Bommel 2013). The dogs bond with a flock of sheep and protect them by scaring away other animals that may be perceived as a threat, such as feral cats or other predators. A certain number of dogs will be kept on a property, according to the size of the property and the number of sheep within a flock. The presence of guardian dogs provides the additional advantage of deterring cats from entering into an area, making it easier to influence cat movements and control their numbers in the associated region (Queensland Government Department of Agriculture and Fisheries 2016).

Maremma dogs have also been specifically trained in some areas to protect wildlife (Van Bommel 2013). In 2006, the first dog was trialled in Warrnambool, Victoria to protect seabird colonies on Middle Island. There are currently two dogs patrolling the island, and since the program's establishment, no seabirds in this area have been killed by feral predators. After this program proved successful, dogs were also placed at Point Danger, near Portland, Victoria, where the only breeding colony of Australasian Gannets on mainland Australia resides (Van Bommel 2013). Following the introduction of the dogs to this area, Gannet populations have increased over a series of successful breeding seasons in association with a decrease in predation by both foxes and feral cats (Van Bommel 2013).

1.2.7 Exclusion fencing

In some instances, exclusion fencing has been used as a technique in feral cat management worldwide. It is currently in the process of being deployed on both Kangaroo Island and the Southern Yorke Peninsula, both in South Australia to assist in the feral cat eradication program at these sites (Kangaroo Island Feral Cat Eradication Program 2018). Fencing has also been used in South Australia's Arid Recovery program, and in numerous Australian Wildlife Conservancy's (AWC) sanctuaries, such as their Yookamurra Sanctuary. At all of these sites, the fencing serves as a means to keep cats, foxes and rabbits out of areas inhabited by threatened species (Arid Recovery 2011; Natural Resource Management Program 2018). This technique is thought to be a humane, non-lethal way of excluding cats, and normally consists of a highly built structure with overhanging features and electric wires that prevent animals from climbing over, as well as a mesh lining to prevent them from digging underneath (Australian Government Department of the Environment 2015c; Bomford and O'Brien 1995). The fencing, even if only temporary, can also serve as a way to manage different sections of land at a time, forming what are known as Operational Management Units (Parkes 2010; Spencer 2004).

Some designs also include an electric grid that is placed over any road or crossing that might otherwise breach the fence, which allows for vehicles to pass through but minimises the chance of feral cats entering the restricted area (Moseby 2006). Although seen as humane, fences are in affect a large semi-captive enclosure, which are costly in terms of resources both to construct and maintain and can also affect the movement and populations of other wildlife in the area. They often require the need for management of more than one invasive species in order to justify being erected (Moseby et al. 2020), and are used in conjunction with at least one other type of control technique, such as baiting or trapping or both to be most effective (McDermott et al. 2013; Phillips et al. 2005). Another major negative impact of exclusion fencing is the need for ongoing management of the native wildlife inside the fence, including both

any native threatened species being re-introduced and those currently extant at the site. Management is required to avoid over-population within the confined area to limit potential impacts such as habitat degradation, starvation and behavioural problems across a suite of species. In some cases, such as on Kangaroo Island where feral cats are targeted for complete eradication, a barrier fence at the narrow isthmus of the island is considered a viable option because it will segregate a portion of the island for a preliminary trial of techniques that may later be used for eradicating cats from the remainder of the island, and to help protect the eradication of the first area (Kangaroo Island Feral Cat Eradication Program 2018). Although costly, exclusion fences have been shown to aid in the recovery of certain native species that have suffered losses from invasive species (Australian Government Department of the Environment 2015c).

1.2.8 Habitat management

An alternative to a large range of techniques that involve physical interactions with feral cats, is the option to modify habitat areas through changes to vegetation management as a way to influence feral cat and prey population numbers and movements. Many cats utilise their habitat in different ways depending on their goal, whether it be hunting, hiding, or resting (Doherty et al. 2014). By using information on home range and habitat use behaviour, it is possible to determine cat density in an area, and this may help in establishing the types of techniques required (Oppel et al. 2014). Although there has been little research on how land use affects feral cat management, it is important to take different types of terrain, land-use and vegetation into consideration when preparing to place devices. Changes to a landscape through development or land use change could potentially affect the types of methods that are acceptable to use in a location (Australian Government Department of the Environment 2015c; Doherty et al. 2014).

With many different potential options available for use in developing and implementing feral cat management campaigns, it is important to the success of any campaign to examine the social factors that influence attitudes towards feral cats as a

species as well as attitudes towards the different management methods. Establishing how different people around the world react to feral cat management and why can aid in improving management for different areas in the future.

1.3 Aims and objectives

This thesis aims to aid feral cat management by adopting an interdisciplinary approach to investigate the social response to feral cat management internationally and within the south-eastern region of Australia. The objectives of this study are:

- To determine if there is a well-grounded universal definition for what a feral cat is, or if definition is dependent on global region.

- To investigate the social media narrative around feral cats to establish public attitudes around feral cats and their management in an international and regional context, which may then aid in gaining additional support for future management.

- To establish the social factors that influence the public's attitudes around and acceptability of feral cat management methods in a regional context, enabling management to better communicate and improve community engagement in the future.

1.4 Study context

To undertake an international analysis, this study examined the significance of perceptions of feral cat management on the success of management campaigns around the world. It also involved collecting data from Twitter to conduct a sentiment analysis on the narrative around feral cats over the course of 5 years from January 2015 to December 2019, based on country and group of users who contribute to the dialogue.

The regional aspect of the study involved examining local residential attitudes towards various feral cat control measures on the 440 km² Kangaroo Island (KI), South Australia and around the 1,672 km² Grampians National Park in Victoria.

Lacking the devastating impacts of the introduced red fox (*Vulpes vulpes*) and European rabbit (*Oryctolagus cuniculus*), KI is known for its ecotourism due to its high levels of biodiversity and its place as a sanctuary for several endangered species (Authentic Kangaroo Island 2020). The island is home to a number of endemic species, such as the KI short-beaked echidna (*Tachyglossus aculeatus multiaculeatus)* and the KI dunnart (*Sminthopsis fuliginosus aitkeni*), and it serves as a sanctuary for vulnerable and endangered species, such as Rosenberg's goanna (*Varanus rosenbergi*) and the southern brown bandicoot (*Isoodon obesulus*) (Natural Resource Kangaroo Island 2013). Along with ecotourism, KI is well known for its livestock industries, including sheep-farming (Authentic Kangaroo Island 2020). The presence of feral cats on KI greatly threatens the biodiversity of the island as well as the livestock industry, and as a result the island established its feral cat eradication program in 2015 (Kangaroo Island Feral Cat Eradication Program 2018; Taggart et al. 2019a; Taggart et al. 2019b Taggart et al. 2020).

The Grampians National Park is also well known for its ecotourism with a wide variety of natural landscapes and native wildlife, and for the surrounding productive sheep-farming and other livestock and industry (Parks Victoria 2020). Invasive predators such as the red fox (*Vulpes Vulpes*), which pose a threat to native wildlife and to livestock in the region are managed using poisoning, fumigation, and fencing (Horner and Platt 1993; Taggart et al. 2015). Feral cats, which were only recently declared a pest species by the state of Victoria in 2018 due to their threat to wildlife and livestock, are currently being integrated into these pre-existing feral predator management campaigns (Victoria State Government 2018).

These two locations were chosen partly because sheep farming and nature-based tourism are essential industries in both places, and partly because of their differing

stages of feral cat management. Efforts to control feral cats on KI are more advanced than those in the Grampians region, with a feral cat eradication program having been established on the island since 2015, but with community control efforts going back to the 1990s (Paton 1994; Paton 2003) and possibly earlier.

1.5 Thesis structure

This thesis consists of six chapters, one of which has been published in the peer-reviewed journal Animals (Chapter 2), and three of which have been submitted for publication (Chapters 3, 4 and 5). The current chapter serves as a general introduction to the topic and its importance, and presents research objectives and aims, the study context, and the outline of the thesis (Chapter 1). Chapter 2 consists of the literature review; a review of the global perceptions around feral cats and the management measures taken to address overpopulation in different countries. It highlights the international and regional differences in the definition of a feral cat and implores management to consider how this may impact perceptions of and support towards management in specific areas. Chapter 3 provides insight into the international narrative around feral cats on Twitter from January 2105 to December 2019 and presents a sentiment analysis that highlights dialogue according to the country and the groups responsible for contributing to the narrative. Chapter 4 takes a closer look at the regional perspectives of feral cat management by examining the attitudes and perceptions around feral cats in the south-eastern part of Australia, on KI, South Australia and in the Grampians National Park region of western Victoria. It investigates how gender and previous knowledge about feral cat management influence the likelihood of participants using various feral cat management methods on their property, finding that men and women view management in different ways and that those who are more familiar with certain methods are more likely to allow their use than those who are not, especially in the case of women. Chapter 5 follows suit by investigating the attitudes and perceptions of landholders with different land use types

on KI and in the Grampians National Park region and determining if there are differences in the likelihood of people with different land use types in different locations using various cat control methods on their property. Chapter 6 summarises key findings, presents broader implications of the research, and highlights opportunities for future research.

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Chapter 2

The Significance of Social Perceptions in Implementing Successful Feral Cat Management Strategies:

A Global Review

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Principal Author

Name of Principal Author (Candidate)	Brooke Deak	
Contribution to the paper	Conceptualization, formal analysis, writing – original draft preparation, writing – review and editing.	
Overall percentage (%)	70%	
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.	
Signature		Date: 11/09/2020

Co-author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Bertram Ostendorf	
Contribution to the Paper	Conceptualization, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Taggart	
Contribution to the Paper	Conceptualization, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Peacock	
Contribution to the Paper	Conceptualization, writing – review and editing.	
Signature		Date: 23/09/2020

Name of Co-Author	Douglas Bardsley	
Contribution to the Paper	Conceptualization, writing – review and editing.	
Signature		Date: 28/09/2020

Abstract

This review examines the social aspects that influence feral cat management. In particular, it examines definitions and perceptions of feral cats as a species in different countries and across cultures. Using case studies from around the world, we investigate the factors that can influence public perceptions and social acceptance of feral cats and management methods. The review then highlights the importance of social factors in management and suggests the best approach to use in the future to ease the process of gaining a social license for management campaigns. Implications of the influence of education and awareness on public perception and acceptance are further explained, and are suggested to be an essential tool in successfully engaging the community about management in the future.

2.1 Introduction

The cat (*Felis catus*) has been associated with human companionship for thousands of years (Driscoll et al. 2009).As well as being considered to be domestic pets, cats also serve as a means of keeping mice, rats, and other rodent populations under control in homes and on-board ships, which in turn has traditionally aided in keeping food and supplies safe, and controlling disease (Driscoll et al. 2009; Spencer et al. 2016). As a result, of their worldwide oceanic journeys however, cats have been introduced to many new environments to which they readily adapted and established invasive exotic populations. Cats now currently inhabit regions of all continents, are present on many islands worldwide, and are impacting the local ecology in those places (Spencer et al. 2016).

Cats are opportunistic feeders that require a high protein diet to sustain themselves, due to their inability to synthesize essential vitamins and minerals (Duffy and Capece 2012). Feral cats, generally defined as cats that have little to no interaction with or dependence on humans, will hunt for food at least several times a day (Dickman

1996; Duffy and Capece 2012). These cats have been at least partially responsible for the extinction of 14% of native bird, mammal, and reptile species worldwide, including in Australia where one third of all recent global extinctions have taken place (Duffy and Capece 2012). In 2001, the species was placed on the International Union of Conservation for Nature (IUCN) list of the 100 worst invasive species worldwide, and was considered the most damaging of the four carnivores on that list due to the impacts they have on endangered species populations (Bergstrom et al. 2009; Nogales et al. 2013). One cat alone is capable of depleting populations of smaller mammals and other animals, especially those that are highly concentrated in one area. Consequently, cats can become a major threat to endangered or vulnerable wildlife, which often persist in small, remnant and isolated populations (Australian Government Department of the Environment 2015c). Even in the case of species of birds and small animals that are not yet vulnerable or endangered, the magnitude of cat predation is high due to hunting by not only feral cats, but by outdoor domestic and stray cats in urban and rural areas as well (Australian Government Department of the Environment 2015c; Duffy and Capece 2012).

Cats are also the primary host for several diseases that pose a significant threat to susceptible wildlife, humans, and livestock, which can in turn generate economic risks (Cove et al. 2018; Spotte 2014). Some of these diseases, such as toxoplasmosis (caused by the microparasites *Toxoplasma gondii*) and sarcocystis (*Sarcocystis gigantean* and *S. medusiformis*), can be transmitted to humans and other animals through physical contact with a cat or its fecal matter but they have no health consequences for the individual infected cat (Australian Government Department of the Environment 2015a; Recio and Seddon 2013). In humans, toxoplasmosis is a parasitic disease that increases the production of dopamine, promoting a rise in reward-seeking and risk-taking behaviors. This disease has been linked to mental disorders such as schizophrenia and attention deficit disorder, and is known to produce a higher probability of miscarriage and still-birth (Hollings et al. 2013; Nogales et al. 2004). Children who contract toxoplasmosis within the womb are at risk of suffering

from blindness, encephalitis, or developmental retardation (Hollings et al. 2013). The disease is also a threat to the livestock industry, as it can cause abortions in sheep or weaken newborn lambs, leading to significant economic impacts in areas where sheep farming is a prominent industry (Millan et al. 2009; Spotte 2014). Toxoplasmosis has been shown to be carried by feral cats throughout regions of the United States (US), South Korea, Australia, Portugal, South Africa, and Spain (Lee et al. 2011; Millan et al. 2009).

Alternatively, Sarcocystis gigantea can cause cysts in the muscle tissue of sheep, leading to carcass trimming, or in severe cases, carcass rejection at abattoirs (Langham and Charleston 2012). The disease is dependent upon the complex lifecycle of the microscopic parasites, which begin their development within the intestines of cats that have fed on infected sheep carcasses. These parasites transition into sporocysts that are transmitted to living sheep that graze on pastures contaminated by cat feces. Once ingested by the sheep, the sporocysts localize in the muscles, creating macro-cysts (Langham and Charleston 2012). Although the disease is present throughout countries such as Australia and New Zealand (NZ), it is more common on islands such as Tasmania, where sheep farming is a prominent industry and where there are significant numbers of feral cats (Gregory 1976).

Furthermore, in regions of Europe, feline leukemia (FeLV) as carried by domestic and feral cats is considered a threat to native wild felids such as the endangered Iberian Lynx (*Lynx pardinus*) (Ferreras et al. 2010; Lopez et al. 2009). FeLV occurs naturally as a family of viruses, and is transmitted between felids through direct contact. Once infected, some individuals may experience persistent viremia, which can lead to diseases such as lymphomas, leukemia, or anemia, ultimately leading to the death of the individual within months or possibly years (Ferreras et al. 2010; Lopez et al. 2009). Due to the solitary nature of the lynx, intraspecific fights are common, and contact between lynx and feral cats is thought to have led to the spread of FeLV throughout Iberian Lynx populations (Ferreras et al. 2010; Lopez et al. 2009). Other felid populations such as that of the European wildcat (*Felis silvestris*) are also

threatened by the presences of feral domestic cats due to the potential for interbreeding (Hubbard et al. 1992). Hybridization between the two species increases the risk of genetic deterioration for the wildcat population, and increases the likelihood of extinction (Pierpaoli et al. 2003).

2.1.1 The need for management

Because of their destructive nature and negative impacts on environmental and economic wellbeing, governments around the world, especially in the US, Spain, Portugal, Australia, Italy and NZ have initiated feral cat impact control and eradication campaigns (Robertson 2008). Due to the vulnerability of local biodiversity and livestock in Australia, feral cat management has become a priority, yet some states are currently only beginning to update legislation and expand their feral predator management programs to include cats (Woinarski et al. 2017). Although there are already existing techniques used to control feral predators such as foxes (*Vulpes vulpes*) in Australia, developing effective control methods specifically for feral cats has been the subject of recent public debate (Loyd and Miller 2010b). In the US, feral cats are often brought to a shelter to be humanely euthanized, or on rare occasions are selected for adoption based on their suitability to be human companions (Flockhart and Coe 2018; Wald et al. 2013). Legislation in some US states such as Florida and California has included the use of trapping, sterilizing and vaccinating cats, and then releasing them back into the wild (Wald et al. 2013). Trap-Neuter-Release (TNR) is considered to be a humane approach to feral cat control, and yet debate still occurs as to whether or not this is the best way to manage local feral cat populations (Loyd and Miller 2010a; Wald et al. 2013). In contrast, Italy has a no-kill policy for stray and feral cats. Instead, it is required by law that any cats caught be sterilized and returned to the wild, and they are not to be euthanized unless found to be terminally ill or dangerous (Natoli 2014; Natoli et al. 2006). Steps towards planning and implementing feral cat management programs depend heavily on the culture of the location and the associated

government choosing an approach that is both socially acceptable and ecologically effective for the region (Stoskopf and Nutter 2004).

The primary goal of feral cat management is generally to diminish the population as quickly as possible through humane means (Australian Government Department of the Environment 2015c). The preferred approach in areas with highly threatened and potentially vulnerable wildlife species is eradication, but eradication campaigns are resource intensive, time sensitive, and costly, especially when applied across large tracts of land where monitoring progress and success can be difficult (Liu and Cook 2016). For eradication to be successful, the rate of removal for the species must increase at all population densities, and all animals must be able to be detected at low densities for targeted interventions. Due to the nature of these requirements, eradication is considered less feasible than control in large areas (Bomford and O'Brien 1995; Jones et al. 2016). However, local eradication is applicable on small islands or within highly managed mainland sites (Bomford and O'Brien 1995; Parkes et al. 2014). In particular, there have been successful eradication campaigns implemented on islands that have a smaller surface area, where low numbers of cats can be targeted and there is a reduced chance of reinvasion (Algar et al. 2010; Hanson et al. 2015).

Instead, most feral cat management plans focus on population control and the minimizing of impacts (Australian Government Department of the Environment 2015c). Management plans that focus on these initiatives tend to be less intensive, and therefore less costly (Invasive Species Council Australia 2018). These programs tend to aim for a gradual decline of the target species population and require a strategic but fluid approach to control in a local area. Although it is important to consider the time and resource allocation required for any program, there is rarely a tangible end goal for control campaigns, with management needing to adjust to changing circumstances. The amount of uncertainty around definitions of program success can often make it difficult to access ongoing funding and continued support for management (Invasive Species Council Australia 2018).

Whether it be for eradication or control, many feral cat management programs have adopted an approach that includes the conjoint use of techniques or methods to abate cat numbers, which may include poison baiting, shooting, trapping, TNR, grooming traps, detector dogs, guardian dogs, exclusion fencing, fertility controls and habitat management (Australian Government Department of the Environment 2015c; Larson et al. 2011). The techniques selected for use are often chosen based on the size of the target region, the terrain and layout of the landscape, the density of the cat population in the region, and the cost-effectiveness of the suitable techniques (Australian Government Department of the Environment 2015c; Baker and Bode 2016). Choice of technique also commonly depends heavily on the budget allocation for the campaign, as well as on the tools, time, labor and other resources that are available (McDermott et al. 2013; Stoskopf and Nutter 2004).

The application of various methods is contentious for several reasons, some of which are due to misunderstandings around the science behind feral cat management and the knowledge gaps that exist around the issue (Moon et al. 2015). There is, however, little debate about the adverse impacts of feral cats on native wildlife. There have been extensive studies conducted on the ecological consequences of feral cat abundance, as reviewed by Tim Doherty, et al. (Woinarski et al. 2017). Experts agree that effective feral cat management needs to be based on the ecology of the predators themselves and their behaviors, while at the same time, acknowledging the strong dependence of any successful ecological outcomes on the effective acceptance and adoption of management by local communities. Thus, research around this topic must take on an interdisciplinary approach (Bardsley and Edwards-Jones 2006; Rotherham 2013).

Debate around the types of techniques that are used within any regional context are dependent on location and the perceived threat of feral cats as a species in that region. There are also concerns that apply to cats that may not apply in other cases of invasive species management. For instance, certain animals appeal to the public imagination more than others, and iconic species are more likely to attract sympathy

and support for their survival (Seymour 2013). Furthermore, while scientists and management authorities tend to rely on a scientific understanding of the concepts involved in management, the general public and those who may have little to no exposure to threats associated with a target

species tend to react to management in an emotional way. This is especially true if the species is one that is considered closely connected to humans, such as the cat (Estevez et al. 2014; Garcia-Llorente et al. 2008).

For this reason, it is imperative that the local communities associated with the areas where management will take place understand the importance of managing invasive species such as feral cats, so that the programs that rely on public funding are able to generate and maintain support from funding bodies (Invasive Species Council Australia 2018). This may be further complicated by the idea that the definition of a feral cat itself varies depending on location and on the situation of the individual cat (Farnworth et al. 2011). This paper contributes to the discussion around the management of feral cats by reviewing the literature on the social aspects of invasive species management with particular emphasis on feral cats, and the influence of these aspects in the effectiveness of outcomes.

2.2 Community influence in invasive species management

Any effective invasive species management campaign requires public support and a social license to act, or in other words, the management goals must meet the demands and expectations of society and not act in a way that society feels is unacceptable (Gunningham et al. 2004). Without such a suitable socio-political environment, it is difficult for management campaigns that diminish species populations to succeed (Bomford and O'Brien 1995). Excessive tension between the community and the administration involved in the delivery of program aims can force management efforts to be frustrated and prolonged (Bomford and O'Brien 1995;

Nogales et al. 2004). In debating the possibility of culling a pest species, particular tensions can emerge between those who are concerned for the welfare of individuals within the target species, and those who are concerned with the welfare of the endangered native species that are at risk due to the presence of the target species (Wald et al. 2013). This can often result in prolonged processes of community engagement, deliberation, and assessment to gain public acceptance, without which there would be denial of access to properties, cooperation, regulatory support or funding (Ogden and Gilbert 2011).

For instance, some studies have examined the critical aspects involved in eradicating invasive species including rodents, feral cats and pigs from local islands of NZ and Australia (Parkes et al. 2017). Although eradicating invasive animals from uninhabited islands is always a management challenge, it was found to be more difficult on islands that were inhabited by people, due to the cost of working to ensure the wellbeing of humans, pets and livestock (Parkes et al. 2017). Island inhabitants hold varying perceptions of the target species, which can prolong program planning. In one particular case study, the residents of Waiheke and Pitt Islands accepted the eradication of mice and feral cats as a benefit to the island, but the eradication of pigs was deemed undesirable as they are considered a hunting asset (Parkes et al. 2017). On Lord Howe Island, the community seemed skeptical about the benefits of an eradication campaign, and ongoing deliberation has since delayed the program. The eradication of stoats (*Mustela erminea*) on D'Urville Island, NZ was also delayed for 10 years due to insufficient community acceptance, and it was only after extensive debate that social support for the control program was generated (Parkes et al. 2017). As a result of the social barriers of acceptance faced by management, gaining a social license has been considered one of the main constraints in planning and implementing invasive species management campaigns (Gunningham et al. 2004; Parkes et al. 2017).

Community engagement can contribute to the generation of social license by involving individuals in planning and management, which ensures learning of the processes involved in management and building upon local skills and knowledge

(Eaton 2016; Howard et al. 2018). One study of community engagement within an Australia region considering wild dog management found that it was essential to contextualize pest management in relation to local concerns to gain community approval, promote understanding and facilitate success (Howard et al. 2018). Other studies suggest including animal welfare organizations in the decision-making process may further increase public support, as doing so is more likely to ensure that the management methods selected are humane and have been discussed from varying, often conflicting viewpoints (Ford-Thompson et al. 2015).

In a similar example, education and knowledge are highlighted as essential factors in increasing support and gaining a social license for management campaigns (Stokes et al. 2006). An Irish campaign was implemented to eradicate invasive muskrats from the country, as they were posing problems for native plants and crops throughout, and were known to damage drainage systems, as well as burrow in unacceptable areas (Stokes et al. 2006). Due to these and other concerns around potential riverbed erosion, the government implemented a plan to eradicate the species. As it was seen by both the community and other stakeholders to be a species that was detrimental to the environmental and economic wellbeing of the country, financial support as well as social license was given to ensure that the eradication program would be a success (Stokes et al. 2006). The program ran for two years, and the success was partially attributed to the education and knowledge within the community, as well as key stakeholders about the species and its impacts (Stokes et al. 2006).

The lack of education and knowledge around a pest species and its impacts can also impact proposed management, as demonstrated by a study of feral cats in University of KwaZulu-Natal in South Africa. The university investigated perceptions of students and staff around the feral cats found in Msinsi Nature Reserve (the Conservancy). The results of the study suggested that although the Conservancy believed the feral cats to be an exotic species of high threat to the native wildlife of the area, most respondents did not define them as exotic or believe that they posed such a

threat (Tennent et al. 2009). While the Conservancy had aimed to eradicate the feral cats, most of the participants in the study believed that only population control and management was necessary, and not eradication (Tennent et al. 2009). Furthermore, there was no consensus on what methods should be used to control the cats in this area due to lack of understanding around the methods. Few respondents were aware of the aims of the Conservancy or of the impacts that feral cats have on native wildlife, and as a result it was suggested that university students and staff be encouraged to learn more about their local ecology, and to volunteer with the Conservancy as a way to learn through experience (Tennent et al. 2009).

Society is sensitive to educational programs, and successful education campaigns can lead to a better sense of awareness about target species and their impacts (Garcia-Llorente et al. 2008). In the Netherlands, a study found that participants who were highly educated or engaged in environmental activities were also more likely to support invasive species management than those who were unfamiliar with the topic (Verbrugge et al. 2013). Those who were more knowledgeable were also more likely to understand the level of risk associated with different invasive species and support their effective management (Verbrugge et al. 2013). The familiarity and perceptions associated with feral cats, though, can differ greatly depending on how a country or groups within a location define the term.

2.3 The elusive definition of a “feral” cat

There are many definitions given to feral cats (Gosling et al. 2013). In a general sense, most definitions suggest that it is a cat that lives in the wild, does not interact with human beings or rely on them for food or shelter (Farnworth et al. 2011). In contrast, stray cats are normally defined as free-roaming cats that stay close to human habitation and rely indirectly on humans for these resources (Farnworth et al. 2010). The greatest confusion seems to occur when discussing the difference between a stray

and a feral cat, as countries such as the US and parts of Europe draw a fine line between these terms, sometimes even using them interchangeably (Gosling et al. 2013; Tasker 2007). For instance, in the US there are cat colonies that consist of both feral and stray cats, often called “community cats” (Hernandez et al. 2018; Loyd and Miller 2010a). These colonies are cared for by volunteers from the community who provide resources for the cats, including sheltered areas and feeding stations (Hatley 2003). The supposed difference between feral cats and stray cats in this instance is that feral cats tend to be incredibly wary of the humans that care for these colonies, and stray cats seem to be more approachable (Hatley 2003). In a formal context, Michigan State University Law School defines feral cats as those that were once owned and were either abandoned, lost, or had run away. The descendants of such cats are referred to as “stray” cats with later generations becoming “feral” (LaCroix 2006). Certain states within the US also have laws pertaining to “owning” feral cats, though these laws are difficult to enforce as multiple counties within a state may have different interpretations (Fry 2010).

Part of the issue in defining what a feral cat truly is may lie in the fact that the status of a cat may change depending on its situation (Gosling et al. 2013; Waller 2016). A domestic cat that has been abandoned by its owners can become a stray or can turn feral, and its offspring would then be considered stray and/or feral as well (Farnworth et al. 2010). Most kittens, if they are found young enough, are usually able to be socialized and adopted out as domestic pets (Gosling et al. 2013). If an adult cat is caught and found tame enough to be adopted, it can also once again become a domestic pet (Gosling et al. 2013). In the case of feline colonies that are maintained by humans, it is difficult to determine whether the cats that live within the colony should be defined as stray or feral, as it seems to depend on whether individual cats use the resources provided by the humans, and whether they are in contact with the humans caring for the colony (Hernandez et al. 2018). As they are mostly defined as “community cats”, the difference between a stray and a feral cat becomes even more vague to the general public (Hatley 2003). Although the Michigan State University Law School has set a

definition for a stray cat and a feral cat, their classification would be difficult to apply for management purposes (Fry 2010; LaCroix 2006). Related documentation refers to a cat's potential behavioral changes over its lifespan as a possible reason for the vague definitions in certain European countries as well (Tasker 2007).

In Spain and Italy, the term feral cat is used to describe a domestic cat that has been abandoned or returned to the wild (Millan et al. 2009; Rodriguez 2016). These cats often live in colonies throughout urban areas and are given food, shelter and other resources by humans (Millan et al. 2009; Rodriguez 2016). They are also referred to as street cats, which one could easily confuse for a stray cat instead of a feral cat (Rodriguez 2016). This is especially true in Rome, where urban domestic cats are known interchangeably as both feral and stray cats, and are believed to be overfed by local citizens who leave an abundance of food out for them (Natoli et al. 2006). Other European countries take a slightly different approach to definition. In Estonia, five types of cat are defined, including feral cats and semi-feral cats (Jaros 2018). In this context, feral cats are known to hunt and fend for themselves, though they will occasionally scavenge leftovers produced by humans. They are considered skittish and are generally afraid of people. Semi-feral cats will hunt but will also accept food left out by humans, and although they show no fear towards people, they will not establish a bond with them directly (Jaros 2018). Pseudo-wildcats are also classified in this study, and are said to be different from feral cats in that they are completely independent of humans (Jaros 2018). In contrast, the UK has no recognized definition of a feral cat, and the wide variations of what people in the country believe a feral cat to be can range significantly due to the belief in the possibility of "taming" a feral cat given time (Gosling et al. 2013).

The differences in definition within these countries may reflect the level of perceived threat that feral cats pose to the natural environment. The US and Europe host native felids that have evolved with the changing environment over time, and the introduction of feral cats into these regional ecosystems has not seemed to have had detrimental impacts. However, this is not the case in countries such as Australia and

NZ, where no native felids existed prior to the introduction of cats. Native ecosystems and associated species within these countries have not had the opportunity to adapt to the presence of cats, and so the threat that stray (semi-feral) and feral cats pose is much higher. The need for management in this case requires a clear and firm definition of what a domestic, stray and feral cat is,
and this cannot be determined by definitions granted by the US or Europe, as the closest definition to a feral cat in the Australian context would likely be that of the aforementioned pseudo-wildcat (Australian Government Department of the Environment 2015c).

Therefore, the differences between a stray cat and a feral cat are far more pronounced in Australia. Stray cats or semi-feral cats are those that were once owned and have either been abandoned or run away (Australian Veterinary Association 2016). They wander through urban areas and adjacent bushland or farmland, hunting and killing wildlife, but also accepting food and resources from humans. They are sometimes thought able to be rehabilitated back into pets. Feral cats in Australia, however, are thought to have never been owned by humans, and inhabit bushland areas away from human habitation (Abbot 2002; Australian Veterinary Association 2016). The Australian government has also nationally declared feral cats as a pest species that requires appropriate management (Australian Government Department of the Environment and Energy 2019).In NZ, research has specifically aimed at defining the nature of different categories of cat, whether they be a Companion, Stray or Feral Domestic Cat (Farnworth et al. 2010). For the sake of management, stray cats were noted as those that live in colonies or close to human habitation, and that indirectly rely on humans for their needs (Farnworth et al. 2010). Their numbers could be augmented by interbreeding with the companion cat population, but they were not considered feral cats. Feral cats were defined as cats that had none of their needs provided for by humans and lived in areas away from human habitation. The feral cat population in this case is said to fluctuate independently of companion cat influence (Farnworth et al. 2010).

With the definition of a feral cat being conditional on the region, there is also a large variance in the way that feral cats are perceived in the media and different parts of the world (Tsetsura and Aziz 2018). Perceptions and attitudes of the general public can be influenced by a range factors, including the knowledge that an individual has around a topic, and the way that information is received and interpreted by that individual (Estevez et al. 2014). Science communication plays a large role in the way people perceive scientific topics such as feral cat management, and this is especially true in highly networked democratic
societies where the public increasingly has a say in the scientific and technological solutions that are implemented by policy (Bickford et al. 2012; Hwong et al. 2017). There has recently been a major push towards improved efficiency in science communication and dialogue between those in management and the general public (Bickford et al. 2012; Ramsey 2010).

Developing a universal and solid definition for the terms associated with both "stray" and "feral" cats may aid in improving this efficiency by allowing better understanding to be formed through different media outlets worldwide. This could further aid in stray and feral cat management, as a better understanding would allow the general public to take a stronger stance on these cats as a 'category of animal' that needs to be managed (Feinstein 2014). It may also enable management authorities to more clearly design cat control measures to address either feral or stray cats, depending on the degree of social acceptance of various control measures for cats within each of these categories.

This may also aid in reducing confusion around how feral cat management should be reported by journalists. Media stories are often presented as quickly as possible and truth can sometimes be skewed, or key details overlooked (Feinstein 2014). Opportunities can often be missed to properly educate the public on the topics that are covered, such as what a feral cat actually is in management terms (Baran and David 2015; Ramsey 2010). As a result, much of the information that the general public is introduced to on scientific topics, including invasive species and their management,

is condensed to highlight only a few main points around which the public can begin to develop an informed stance (Ramsey 2010). As most people rely on old or new media sources for news in a global and local context, the way this information is received can affect the way that an individual views the topic through way of agenda-setting (Fisher et al. 2013; Wanta et al. 2004). First level agenda-setting theory suggests that media coverage can influence what people think about a topic, with second level agenda-setting prying deeper to suggest that it also influences how people think about that topic (Wanta et al. 2004).

In reference to feral cats, news stories tend to be divided depending on narrative framing, either reflecting a positive or negative view of cats (Fisher et al. 2013; Hwong et al. 2017). One news source in particular, the New York Times, has written stories throughout the years that frame cats in multiple ways, including as villains, victims, heroes, commodities, and as women's best friend, which may further confuse the perception of the public (Ehrlich 2016). When faced with numerous stories framed in a specific way, an individual may form a perception that is associated with these views (Fisher et al. 2013). Word choice dependent on the narrative framing of the story can further impact perception, as people are more sympathetic towards terms such as "community cat" or "outdoor cat" than they are to "feral cat," even if both terms are referring to the same animal (Wald et al. 2013).

2.4 Perceptions around feral cats and their management

General public perceptions around an invasive species can vary dramatically, making it difficult for those in management to appeal collectively to a diverse group of stakeholders (Tennent et al. 2009). Even if most stakeholders hold similar perceptions about a species and the risks associated, opinions of management interventions can vary. In most cases the general public is familiar with an invasive species issue within the local context due to direct experience or what they view in the local media. Early

stages of stakeholder consultation on the risks posed by the species is often considered the best approach to incorporating public values into policy and drawing support from the community (Stokes et al. 2006; Tennent et al. 2009). In the case of feral cats and their management, there is often a high level of contention within the general public, as many people make the emotional connection with cats and relate feral cats to privately owned domestic cats, while others focus on direct negative impacts (Loyd and Miller 2010b).

In Australia, native fauna is highly regarded and widely valued by society. Feral cats are considered a threat by many, though there are various views shared by different demographic groups (Trigger et al. 2008). Cultural views often influence an individual's perception of the human-nature relationship, and can thereby frame individual views of a certain species within the natural environment, whether it be native or non-native (Trigger et al. 2008). For instance, within indigenous Australian culture, some individuals view feral cats as a threat to native fauna, whereas others accept them as an introduced part of the landscape, or view them as an integral part of their Dreaming, or their understanding and interpretation of the world and how humans fit into that world (Trigger et al. 2008).

A Danish study found that most of the population, about 60%, did not see a problem with allowing cats to roam freely, while about 27% did consider them to be an issue (Sandoe et al. 2018). The other 13% in this study had no opinion on the topic. Most of the people who did consider roaming cats to be a problem had never had a cat for a pet, and those that had were more likely to accept the free roaming of cats (Sandoe et al. 2018). Though perhaps not directly labelled as feral cats in the study, the sentiment of non-cat owners expressing stronger dislike for roaming cats may present a common theme in studies of perception around feral cats and their management, and should be carefully considered (Sandoe et al. 2018).

In some European countries such as Estonia and Italy, feral cats are perceived to be both a nuisance and a staple of the urban environment (Jaros 2018; Natoli 2014). In an urban setting, feral cats are often thought to add to the aesthetic of the

environment, as they have roamed the streets of the Western world since ancient times and are today considered part of the décor (Jaros 2018; Natoli et al. 2006). As well, these cats are believed to benefit the lives of the elderly women who care for them, and who are often called “feeding ladies” and are part of an intercultural theme that occurs in much of Europe and the US (Hatley 2003; Jaros 2018). Another practical benefit in both urban and rural locations throughout these countries is that feral cats are considered an integral part of controlling rodent populations, and they are sometimes even adopted onto farms as “barn cats” for this specific reason (Jaros 2018; Loyd and Miller 2010a; Natoli et al. 1999). On the other hand, feral cats are also seen as a nuisance by some in Europe due to the diseases they potentially carry, their threat to native wildlife, and their behaviour in public areas, such as defecating in public spaces and yowling or hissing at night (Jaros 2018; Natoli et al. 1999). At the same time, they are not necessarily considered a pest species in these spaces, and for that reason they are treated with concern and care when it comes to management (Jaros 2018; Natoli et al. 2006). Instead of lethal methods, the method often used in their management is TNR, with the aim of reducing the breeding population. This method is viewed by the European and US public to be a humane option to controlling feral cat populations as opposed to trapping and euthanizing the animals (Hatley 2003; Jaros 2018).

Along with the general public’s perceptions, different stakeholder groups often hold their own views on feral cats, which may be linked to the nature of and culture within the group (Sandoe et al. 2018). Natural resource managers, conservation groups, and landowners that have dealt directly with feral cats are knowledgeable and aware of the impacts that they can cause to the natural environment, and will normally take steps to mitigate these impacts (Liu and Cook 2016; Spencer et al. 2016). In contrast, animal welfare activists, cat owners and cat colony enthusiasts are likely to strongly argue against the culling of feral cats, or against certain lethal forms of management that are lethal such as poison baiting (Liu and Cook 2016; Spencer et al. 2016).

2.5 Controversy around management methods

As governments in various countries implement feral cat management plans, the subject of *whether* the cats should be managed shifts to a question of *how* to manage them, creating additional controversies (Shine and Doody 2011). Community and stakeholder participation is vital to gain support for an approach that is considered ethical and acceptable by the majority, and for that reason it is essential to examine opposing views associated with all relevant management techniques in an area (Shine and Doody 2011). Some techniques, such as baiting with different types of poison, are perceived to be unethical due to their nature and the amount of time required to work. Additional hesitation in adopting techniques comes from the potential threat posed to domestic pets or other non-target animals that may be exposed (Green and Rohan 2012; Palmer 2014).

For example, a particular method within Australia that has been met with negative feedback by the public according to social media and news sources is the use of the chemical sodium fluoroacetate, commonly known as 1080, in baiting and in grooming traps (Green and Rohan 2012). This chemical is considered unethical by some stakeholders due to the amount of time required to take effect, and because of the symptoms of apparent discomfort that animals may exhibit as the poison takes effect. There is also fear among the public about the potential for pets to ingest the poison, which could lead to death. Although the chemical is found in native plant species in Western and central Australia, it is also thought to be potentially dangerous to native non-target species in areas outside of the state, or areas that are far from these plants (Green and Rohan 2012). For that reason, a permit is required for use in other states within Australia and NZ, and it is highly restricted for use in other countries such as the US, which heightens the debate over its use in feral cat management overall (Green and Rohan 2012).

In the US, where the TNR method is highly controversial, it is up to the discretion of the state and local governments to control feral cat populations, and many

have adopted TNR as a normal practice (Longcore et al. 2009). However, some scientists believe that this method is ineffective in controlling feral cat populations, and that it does not negate the impacts of the cats (Loyd and Miller 2010a). They believe, instead, that trapping and euthanizing individuals would be a more effective means of control. This also applies to organizations such as the Audubon Society, which has openly criticized the technique for not eliminating the threat to wildlife or reducing cat numbers (Wald et al. 2013). The organization instead aims to encourage pet owners to keep their cats indoors to reduce cat populations and decrease the risk to wildlife. In contrast, feral cat advocates claim that the risk these cats pose to wildlife is widely overestimated, and they fully support TNR as a way of promoting the benefits of feral cats and their colonies (Wald et al. 2013). Demographics within the US may further influence attitudes towards management methods with research suggesting that people who live in rural areas tend to be more in favour of lethal control of feral cats, and that shooting was the preferred method. It was also noted that this may be dependent on the values of the people within the rural regions, as they view animals according to their usefulness, and feral cats were seen to be more destructive than beneficial to the natural environment (Palmer 2014; Verbrugge et al. 2013). On the other hand, those who lived in urban areas preferred TNR programs over euthanasia, and this may be a reflection of their values, their views of feral cats in the natural environment, and their level of knowledge around cat impacts on native wildlife (Palmer 2014).

This review has found that a range of studies have examined perceptions of feral cats and their management in different places worldwide, though most of these examine methods that are suited specifically to target areas. Also, each country has its own definition of a feral cat, and therefore the contest of the approach to feral cat management depends on the culture, beliefs, gender differences, and perceptions of its people. Due to these variances, there is no universal understanding of how the general public views either feral cats or different feral cat management methods (Palmer 2014; Shine and Doody 2011). Furthermore, recent studies on perception around feral cat management have focused on a broad overview, but there is little to no research that

compares how participants in different locations may view the potential for management methods being used near their land. There is also little to no research around attitudes towards having certain management methods used directly on individual properties, or how this may vary according to certain demographics such as location, occupation, or land use. This type of research could help decision-makers in determining what methods may be viewed as acceptable by both individual and broader geographic communities, and which methods may be more feasible in gaining social license for management in any given location.

2.6 Conclusions

This review has highlighted the importance of consulting all stakeholder groups that have an interest in feral cat management, including the general public, prior to plan implementation. It has also outlined the benefits that may accrue through more thorough investigation of public perceptions and attitudes that influence views about feral cats and cat management among stakeholders. This includes assessment of the public's knowledge and familiarity around feral cats and their impacts, and the potential for increased education campaigns to impact decision-making.

Furthermore, a general understanding of the level of threat that feral cats pose within different regions needs to be developed with associated knowledge of how these threats vary in relation to the different categories of cat. Developing a solid, universal definition about what a feral cat is, as opposed to a stray cat, will aid in improving the efficiency and effectiveness of management and will serve as the starting point for identifying what actions need to be taken in relation to eradication or impact control. This development will also aid in bridging the gaps in knowledge and understanding between scientists and management authorities designing management plans worldwide. From there, guidelines and education campaigns could be developed to efficiently communicate these differences to the public and to raise awareness around

the threats of feral cats. With a firmer understanding of what feral cats are and the threats they pose, there is a higher chance that the public will support management efforts. Furthermore, research into the types of technical solutions that would meet and abate social concerns in different regions may aid in helping managers to identify techniques that may be seen as less controversial while still being effective.

Research would also benefit from investigating the drive behind general public and stakeholder interests, the cultural values and definitions associated with feral cats as a species, and in further detail the attitudes and values of the individuals associated with feral cats and management. This may help to determine the types of individuals that favour feral cats and non-lethal methods as opposed to those who would prefer to remove these cats by any means necessary. It would also aid in identifying the communities, either local or global, that are in support of managing feral cats, those that are not, and how to properly approach these different communities and communicate in a way that will help to gain social license for feral cat management.

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Chapter 3

Feral Cats: Helpless or Harmful? Examining the Twitter Narrative

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Principal Author

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Name of Co-Author	Bertram Ostendorf	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	Douglas Bardsley	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Taggart	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Peacock	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 23/09/2020

Abstract

Social media allows us to share information on invasive species and has increasingly influenced environmental perceptions worldwide. This study examines the narrative around feral cats on Twitter at international and regional scales to determine how countries and groups share online information about feral cats. It assesses differences in sentiments around feral cats as they relate to the online dialogue and language used by groups including individuals, animal welfare organisations, scientists, and government within different countries. Sentiments vary by country and group, and perceptions are influenced strongly by the online content being generated in each country. While social media can influence feral cat perceptions at a regional level, there is little international influence on perceptions across different countries. Social media is becoming an effective way to engage with the public about feral cat management, but it will be increasingly important that the dominant narratives are influenced by science and a broad community deliberation on the emergent issues.

3.1 Introduction

The definition of a feral cat (*Felis catus*) varies depending on the perceptions and beliefs of people in different regions of the world. In some countries such as the United States of America (USA), Canada, the United Kingdom (UK), and parts of Europe, the term feral cat is often synonymous with outdoor, stray or street cats, and though these cats have some negative attributes and are sometimes considered a nuisance, they are widely considered a legitimate component of the urban environment in which they live (Natoli et al. 2006). The only way to distinguish a truly feral cat from others in these countries, notwithstanding animals with home ranges distant from human habitation, is to examine how much interaction the cat has with humans (Deak et al. 2019; Natoli 2014). If the animal is fearful of humans or stays out of reach until a human has left the vicinity, then it is more likely to be labelled as a feral cat than as a stray. Stray cats will typically approach humans and are more likely to accept food and

resources that are provided for them (Farnworth et al. 2011). In other countries such as Australia and New Zealand, feral cats are considered a pest species and are managed as such (Australian Government Department of the Environment 2015b; Farnworth et al. 2010). The definition of a feral cat in these countries is straightforward and refers to a cat that tends to inhabit landscapes away from human habitation, is born or breeds in the wild, and does not rely on humans for food or other resources (Spencer et al. 2016). These cats are considered to be descendants of domestic cats who were released or have run away and are unlikely to have interacted with humans previously, leaving them wary of people and human habitation – and extremely dangerous for native prey species (Woinarski et al. 2017). Reasons for these differences in definition may include the fact that native felids have long inhabited areas of the Americas and Europe long before human intervention, leading to ecosystems that are more resilient to cat predation today (Hunter and Brisbin 2016; Natoli et al. 1999). On the other hand, Australia and New Zealand did not have established native felid populations prior to European colonisation, and so the ecosystems and wildlife populations in these countries are less tolerant of cat predation (Australian Government Department of the Environment 2015b).

Approaches for cat management are often heavily contested and debated in countries with more flexible definitions for a feral cat, particularly in urban areas where there are concerns about ownership of cats (Hunter and Brisbin 2016). Much of the contestation relates to the use and effectiveness of lethal or non-lethal methods of management. These debates often involve animal welfare organisations as well as individuals, and can escalate to include local and state governments, influencing pet licensing and housing legislation (Hunter and Brisbin 2016). In the UK, however, feral cats are protected under the same laws as domestic cats and there is less debate over ownership and management by different parties, as most responsibility for these cats is primarily taken on by individuals rather than animal welfare groups (Cats Protection 2020; Pets4Homes 2020; RSPCA 2020). Unlike in the USA and Canada, it is legal in

the UK for feral cats to be culled under certain circumstances, though the culling must be done humanely (Game & Wildlife Conservation Trust 2020). However, most management in the UK, the USA and Canada, does include a method known as trap-neuter-release (TNR), which involves private individuals, animal welfare groups, or animal service officers trapping the outdoor-dwelling cat and taking it to a local veterinarian to be neutered, vaccinated and ear-tipped for easy identification at their own expense before returning it to the outdoor area where it was originally found (Crawford et al. 2019; Foley et al. 2005). TNR is commonly considered the primary option for managing feral cat populations in countries where lethal responses are unacceptable (Crawford et al. 2019).

Due to the nature of feral cats and their need for a high protein diet, they will hunt for food several times a day (Denny 2010; Doherty et al. 2016). Within countries such as Australia and New Zealand, their prey range often includes small native mammal, reptile and bird species that are already considered threatened or endangered, leading to the possibility of these species becoming extinct if the cat populations are not controlled (Doherty et al. 2015; Plantinga et al. 2011; Woinarski et al. 2017). Due to the serious threat feral cats pose to native wildlife, feral cat management is deemed essential and is aimed at controlling or, where possible, eradicating the species (Australian Government Department of the Environment 2015b; Denny 2010). Because of the scale of the issue in Australia and its lack of effectiveness, TNR is not seen as a viable control method by state governments, though some animal welfare organisations have lobbied for its use. There are several other methods that are used in combination for feral cat management within this country (Crawford et al. 2019; Doherty et al. 2016; Longcore et al. 2009). These alternative methods include baiting with Eradicat® or Curiosity® poison baits, padded leg hold traps, shooting, cage trapping, and exclusion fencing (Doherty et al. 2016).

The broad scientific consensus within Australia and New Zealand is that feral cats are a species that urgently need to be managed by government, but in the USA and

Canada feral cat management is not seen as being an urgent matter that requires government intervention, and this could be because of ecological differences between countries (Farnworth et al. 2011; Ogden and Gilbert 2011). For instance, in North America as well as throughout Europe, the landscape and ecosystems have evolved with the presence of native felids, creating resilience among native wildlife populations of birds, reptiles, and smaller mammals (Deak et al. 2019). In Australia and New Zealand, there was a lack of native felid species and the ecosystems and wildlife within did not evolve with a resilience to these creatures. Therefore, when cats were introduced to these landscapes the native wildlife populations were left more vulnerable than their North American counterparts (Deak et al. 2019).

It could also be because of the dialogue that has occurred and is still happening about feral cats in different countries, and the relative opinions of people responsible for contributing to that dialogue (Zorn et al. 2010). In addressing such a potentially polarising issue as feral cat management, different vested interest groups apply unique strategies to communicate their ideas and try to persuade the general public about the issue (Freberg 2019; Misra and Walker 2013). Animal welfare groups are known for cherry-picking facts that they want to use, and employing emotive language to evoke an emotional response from their audience, whereas scientists are often held to a higher standard of information provision and are expected to relay all highly-scrutinised facts related to management, leading to delayed or inadequate management responses (Feinstein 2014; Hwong et al. 2017). In particular, government often utilises key arguments associated with economic or ecological costs that come under high levels of scrutiny by the news media, and for that reason must carefully relay information using precise language that is factual but minimises potential controversy (Gunawong 2015; Johnson and Kaye 2015). Unfortunately, it is exactly such controversy that can capture people's attention in an information rich society and sway perceptions about the different management approaches.

With the increased use of social media platforms, a range of non-traditional groups are also able to contribute to the online narrative. Individuals who have no affiliation with any organisation or related occupation, can use platforms such as Facebook and Twitter to share opinions and information to sway the opinions of others, often by misrepresenting the science, but sounding credible in their awareness and use of knowledge that may or may not be factual (Mehmet and Simmons 2018; Zorn et al. 2010). Information generated on the topic of feral cats is highly debated online and can often include strong arguments from multiple individuals who either support or wish to halt the use of certain methods to manage feral cats. Information shared on online platforms is not limited to a particular regional location, but can be read and shared by others internationally, which can generate further noise within communication channels, especially as misunderstandings can be repeated or expanded upon due to cultural differences (Han et al. 2014). For instance, in July 2015, the Australian government used social media as one of several channels to declare a "war on cats," and stated that it aimed to cull 2 million feral cats by 2020 (Australian Government Department of the Environment and Energy 2019). Over subsequent years, numerous studies have supported that governance statement by presenting information on the impacts that feral cats have on native wildlife populations in Australia (Legge et al. 2017; Woinarski et al. 2017). Nevertheless, the governance position gained international attention, and in April 2019, *The New York Times* newspaper released an article on the management of feral cats in Australia, which generated some international controversy due to cultural differences in views and beliefs (Aguirre 2019).

Due to the different beliefs and opinions around feral cats relative to a country or group, it is difficult to determine whether there are more positive or negative attitudes towards feral cats on an international level. Though sentiments towards feral cats in specific countries are often assumed based on the national news media dialogue, it is not certain what kind of influence this dialogue is having on national and

international conservation efforts, or how it may be used to persuade the general public in one direction or another in relation to feral cats. Studies that have focused on perceptions and attitudes around feral cats and their management have largely done so in a regional context in a way that relates to management within a particular area (Bester et al. 2002; Farnworth et al. 2011; Natoli et al. 1999), but there are few studies that contrast differences in attitudes between countries. In fact, there is also little to no research on how much influence different groups have in the conversation about feral cats regionally or internationally. Investigating differences in the dialogue around feral cats according to country, and how those online discussions influence perceptions of feral cats, could aid understanding of effective approaches to online communication to guide narratives around feral cat impacts and management. Such research also offers insights into what groups or organisations within countries are contributing to and influencing the dialogue, and how clarity could be provided in certain instances for improved communication outcomes that are informed by science.

Social media platforms can influence the type and amount of information that people receive on various topics in both a regional and international context (Han et al. 2014; Misra and Walker 2013). Many people rely on online platforms to provide them with immediate news and information on topics of interest, and information is often presented on a timely basis, appearing on an individual's timeline in a series of consecutive posts that are unrelated to each other (Heiss and Matthes 2019). Stories are often shared in the form of short notes known as "snack news," in which individual users receive a short synopsis of a story without full detail, allowing them to form an opinion on the topic before scrolling ahead (Heiss and Matthes 2019). More elaborate stories tend to encourage individual users to engage with and read further into a topic rather than simply scrolling forward. However, due to the fast pace at which these posts occur, an individual user's response and attitude to each post may rely largely on the small amount of sensationalised content of any post encountered (Heiss and Matthes 2019; Sisson 2017). Further, the speed at which new stories and information are

presented on these platforms means that most of the information encountered by individuals is by chance rather than intention, allowing for only a brief window in which to attract interest and influence opinion (Heiss and Matthes 2019).

Of the social media platforms available, Twitter is one of the most well-suited for snack news because it limits individuals to only using up to 280 characters per post, making it a platform better designed for sharing information than holding debates on controversial topics (Fischer and Reuber 2011; Heiss and Matthes 2019; Small 2011). Animal welfare organisations may aim to use Twitter to get a prompt message across about the hardships experienced by feral cats and garner support through emotional messaging, which benefits from the short word limit and the fact that there is insufficient space to delve fully into the full scientific debate (Schattke et al. 2018; Smith and Lelserowitz 2014). Scientists and government bodies who rely on developing a comprehensive understanding of the facts may have more difficulty sharing information, especially with Twitter's limit on characters. To compensate, these parties often provide links to a full story or study, but it has been shown that such extensive, scientific content is rarely engaged with by Twitter users unless the original tweet generates an emotional response through either humour, spectacle or fear, and science and governments have, at least traditionally, tended to rely more heavily on fact and logic than such emotional messaging in western democracies (Bickford et al. 2012; Heiss and Matthes 2019).

Further, Twitter as an international social media platform allows for information to be spread globally as well as locally (Han et al. 2014). International news and culturally varied opinions on different topics are able to be shared between countries, allowing for global perceptions to take shape around a topic and also around a country's opinion of a topic (Han et al. 2014; Wanta et al. 2004). However, little research has been conducted on cross-cultural comparisons of perceptions towards certain topics such as feral cat management as portrayed in social media. For instance, countries that hold certain sentiments towards feral cats may practice different forms

of feral cat management, and these approaches may be perceived as controversial to people in other countries. In particular, individuals within the USA or parts of Europe where TNR is solely practiced may perceive Australia's more direct and lethal methods of feral cat management as inhumane. This could potentially lead to international debate and misinformation being spread on social media, and depending on the group that is responding, may lead to further confusion among the general public in different countries over how feral cats should be perceived of and are, or should be, managed (Shin et al. 2018).

To examine these issues, this paper aims to investigate the narratives concerning feral cats on Twitter over a five-year period from January 2015 to December 2019 when significant events around feral cats were taking place in Australia. It investigates the shift in the narratives on feral cats during this time, and also examines if there are variations in dominant terms and expressions used to discuss feral cats between countries and the prominent groups within that were presenting information. Such an analysis provides an indication of who is contributing to the dialogue around feral cats and raises important questions about how they may be influencing an increasingly global narrative on the topic.

3.2 Methods

To examine the changing narrative around feral cats we used the R 'sentimentr' package to investigate shifts in the dialogue and sentiments around feral cats on Twitter across different groups and countries over the course of five years from January 2015 to December 2019. These dates were chosen based on the feral cat management events taking place in Australia, especially triggered by the national declaration of the feral cat cull in July 2015. The analysis of the shifts in dialogue allowed us to determine which topics were most common at different times and how these topics could potentially influence perceptions of feral cats in different countries.

Twitter data was collected in the form of tweets from the Twitter application processing interface (API) using the R package 'rtweet'. The key term "feral cat" was used to extract tweets that mentioned feral cats for each month between these years. This term was selected on the basis that this is the term commonly used worldwide to discuss wild domestic cats that live outdoors and are not pets, and the reaction to this specific type of cat is what we were most interested in investigating in this study. Though Twitter increased the number of characters allowed per tweet in early 2018 from 140 to 280, this does not mean that every user would have used the exact number of characters allowed in every tweet they generated over the years. Therefore, this is thought to have little to no impact on the results of a sentiment analysis between these years. As the maximum for the API subscription was 500 tweets per search, this was the number of tweets that were collected for each month. In searching for tweets that included the term "feral cat," often times less than the requested amount was available, meaning that we were able to collect all of the available tweets about feral cats for each month to use in analysis. Retweets provided duplicate information to their original tweet, and so were removed from the dataset. Quoted tweets were treated as original content because they included new text from the users who decided to retweet the information. Only English tweets were included, and all other languages were removed. Usernames were replaced with categories depending on the nature of the user, and these categories included Individual or those who were not formally affiliated with any other group, Science including scientists and research facilities, Vet, Government, Environmental Organisation, Animal Welfare Organisation, Landcare Organisation, Commercial Operation, News Media, and Blogs and Advice. These categories were created manually and were assigned by viewing the user description in each Twitter user's profile and determining their affiliation according to the description they themselves had written. Any user with a personal profile and no affiliation was listed as an individual, whereas all other categories were assigned based on formal affiliations. An additional column was added to the dataset labelled "Animal Lover," which recorded a 1 for any person in the Individual category who included reference to being

an animal or pet lover in their profile description, and a 0 otherwise. The number of overall tweets available for analysis was 13,030, however tweets that did not include a location for where the user was from were removed, leaving 10,547 available to analyse over the five-year period.

The 'sentimentr' package was employed in R to perform a sentiment analysis on the data, where the hash_sentiment_huliu lexicon was used to determine sentiment scores, which would later imply whether the narrative for each tweet was positive, neutral or negative towards feral cats (Naldi 2019). Sentiments were calculated and averaged for each month to provide an overall assessment of positive (>0), neutral (0), or negative (<0) sentiments over the course of the five years. These sentiments provided an indication of the dialogue used around feral cats, where positive sentiments indicated an aim towards saving or caring for feral cats, whereas negative sentiments suggested the need for management and highlighted the impacts of feral cats. Neutral scores were calculated as those that presented information about feral cats but did not include words that presented a positive or negative stance. These scores were then defined as 0. The score key was adjusted to include words that are commonly used in reference to feral cat management worldwide, such as biodiversity, adoption, and TNR (Appendix A). The terms "manage," "managed," "management" and "managing" were all included in the score key and aligned with a score of 0 to separate the sentiments about management specifically from sentiments around feral cats as a species. At the same time, the terms "feral" and "cat" were excluded from the score key as the words were present in every tweet and if included, this would have biased the sentiment analysis. Each word received a sentiment score of either -1 (negative), 0 (neutral), or 1 (positive) as appropriate for the use of the word as spoken about in relation to feral cats. Sentiment scores can include up to several decimal places, and all of those with a score higher than absolute 0 were categorised as positive, and all of those with a score lower than absolute 0 were categorised as negative. For instance, in scientific papers that discuss feral cats, the word "biodiversity" is often used to denote

the danger that feral cats pose, and so this word received a score of -1. In contrast, when speaking about efforts to save feral cats, words such as “TNR” and “adoption” are included, and so these words received a positive score of 1 in the key. Further, the total number of tweets per month as well as the total number of tweets per month according to country were calculated. Raw sentiments were calculated and added to the original dataset, and average sentiments were calculated for each month, and also for each country, country per month, group, and group per month. Due to the skewed nature of the data, non-parametric Kruskal-Wallis tests were used to determine if sentiments were significantly different depending on date, country, or group. Percentages were calculated for overall tweets per country and then per group, and also per group per country for the four countries examined in further detail, being the English-speaking USA, Australia, the UK and Canada. For comparison, word clouds were created to identify the top 100 words frequently used within each of these countries.

3.3 Results and discussion

The number of tweets per month relating to feral cats fluctuated over the course of the five years between January 2015 and December 2019, rising slightly from 2015 to 2016, declining steadily from July 2016 to July 2017, and then from July 2017, generally increasing over time until December 2019 (Figure 1).

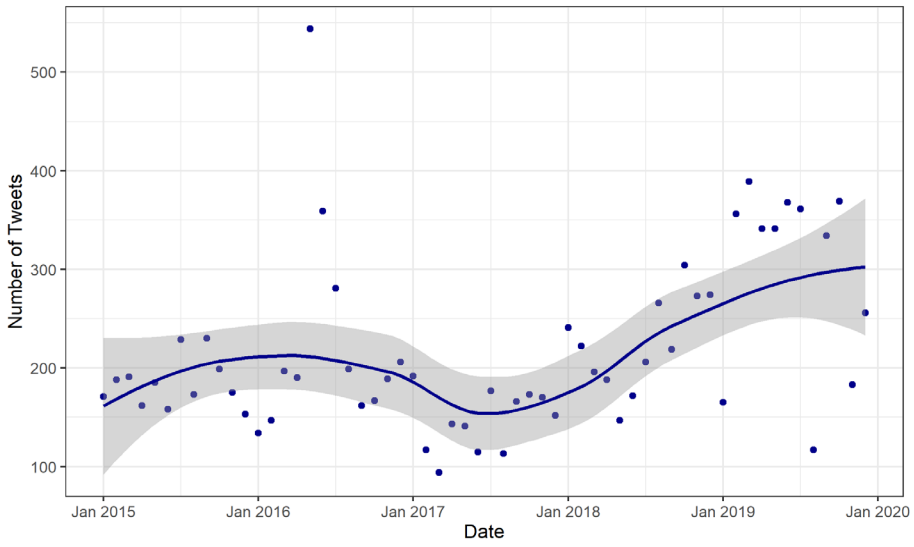

Figure 1. A breakdown of the number of tweets about feral cats generated by the Twitter API per month per year from January 2015 to December 2019. Shading indicates the smoothing (loess) used to identify the trendline over the course of the five years.

The average sentiments around feral cats between January 2015 and December 2019 were mostly positive (Figure 2). There was a slight decline in sentiment from January 2015 to December 2017, but a general increase occurred between January 2018 and December 2019. Though there are shifts between sentiments according to date, the results of a Kruskal-Wallis rank sum test show that varied sentiments are significantly contributed to by country and group, but not by date (Table 1).

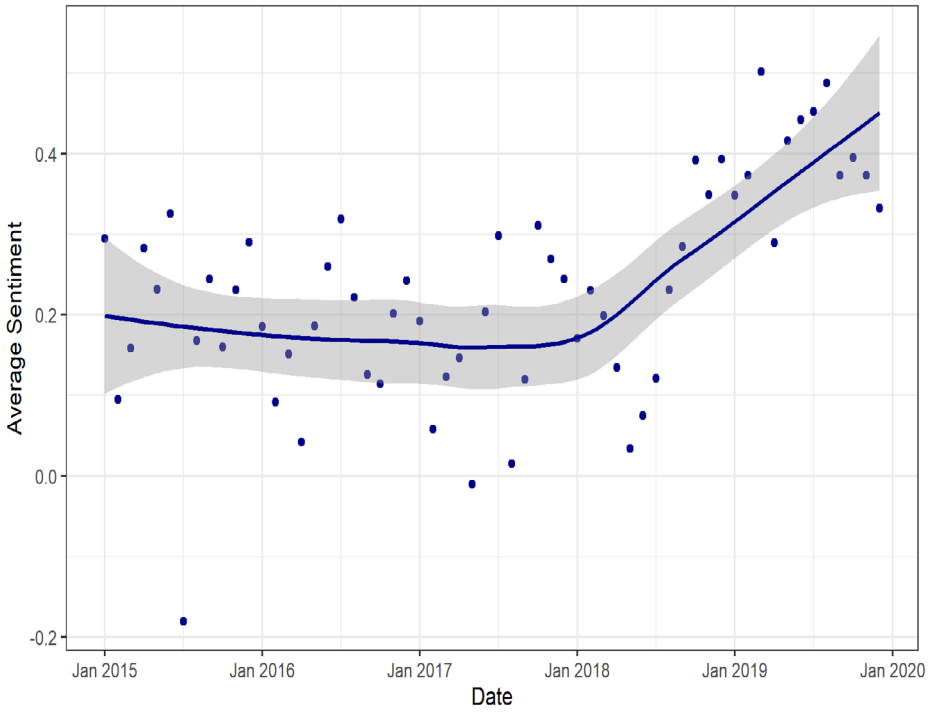

Figure 2. A breakdown of average sentiments calculated from tweets about feral cats for each month per year from January 2015 to December 2019, ranging from -1 (negative) to 1 (positive). Sentiments above 0 indicate positive sentiments. Shading indicates the smoothing (loess) used to identify the trendline over the course of the five years.

Table 1. A Kruskal-Wallis test was used to determine the influence of date, country and group on average sentiments around feral cats for each month from January 2015 to December 2019. Values indicate significance (p) where values < 0.05 are significant.

Variable	Kruskal-Wallis P-Value
Date	0.569
Country	p< 0.001
Group	p< 0.001

3.3.1 Tweet composition and sentiments by country and year

Our dataset contained tweets from 55 different countries. Most tweets about feral cats (65%) were generated by the USA, followed by Malta (13%) and Australia (12%). Three percent of the remaining tweets came from Canada, 2% the UK, and 1% came from other countries. The majority of tweets in any given year came from the USA, except in 2016 when Malta produced the highest percentage of tweets (33.8%),

followed by the USA with 28.7% and Australia with 13.9% (Table 2). It was discovered that the reason for the high percentage of tweets coming from Malta in 2016 was because of an e-book that had been published that year called *Island of Cats*, which was about the lives of people who take care of feral and stray cats in the country. The number of tweets produced by Malta is represented in the outlier points seen between January 2016 and January 2017 in Figure 1. The remainder of the study focused on the four countries that generated consistent contribution of over 1% each year to the feral cat dialogue on Twitter from January 2015 to December 2019, which included the USA, Australia, Canada, and the UK.

Table 2. Percentages were calculated for each of the 55 countries in the dataset that produced tweets about feral cats for each year from 2015 to 2019. Overall, the USA produced 65% of tweets, Malta 13%, Australia 12%, Canada 3%, the UK 2%, and the other countries produced up to 1%. Countries that generated 1% or more of overall tweets were calculated separately for percentage of tweets produced per year, and countries that generated less than 1% were placed in the "Other" category and calculated together for percentage of tweets produced per year.

	2015	2016	2017	2018	2019
USA	50%	28.7%	53.3%	63.1%	65%
Australia	19.7%	13.9%	22%	14.3%	10.8%
Canada	4.7%	3.8%	6%	3.9%	2.9%
UK	1.6%	1.3%	2.1%	1.3%	1%
Malta	0%	33.8%	2.6%	7.5%	5.1%
Other	0.6%	2.7%	4.2%	2.7%	2.1%

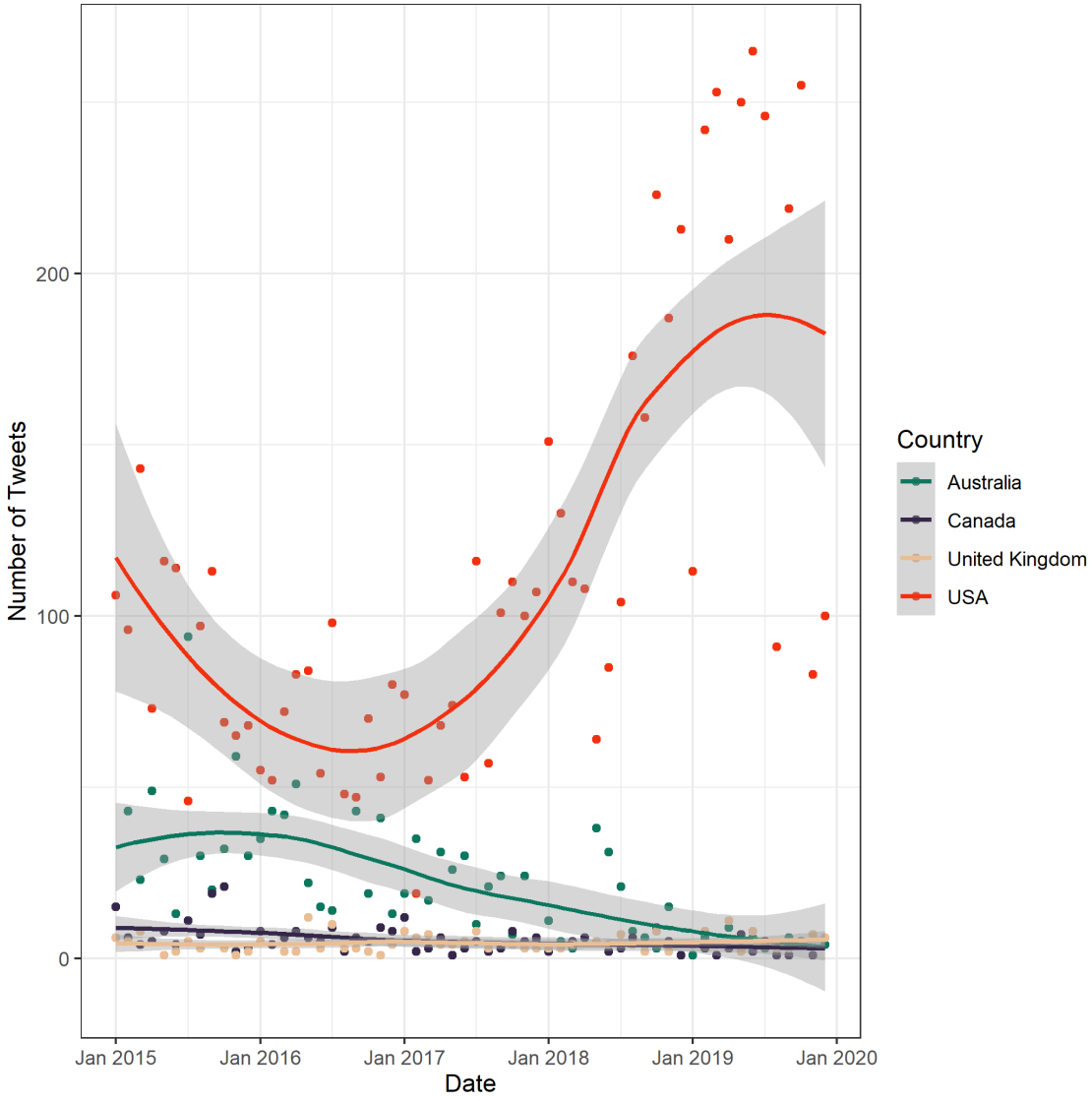

Figure 3. A breakdown of the number of tweets about feral cats generated by the Twitter API per month per year from January 2015 to December 2019 for Australia, Canada, the UK and the USA. Shading indicates the smoothing (loess) used to identify the trendline over the course of the five years.

Based on the analysis, the average sentiment around feral cats for the USA, Canada, and the UK over the five-year period were consistently positive, whereas average sentiment in Australia over this time were generally more negative (Figure 4). This suggests that the dialogue in the USA, Canada, and the UK likely inferred a fondness for feral cats and an interest in their wellbeing, whereas in Australia the focus of the dialogue was around the impacts that feral cats pose to wildlife. The USA and Canada held the most positive sentiment towards feral cats throughout the five years, although sentiment in the USA declined slightly between 2015 and 2017 and then

increased strongly from 2017 to 2019. Australia held the most negative sentiment towards feral cats until midway through 2018, when sentiment began to increase in positivity. Sentiment towards feral cats for all countries declined in July 2015, when they were also at an all-time low in Australia, potentially as a result of the Australian Federal government declaring that it would aim to cull 2 million feral cats by the year 2020 (Australian Government Department of the Environment and Energy 2019). Over the five-year period the USA generated the most tweets for each month, except in July 2015 and February 2017, when Australia produced the highest number of tweets.

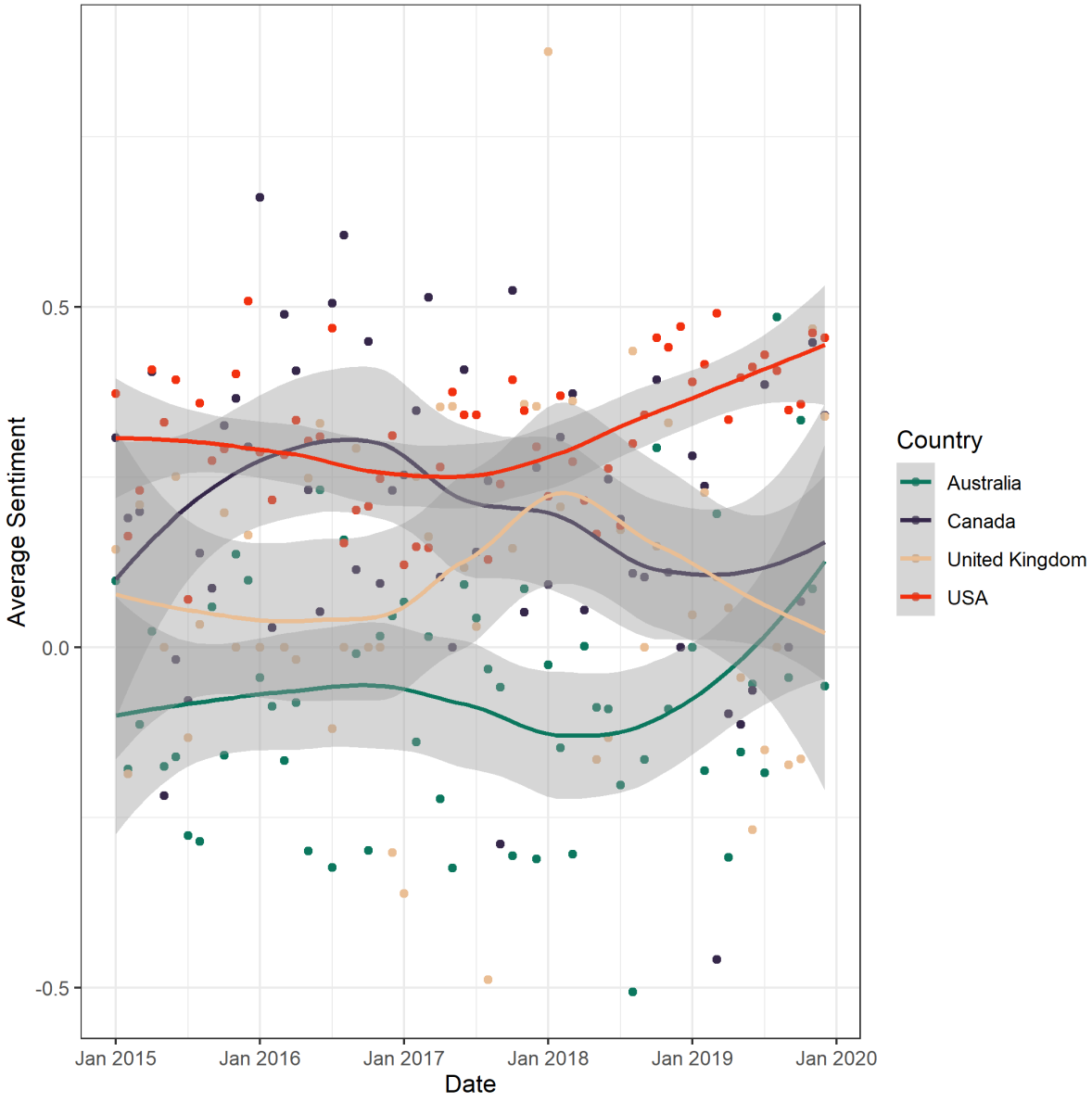

Figure 4. A breakdown of average sentiments calculated from tweets about feral cats for each month per year from January 2015 to December 2019 for the USA, Australia, Canada, and the UK. Shading indicates the smoothing (loess) used to identify the trendline over the course of the five years.

3.3.2 Tweet composition and sentiments by country and group

In investigating separate groups that were responsible for producing the tweets over the full five-year period, we found that individuals with no formal affiliation primarily shared positive or neutral sentiments about feral cats on Twitter, as did animal welfare groups (Table 3). Scientists or scientific research facilities tended to share more negative or neutral sentiments, and government sentiments varied as 37.2% were positive and 33.1% were negative, with 29.7% of tweets from government groups

remaining neutral. This could be a result of government bodies attempting to appear unbiased or non-controversial, depending on the country or the state of feral cat management at the time, or the approach that might gain additional political approval for the government (Gunawong 2015; Johnson and Kaye 2015). A comparable difference was found between environmental groups focused on conservation and Australian Landcare groups which consisted largely of landholders, as 70.2% of tweets from environmental groups contained a neutral sentiment, whereas 44.4% of tweets from Landcare groups were negative and 33.3% were neutral (Table 3). This suggests a difference in priorities between the two groups as they relate to feral cats. Environmental organisations are seen to focus more on education more broadly, whereas Landcare groups focus more often on action taken to aid farmers and other landholders in preserving their private or local environment and economic interests, which may be threatened by the presence of feral cats (Glen et al. 2016). Commercial groups or those selling products were more likely to produce tweets with positive sentiments, possibly to encourage the sale of cat food and other amenities, and the blogs and advice provided on Twitter consisted of a mix of pet information as well as pest control information, and so the sentiments for this group were almost equally distributed between positive, neutral, and negative (Table 3).

Veterinarian groups produced mostly positive sentiments towards feral cats, and news media groups remained neutral or presented positive sentiments (Table 3). The information shared by news media groups depended on the country, as well as story angle, as journalists tend to use different language depending on what story they intend to tell and how they want to present it to the public (Johnson and Kaye 2015; Wanta et al. 2004). Also, debates often take place between those who wish to save feral cats and those who prefer to have them removed, and such debates can escalate to local government level, making the topic more likely to be covered by journalists and mainstream news platforms (Hunter and Brisbin 2016). This escalation of the debate is less likely to happen in a country such as Australia, where the important impacts of

feral cats are more focused on depleting important biodiversity in bushland away from dense human habitation (Denny 2010).

Table 3. Percentages of positive, neutral, and negative sentiments of each group. Values indicate significance (p) where values < 0.05 are significant.

Group	Positive	Neutral	Negative
Individual	49.6%	36.4%	14%
Animal Welfare	47.3%	41.9%	10.5%
Science	28.4%	35.6%	36%
Government	37.2%	29.7%	33.1%
Environmental	12.2%	70.2%	17.6%
Landcare	22.2%	33.3%	44.4%
Vet	54.4%	38.6%	7%
News Media	34.5%	45%	20.5%
Commercial	60.4%	22.9%	16.7%
Blogs and Advice	35.4%	33.8%	30.8%

Looking more closely at the groups within the countries, the majority of tweets about feral cats generated by the USA came from individuals (69.6%), with 23.8% coming from animal welfare groups (Figure 4). Eighty-four percent of the individuals tweeting from the USA claimed in their descriptions to be animal or pet lovers. The average sentiment for individuals within the USA was 0.21 on a scale of -1 to 1, implying that the majority of people tweeting about feral cats in the USA have a positive outlook on outdoor cats in general and aim to encourage behaviours such as TNR and adoptions from shelters. The words most frequently used in tweets about feral cats from the USA included “rescue,” “friends,” “adoption”, and “rehoming,” as well as words that elicit emotions, such as “caring,” “loving,” and “hateful” (Figure 5). This indicates that the discourse around feral cats in the USA was often positive and aimed at saving and caring for the cats and gaining support from the general public by evoking an emotional response. The groups who were most likely sharing this information in the USA were animal welfare groups and individuals as opposed to scientists or government officials who are often held to a higher standard and generally do not use words to illicit emotions when providing information to the general public (Hwong et

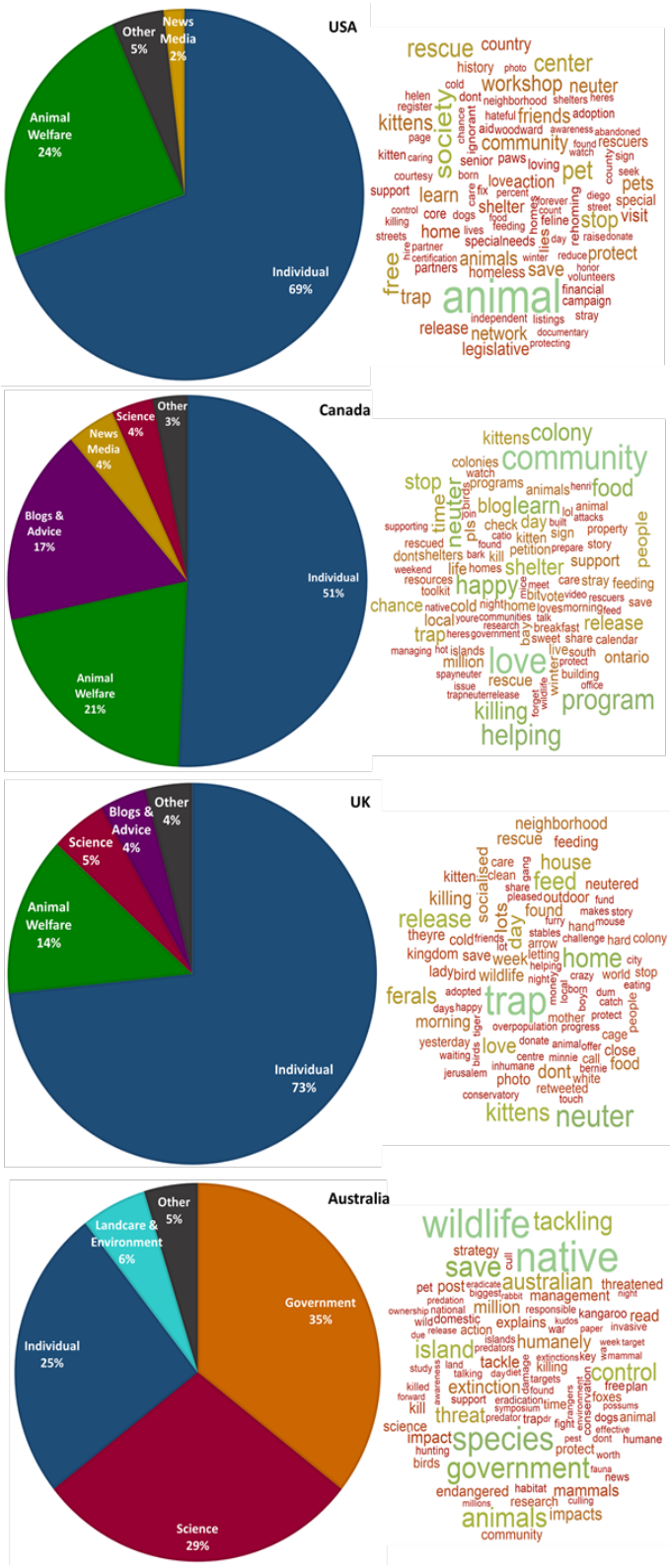

Figure 5. A breakdown of the percentage of tweets about feral cats contributed to each country by group for the USA, Canada, the UK, and Australia from January 2015 to December 2019, as well as the 100 most frequently used words in the tweets from each country during this time where size indicates frequency of use. Larger words indicate higher frequency and smaller words indicate lower frequency.

al. 2017; Schattke et al. 2018). It might also suggest that feral cat management in the USA is largely a responsibility largely taken on by animal welfare organisations and community volunteers, rather than government officials, and the TNR method is most commonly used.

The USA results contrast strongly to those from Australia, as a mix of government officials (35.6%), scientists (28.8%) and individuals (25%) mostly generated Australian tweets. Of the individuals, only 13% claimed to be animal and pet lovers, and because the average sentiment was -0.14 this implies a greater influence of science and government policy on individual dialogue around feral cats than by animal welfare groups, unlike in the USA. Australian tweets commonly included words such as “native”, “wildlife”, “government”, “control”, and “research”, because the main groups tweeting about feral cats in the country aimed to use available facts rather than emotive words to convey information to the general public,

which in turn brought the average sentiment score for the country down (Figure 5). The Australian tweets generated a distinct narrative on feral cats focused on practical approaches to reducing feral cat populations rather than saving them or helping them to thrive. These results also indicate that government is a main source of information regarding feral cats within the country, and that individuals take interest in sharing and discussing the information that has been provided to them (Heiss and Matthes 2019). The messaging in a regional context for Australia may have an important impact on the local demographic, and this may also have contributed to the consensus among individuals across different regions of the country that feral cats need to be managed and eradicated where possible. This Australian result suggests that if used properly and consistently, Twitter and similar platforms could provide an effective mechanism for government entities and scientists to communicate information to the general public about feral cats and possibly other environmental topics on a nationwide basis (Fischer and Reuber 2011).

Where tweets from users in the USA seemed to rely on triggering an emotional response from readers, tweets from users in Australia relied more heavily on practical ecological data and experiences to relay messages and sentiments around feral cats (Figure 5). This provides further evidence that scientists and government use different kinds of language in addressing the general public than animal welfare groups. Work by Freberg (2019) suggests that the incorporation of scientific facts and language into animal welfare campaigns regarding feral cat management may deter people from participating in or donating to an organisation's cause, especially if they find the narrative dull or in conflict with their broader beliefs, which in turn may be the reason for little to no scientific information about feral cats being provided on the platform from the USA (Freberg 2019). There is also a chance that even if some USA scientists were tweeting about feral cats, animal welfare groups may well have overwhelmed a communication channel, generating too much noise for an alternative narrative to be

heard and leaving little opportunity for scientific information to influence perceptions of feral cats (Bickford et al. 2012; Freberg 2019).

Feral cat tweets from Canada were also largely from private individuals (50.8%), and of these individuals, 44% claimed to be animal lovers. Average sentiments from individuals within Canada were slightly higher than those in the USA at 0.27 (c.f. 0.21) on a scale of -1 to 1, indicating that the dialogue used by these individuals to discuss feral cats was highly positive. Like the USA, 20.9% of the tweets generated in Canada were from animal welfare organisations, and it is thought that there might be a similar narrative occurring between Canadian and American tweets, though animal welfare sentiments towards feral cats in Canada were at 0.17, which was lower than animal welfare sentiments in the USA (0.32). Words such as “help,” “please,” “community,” and “love” were commonly used in Canadian tweets, as well as words such as “trap,” “neuter,” and “release.” Further, approximately 17% of the tweets in Canada came from blog and advice forums that covered a range of topics from pets to pests, which were not well represented in any of the other countries. There is also evidence of scientific tweeting about feral cats. Four percent of Canadian tweets were from scientists or research facilities, and the average sentiment for tweets from this group was -0.13 on a scale from -1 to 1, suggesting that most of the dialogue around feral cats in this regard was about the environmental impacts of feral cats. This implies that Canada, much like the UK, may be more exposed to scientific information about feral cats than those in the USA, though less so than those in Australia, and that this may contribute to the shifting dialogue about feral cats in the country.

Approximately 73% of the tweets from the UK were generated by individuals with no formal links to organisations, 45% of whom claimed to be animal or pet lovers in their descriptions, with an average sentiment of 0.1 on a scale of -1 to 1. This is the largest percentage of unaligned individuals of any country represented, though there is a much lower sentiment score than for those in the USA and Canada, but still higher than for individuals within Australia. In contrast to these countries, 13.5% of UK tweets

about feral cats were from animal welfare groups, which is understandable given that feral cats are not as large of a focus for animal welfare groups in the country as other animals (Pets4Homes 2020; RSPCA 2020). At the same time, the words most frequently used in tweets from the UK included similar words to that of Canada and the USA, which focused on help, support, and TNR, unlike in Australia where most words focused on the impacts of feral cats. This language alone implies that there is likely a greater proportion of individuals and animal welfare groups generating information on feral cats in the country than scientists or government officials. However, there were fewer emotive words used in UK tweets than there were in tweets from the USA and Canada, and words such as "wildlife" and "overpopulation" stood out. This implies that although the majority of tweets are generated by animal welfare groups and individuals in the country, there may be a greater emphasis on scientific information than there is in the USA or Canada, though possibly less so than in Australia. Five percent of the tweets generated in the UK were by scientists, suggesting that science is present within the regional dialogue around feral cats, and that this may be influencing the views that individuals have on feral cats in the country, as indicated by the lower average sentiment score than for individuals in either the USA or Canada, though higher than for those in Australia.

It is important to be aware of where the information about feral cats is coming from, so that scientists, management authorities, and other officials can determine where to spend their energy and what they might be competing with in terms of content. In the USA, Canada and the UK, the discourse around feral cats is maintained largely by individuals who are fond of feral cats, and animal welfare groups that would like to see them thrive. There is scant evidence of any scientific discussion around the impacts of feral cats being added to the conversation on Twitter from the USA, though Canada and the UK have a scientific base on which to work and potentially improve. However, as the USA is the main overall producer of tweets about feral cats, most of the overall information being shared about feral cats on Twitter is positive in sentiment,

emotional in context, and likely not drawn from scientific sources. At the same time, while the discourse around feral cats in the UK and Canada included some scientific information, the Twitter discourse on feral cats in Australia was contributed to widely by branches of government, politicians, scientists, scientific research facilities, and individuals. This was not the case for the USA, and though the USA may contribute most to the Twitter narrative around feral cats based on the number of tweets it generates, the amount of tweets generated by one country may not influence the perceptions of individuals within different countries as heavily as first believed (Han et al. 2014).

Social media provides an opportunity for each country investigated in this study to focus on the future delivery of feral cat scientific material with an improved understanding of how the channel could influence perceptions of individuals within that country (Misra and Walker 2013; Taddicken et al. 2019). As an interactive forum, Twitter also presents an opportunity for individuals to engage with scientists and government about feral cats and their management. That two-way dialogue appears particularly important for providing opportunities for individuals to become educated about the science behind the issue rather than simply being swayed by emotional attempts to capture opinions, especially by animal welfare organisations, which often appear to be discounting the welfare of the prey species (Freberg 2019; Haider 2016). Future research would benefit from investigating the detailed information and content that is shared by animal welfare groups and individuals in each country and contrasting that information to the material shared by scientists to determine the amount of misinformation that may be shared through social media platforms, and to work towards targeted mitigation of this misinformation by addressing it directly in a manner that engages Twitter users.

3.4 Conclusion

There is no commonly shared global sentiment on feral cats, as each country has its own beliefs, dialogue and approaches to feral cat management. However, social media platforms provide important opportunities to share information about feral cats and to shift national sentiments, though consistent efforts may be required from interest groups to achieve outcomes directly tied to scientific knowledge. In particular, social media provides opportunities for open dialogue and engagement between practitioners and the general public on any issues that may arise as a result of management.

Over the five years of this study, individuals and animal welfare groups from the USA dominated the international narrative around feral cats, leading to most of the information on social media expressing concern and care for the cats. However, this dominance appears to have had less of an effect on sentiments in other countries than originally believed. Further, the amount of scientific information being shared about feral cats within the various countries examined differs depending on the country and the groups responsible for sharing most of the information. Although these countries contain entirely different ecosystems and environments, the fact remains that feral cats in all countries are the same species and need to be addressed and managed properly with regard to social values and the local ecology, and with the support of scientific evidence. This study shows that measuring social media sentiments could be a productive way forward to initially gauge regional and international audience attitudes towards invasive species such as feral cats, which in turn could inform future communication strategies on the topic.

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Chapter 4

The significance of landholder gender and previous knowledge of control methods for effective feral cat management in south-eastern Australia

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Principal Author

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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

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Name of Co-Author	Bertram Ostendorf	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	Douglas Bardsley	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Taggart	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Peacock	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 23/09/2020

Abstract

Invasive animals, such as feral cats, are considered non-threatening by some social groups due to their similarity to companion animals, and this can pose a threat to the success of invasive species management through lack of support. Feral cat management is undertaken across southern Australia, and it is therefore important to determine the social factors that influence levels of support for different control measures amongst stakeholders. In this study, we use a landholder questionnaire to assess acceptance of feral cat control methods on properties on Kangaroo Island, South Australia and near to the Grampians National Park in western Victoria. We found that differences in opinion between genders and levels of previous knowledge of feral cat management methods influenced the likelihood that landholders would allow the application of particular methods on their properties, and that men were more likely to accept all available cat control methods than women. Management authorities are recommended to tailor messages across genders in a way that introduces the facts surrounding both feral cat impacts and management programs.

4.1 Introduction

Invasive species management can be controversial depending on the species in question, and where and how it is managed (Invasive Species Council Australia 2018; Gosling, Stavisky, and Dean 2013; Garcia-Llorente et al. 2008). Though management has benefitted greatly from a wealth of research on technical aspects, less has been done to investigate the social factors that influence the success of various campaigns to control invasive species or the debates that occur as a result of management planning and implementation in different regions (Garcia-Llorente et al. 2008). Research undertaken in this field is often focused on community perceptions of specific invasive species within one location and findings suggest that those perceptions can be heavily influenced by demographics, culture, and individual values (Bardsley and Edward-Jones 2006; Frewer 1999). Further, it has been found that our value systems together with levels of risk perception aid in shaping our view of the environment more broadly, which in turn can

influence reactions towards invasive species and their management (Estevez et al. 2014; Farnworth, Campbell, and Adams 2011).

In some instances, invasive species are not perceived to be a threat by community members and are instead thought to need saving and nurturing (Hatley 2003; Hunter and Brisbin 2016; Pets4Homes 2020). This may be because species such as feral cats (*Felis catus*) are the same species as their companion animal counterparts, which are generally viewed as cuddly, cute, and non-threatening, often with high levels of associated anthropomorphism (Bickford et al. 2012). In countries such as Australia and New Zealand, feral cats are more often perceived as damaging invasive species that need to be managed because of the threat they pose to vulnerable native wildlife populations (Australian Government Department of the Environment 2015a; Aguilar and Farnworth 2012). Nevertheless, the idea of using a range of lethal control methods on a feral animal that is also the same species as a companion animal can cause ethical dilemmas, which in turn can reduce support for particular management interventions (Green and Rohan 2012; Deak et al. 2019). The question then becomes whether the public has considered the implications of using non-lethal versus lethal methods of management on feral cats, and how vulnerable populations of native wildlife would be impacted if the cats are not removed. We have previously approached this question by investigating different social aspects that may influence feral cat management, including land-use type, location and differences in island versus mainland communities, but focus here on the demographic attributes that could influence feral cat management, with a focus on gender and its potential relationship with levels of knowledge of invasive species management.

4.1.1 Attitudes and gender differences in invasive species management

Previous research suggests that gender is an influential factor in developing values in relation to society, and that these values help to shape attitudes around wildlife and its management (Loyd and Miller 2010). Traditionally across cultures, women are

taught to be more compassionate and to have stronger "ethics of care," whereas men are taught to focus on building competitiveness, a sense of independence and family protection (Zelezny, Chua, and Aldrich 2000). This can translate into the different roles that men and women play in managing the environment, where men also tend to hold more authoritative positions in organisations and to value direct action in dealing with threats (Fish et al. 2010). However, the theory that a compassionate nature imparted through culture translates to women caring more about the environment is only one of many potential theoretical influences over a person's perceptions and behaviours (Wehrmeyer and McNeil 2000). An emerging theory held by more critical ecofeminists, states that the female compassion for nature develops from a recognition of the oppression felt as a result of sustained dualism that can be seen in culture/nature, as it is seen in male/female relationships (Wehrmeyer and McNeil 2000). Such an argument infers that women treated as subordinate figures may have a greater sense of connection with the natural world, as they are more familiar with oppression in society (Wehrmeyer and McNeil 2000).

In many historical and contemporary societies, women have less access to resources, less ownership of property, and less decision-making powers than men, which in turn can increase their vulnerability to negative environmental impacts and change (Fish et al. 2010; Zelezny, Chua, and Aldrich 2000). Lack of power leaves many women more susceptible and risk averse to environmental shocks, which may also lead them to be more hesitant to support strong environmental management interventions than men (Fish et al. 2010; Wald et al. 2018). It is also often assumed that men are more pragmatic and accepting of lethal methods, especially in invasive species control, and are more likely to agree that their welfare can to some extent be discounted in their eradication (Dougherty, Fulton, and Anderson 2003; Zinn and Pierce 2002; Bremner and Park 2007). Women on the other hand are generally seen to be more influenced by emotion, basing their attitudes toward lethal control on their beliefs, attitudes and values around pain, suffering and death (Dougherty, Fulton, and Anderson 2003; Zinn and Pierce

2002). In fact, a range of studies suggest that due to their personal understanding of risk, women often have a deeper consideration of the state of the environment, and the risks that accompany its management (Zinn and Pierce 2002; Fish et al. 2010; Sharp, Larson, and Green 2011).

Even if men and women hold broadly similar environmental values, women have been shown to be more likely than men to respond with higher levels of concern for any environmental action that could potentially harm themselves, other humans, or other living creatures (Wehrmeyer and McNeil 2000; Zelezny, Chua, and Aldrich 2000). For example, a study of deer control in New York found that men were more likely to support lethal control methods, whereas women were more likely to choose contraception as the most appropriate method. This was thought to be partially due to women taking greater consideration than men both of animal welfare and of associated risk factors to the community (Dougherty, Fulton, and Anderson 2003; Wehrmeyer and McNeil 2000).

Further, it is important to consider the possible influence of the "white male" effect on gender differences in risk perception in invasive species management (Finucane et al. 2000). This theory implies that white males may perceive less risk than other groups, including women, because they are usually more directly involved in the creation, management, and benefits of any particular technology, making it more likely for men to support both lethal and non-lethal management options (Finucane et al. 2000). This theory goes on to suggest that because of their technical response capacities, white males exhibit less concern for environmental change or the consequences of technological interventions in the natural environment (Zelezny, Chua, and Aldrich 2000). These differences reflect the idea that direct impacts of invasive species and their management are felt differently depending on gender, and that this might further influence attitudes towards using non-lethal methods as opposed to lethal methods to manage species such as feral cats.

All of this earlier theory and research has important implications for feral cat management, because according to the Theory of Planned Behaviour (TPB), individuals

who hold more positive attitudes towards a behaviour and recognise a strong social norm in participating in the behaviour are more likely to support or perform the behaviour (Kalnicky, Brunson, and Beard 2018). In addition, those who believe that their actions will likely result in the desired effect are also more likely to support or perform the behaviour (Kalnicky, Brunson, and Beard 2018). Therefore, in relation to our particular study, the TPB would suggest that because men perceive less risk and are more pragmatic towards feral cat management, they would be more likely to accept and potentially participate in using or allowing the use of all management methods than women who would be more reticent to accept or participate in certain management interventions.

While we examine the gender implications of the TPB in this paper, previous work also suggests that individual values and attitudes may also differ based on the circumstances of a person's experiences and situation (Bremner and Park 2007; Zelezny, Chua, and Aldrich 2000). For instance, a study of mountain lion management found that differences were evident in the acceptability of management methods between men and women where a mountain lion had killed a human (Zinn and Pierce 2002). However, there were no significant differences in attitudes when a lion had only been seen in the area or had killed a domestic pet. This response suggests that gender alone is unlikely to determine the likelihood of any individual's response to particular management approaches, and that other issues will influence perceptions of risk or value that will in turn impact upon levels of support for particular interventions (Wehrmeyer and McNeil 2000). For instance, levels of prior knowledge about any particular invasive species, such as feral cats, and their impacts could be a factor in determining levels of support for a management campaign (Deak et al. 2019). Thus, it is important to understand how demographic factors such as gender interact with other variables to alter a person's willingness to support or reject different forms of intervention to manage invasive species (Zinn and Pierce 2002; Wehrmeyer and McNeil 2000).

4.1.2 *Knowledge and familiarity in invasive species management*

Knowledge of a particular topic is hugely influential over environmental management decisions. Knowledge limitations or misunderstandings may reduce support for feral cat management, which would suggest a need for analyses of the knowledge that different demographic groups hold about the management of the species to guide development of targeted educational resources (Sharp, Larson, and Green 2011). For that reason, workshops and community education programs often focus on informing a community about a target invasive species and the threat that it poses to their particular environment, industry or community, both to influence public perceptions and gain support for management programs (Deak et al. 2019; Bardsley and Edward-Jones 2006). In a study on public perceptions of invasive, exotic species in Scotland, it was found that the majority of participants were broadly interested and supportive of conservation management efforts, but that the community required additional information about invasive species management if interventions were to include the use of lethal control methods (Bremner and Park 2007; Sharp, Larson, and Green 2011). Further, in a study specifically examining the relationship between the TPB and invasive species management (Kalnicky, Brunson, and Beard 2018), community attitudes towards the management of the species itself were found to have a significant influence over whether they would participate in management or support particular interventions. Such research suggests that by developing new knowledge about the complex interactions between gender, knowledge, social perceptions and support for feral animal management, more sophisticated management approaches could be developed that have the potential to improve outcomes.

4.1.3 *Feral cat management in south-eastern Australia*

Feral cats pose a significant threat to wildlife, livestock and humans around the world, and particularly in Australia (Spotte 2014; Doherty et al. 2016; Taggart, Fancourt, et al. 2019; Taggart, Stevenson, et al. 2019). Regions of Australia, including the states of Victoria and South Australia, have begun to take action to create and implement feral cat

management programs to control populations within their jurisdictions (Victoria State Government 2018; Natural Resources Kangaroo Island 2015). In South Australia, a Kangaroo Island Feral Cat Eradication Program has been created and is currently in the process of being implemented in line with an action plan which aims to eradicate feral cats from the 440,500 hectare island by the year 2030 (Natural Resources Kangaroo Island 2015). This program has been in effect since 2015, and has trialled numerous feral cat control methods on the island to determine the best course of action that will eliminate cats with minimal risks to wildlife, working animals and stock (Kangaroo Island Feral Cat Eradication Program 2018). In Victoria, feral cat management has only recently been considered, following the declaration of feral cats as an exotic pest in July of 2018 (Victoria State Government 2018). The Victorian Feral Cat Declaration was written to provide potential guidelines for the management of feral cats within the state, although a firm action plan has yet to be established (Victoria State Government 2018). Research into community attitudes around various cat control methods in this region is an important part of planning and implementation in the future, especially regarding the use of poisons, which generated community concerns after being used previously in other feral mammal management campaigns in the area.

Feral cat management programs generally involve the conjoint use of methods, and in both South Australia and Victoria these include poison baiting with either Eradicat® (sodium fluoroacetate; '1080') or Curiosity® (paraaminopropiophenone; 'PAPP'), shooting, cage trapping, padded leg-hold trapping, detector dogs, Maremma dogs (used as guardian dogs), exclusion fencing, and a new trial method, known as the Felixer™ grooming trap (Larson et al. 2011; Australian Government Department of the Environment 2015b; Read et al. 2019). The application of any particular method can be contentious for a number of reasons, some of which are due to misunderstandings and knowledge gaps around the science behind feral cat management (Moon, Blackman, and Brewer 2015). Although both South Australia and Victoria briefly address the technical aspects associated with management in their Feral Cat Management documentation,

there has been little analysis or discussion about community attitudes towards feral cat management in the target areas, especially as they pertain to use on private property (Victoria State Government 2018; Natural Resources Kangaroo Island 2015).

It is important that local communities understand why invasive species such as feral cats are being managed, so that programs reliant upon both cross-tenure logistical support and government funding are able to maintain public backing (Invasive Species Council Australia 2018). Further, when a social license for government officers to act is contested, such as when there are polarised differences in public levels of support for any action, it becomes essential to recognise what factors may be causing this polarisation to determine how changes could be made to facilitate effective management outcomes (Herzele, Aarts N, and Casaer 2015). This paper examines the influence of gender on different attitudes towards feral cat management methods within each community (Kangaroo Island, South Australia; and Grampians region, Victoria) in association with knowledge of non-lethal and lethal feral cat control methods. The analysis of the relationship between gender and knowledge informs a discussion of the implications for the planning of invasive species management programs. The specific hypothesis tested is that the levels of social license to implement particular feral cat control methods on private property will differ significantly with an individual's gender in association with their previous knowledge of feral cat management methods.

4.2 Methods

4.2.1 Study areas

This study examined local residential attitudes towards various feral cat control measures on the 440,500 hectare Kangaroo Island (KI), South Australia and around the 1,672 km^2 Grampians National Park in Victoria (Deak et al. 2019). KI is fortunate to have been spared the devastating impacts of the introduced red fox (*Vulpes vulpes*) and European rabbit (*Oryctolagus cuniculus*), and is thus renowned for ecotourism values associated with its high levels of biodiversity and role as a sanctuary for several endangered species, such as Rosenberg's goanna (*Varanus rosenbergi*) and the southern

brown bandicoot (*Isoodon obesulus*) (Natural Resource Kangaroo Island 2013). KI is also home to a number of endemic island species, such as the KI short-beaked echidna (*Tachyglossus aculeatus multiaculeatus)* and the KI dunnart (*Sminthopsis fuliginosus aitkeni*). Along with ecotourism, the island has important livestock industries, including sheep-farming (Spence 2020). The presence of feral cats on KI threatens both the biodiversity of the island through direct predation of wildlife, and the livestock industry through disease transmission (Taggart, Fancourt, et al. 2019). As a result the island established a feral cat eradication program in 2015 (Kangaroo Island Feral Cat Eradication Program 2018; Taggart, Stevenson, et al. 2019; Taggart, Fancourt, et al. 2019; Taggart et al. 2020).

The Grampians National Park is also well known for its ecotourism with a diverse array of natural landscapes, native wildlife, and endemic plants, and for the surrounding productive sheep-farming and other livestock related industries (Parks Victoria 2020). Invasive predators such as the red fox (*Vulpes Vulpes*), which pose a threat to native wildlife and livestock in the region, are managed using poison baiting, fumigation, and fencing (Horner and Platt 1993; Taggart et al. 2015). Feral cats were only recently declared a pest species in 2018 by the state of Victoria due to their threat to wildlife and livestock, and are being integrated into the pre-existing feral pest predator management campaigns (Victoria State Government 2018).

The two locations were chosen for this study, partly because sheep farming and nature-based tourism are essential industries in both places; partly because foxes and rabbits are absent from one landscape and not the other; and, partly because of their differing stages of feral cat management. Management of feral cats on KI is more advanced than those in the Grampians region, with community control efforts on the island going back to the 1990s and the formal feral cat eradication program established in 2015 (Paton 1994, 2003). It was recognised that differences in the planning and implementation of the feral cat control programs in the two places could provide useful insights into the importance of levels of community awareness of feral cat management.

By undertaking the comparative case-study, we hope to develop a sophisticated understanding of how gender and prior knowledge in both locations links to willingness to support the development of more effective management actions.

4.2.2 Study design

To examine the relationships between prior knowledge and demographic characteristics of the KI and Grampians communities and their attitudes toward feral cat control, a questionnaire was designed for distribution to landholders and other members of the public at both locations. A survey questionnaire was chosen as a means to approach the community, as opposed to interviews or focus groups, as it allowed for a large sample to receive and respond to an exact set of questions within each location during the same time period. The survey consisted of a number of short answer and multiple-choice questions, and both quantified and qualified answers using Likert scales, a heat map and written responses.

Questions were designed to examine familiarity with and social acceptability of feral cats and particular management methods, as well as demographic questions that included a map for participants to select their most relevant property for which their answers related. After assessing respondents' awareness of different feral cat management methods, the questionnaire then included a brief description of each control method (Appendix B) to allow respondents to subsequently answer questions regarding the likelihood of them allowing the use of particular control methods on their land. The descriptions of each method were kept as short as possible, with about four to five sentences explaining what was entailed and how effective it was in relation to its cost. The potential risks to native wildlife and domestic pets were also highlighted where necessary, in order to present participants with as much information as possible as to the benefits and risks of different methods. The questionnaire was reviewed by both Parks Victoria and the KI Natural Resource Management Board and was pre-tested by colleagues in the University of Adelaide Ecology and Evolutionary Biology department.

The questionnaire was designed to take respondents approximately 15 to 20 minutes to complete. It was made available online, with an anonymous link used to access the site over the internet. Previous studies have shown that online questionnaires may not be as successful in reaching a full range of landholders as mail-out questionnaires, and so we decided that mailing out hardcopies of an invitation to the questionnaire would enhance our response rate (Fielke and Bardsley 2014). It was also acknowledged that a hardcopy invitation requires a further level of interaction involving the person choosing to participate or not. To prevent participants taking the questionnaire more than once, a "Prevent Ballot-box Stuffing" option was developed through cookies placed on any previous participant's browser.

Participant Information Sheets were sent out to 1,508 addresses on KI and 3,500 post office box addresses in the Grampians National Park and surrounds in western Victoria, using the Australia Post Unaddressed Mail Service. A Facebook page was also created to promote the questionnaire with the same link that had been included on the Participant Information Sheets, but with a different code for entry in order to trace where participants had sourced information about the questionnaire. Facebook Community groups for the designated localised areas were contacted and asked to promote the page or the link within their group pages. A local radio station near the Grampians region (ABC Ballarat) and the local newsletter on KI (The Islander) also provided a means of promoting the questionnaire. The questionnaire was open from 26th September 2018 to 31st January 2019 in order to allow time for farmers and other landholders to receive the letter or flyer in the mail and to fill out the questionnaire at their leisure.

To access the questionnaire, participants were required to enter a code that was provided to them via the targeted invitation letter or the online Facebook advertisement. Participants were then asked whether they were responding for KI or the Grampians region, and their answer determined which version of the questionnaire they could access. Although the two questionnaires were very similar, one question was added to the Grampians version that was not relevant to KI residents about whether or not private

property as well as Crown land should be managed, and a region-specific map was provided in each case to give participants the opportunity to identify the location of the property for which they had answered.

After the 31st January 2019, results were collected from the online survey program and were exported into an Excel spreadsheet, which could then be read into the program R. We had a 5% response rate from the initial contact through the Participant Information Sheets, with a 72% completion rate, receiving back 243 completed questionnaires, and 93 partially completed questionnaires. To clean the data, any questionnaires that were only partially completed or did not include key demographic information were removed, leaving 202. Only questionnaires completed by participants who marked their gender as either male or female could be included in the analysis, as the 8 participants who listed their gender as other did not allow for an adequate representation sample. In the end 194 questionnaires were analysed, with 101 female respondents and 93 male respondents. Results were analysed using Mann-Whitney U tests initially to examine broad relationships, followed by the application of an Ordinal Logistic Regression Model to discern differences in influence between factors and to create predictions. Written responses were analysed by gender according to coded themes in answers as to why or why not respondents would support different methods of feral cat management.

4.3 Results

4.3.1 Likelihood of using various feral cat methods on private property

Of the 194 participants, 52% of respondents were female and 48% were male. There was an equal number of participants from each location, with 51% of respondents from the Grampians and 49% from KI. Almost half of the participants (48%) were between the ages of 45 and 64, and most either lived in a house on a large acreage (37.6%) or on a residential sized block (21.1%). Of the methods of communication listed, this study's survey was considered to be the most useful for learning about feral cat management, with 63% of participants finding it to be highly useful, 32% saying that it was somewhat useful and 5% saying that it was not useful at all. Forty-nine percent of participants considered online news to be a highly useful method for learning about feral cat management, with 32% calling it somewhat useful and with 9% claiming that it was not useful at all. Ten percent of participants said that they did not use online news to learn about the topic. Sharing information about feral cat management through word-of-mouth was considered highly useful by 47% of participants, somewhat useful by 45% and not useful at all by 2%. Five percent of participants said that they did not use word-of-mouth. The least popular communication method for learning about feral cat management was through blogs, as only 6% of participants found blogs to be highly useful and 25% considered them to not be useful at all, with 37% saying that they were only somewhat useful. Thirty percent of participants said that they have not tried to use online blogs to gather information on feral cats.

Table 1. Demographic make-up of feral cat management questionnaire participants (n=194). This questionnaire was distributed to landholders on Kangaroo Island and in the Grampians and surrounding suburbs, and to assess how demographics could influence attitudes around feral cat management requested demographic information including gender, location, age, property description.

Gender	
Male	52%
Female	48%
Location	
Kangaroo Island	49%
The Grampians	51%
Age	
18-24	1%
25-44	27.3%
45-64	48%
65+	23.7%
Property Description	
House on a large acreage (>10 ha)	37.6%
Small acreage (6-10 ha)	10.3%
Larger sized block (2-5 ha)	13.9%
Residential sized block (<2 ha)	21.1%
Unit or apartment	4%
Other	13.4%

The majority of participants had strong opinions regarding the techniques that they would or would not allow to be used on their property. Cage trapping was found to be the most acceptable technique for use with 85.5% of all participants agreeing that they would be "Highly Likely" to allow the use of this method of cat control on their property. Other cat control methods with good support included shooting (63.7%) and the use of detector dogs (57%). Baiting with Curiosity® was one of the least popular options, with only 39.4% of questionnaire participants listing that they would be "Highly Likely" to use this method of cat control on their property, and 39.4% of participants agreeing that they would be "Highly Unlikely" to support this management option. Baiting with Eradicat® was slightly more popular with 40.2% of participants indicating that they would be "Highly Likely" to allow the use of this control method, and another 39.7% indicating that they would be "Highly Unlikely" to allow the use of this technique on their property. The use of Felixer™ grooming traps was a method that was more supported than baiting with Eradicat® or Curiosity®, with 51% of participants agreeing that they would be highly likely to allow the use of this cat control method as opposed to the 34.4% that were

highly unlikely to use these traps. This result was despite the Felixer™ grooming trap delivering the same poison as used in Eradicat® baits, which had been explained to participants prior to them answering the question. These differences may be a result of how information about the Felixer grooming traps has been disseminated throughout the different regions, and participants may not have made the connection between Felixer™ grooming traps using the same poison as used in Eradicat® baits. Conversely, participants may have understood that risk of non-target species poisoning was lower when using Felixer® grooming traps due to specific targeting of predator species using species recognition software, compared to the less target specific aerial or ground baiting techniques.

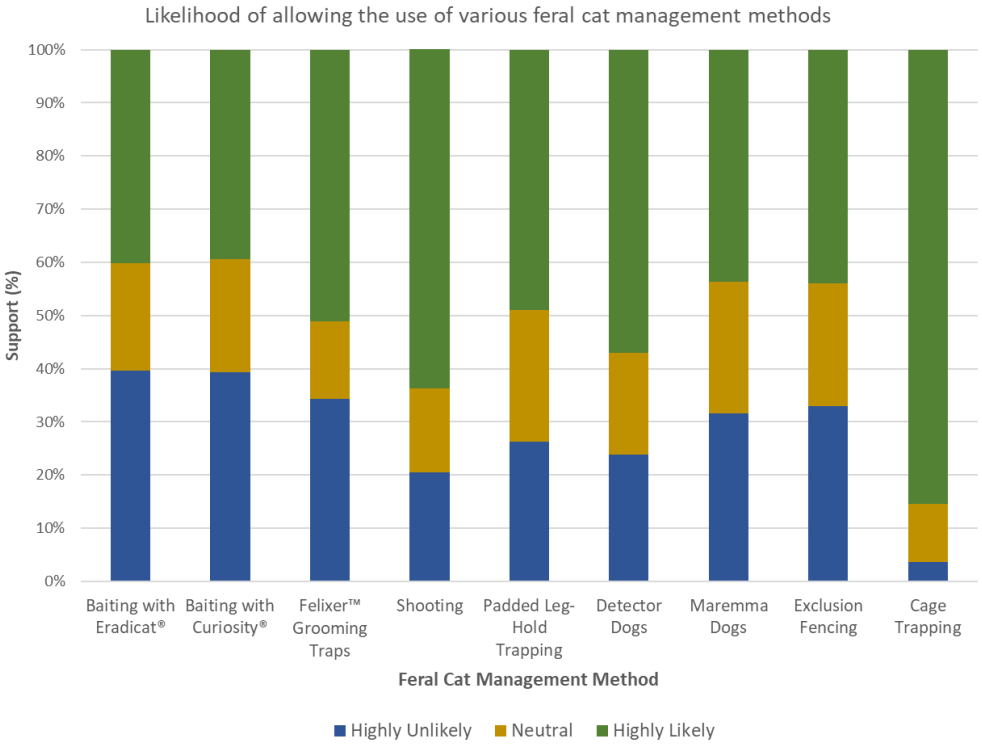

Figure 1. The overall results of a set of survey questions that were designed to examine the likelihood of allowing the use of several feral cat (*Felis catus*) control methods on private properties on Kangaroo Island and in the Grampians (n=194). Participants were asked to rate their likelihood of use for each control method on a 7-point Likert scale of 1 to 7, which was then grouped into three sections for analysis including Highly Unlikely (1-2) (blue), Neutral (3-5) (gold), and Highly Likely (6-7) (green).

The differences in opinion observed between those who indicated that they were highly likely to allow the use of cat control methods that contain poison and those who indicated that they were highly unlikely to allow the use of these methods suggests that

the data and therefore people's opinions are highly polarised on this issue (Figure 1). This polarisation could potentially be explained by the demographic makeup of the participants (Table 1).

4.3.2 Influence of gender differences

In this study, gender difference was analysed in association with previous knowledge of feral cat control methods and location (KI and the Grampians) in relation to the likelihood of participants allowing the use of feral cat control methods on their land (Table 2). Gender differences presented significant evidence of influencing polarisation within the data, as did previous knowledge of cat control methods, however location itself did not have a significant influence on the likelihood of allowing the use of various methods. Though other attributes including land use type and education were also tested in this study, the strong evidence around gender differences and previous knowledge of cat control methods as significant factors influencing the likelihood of allowing the use of various methods led to a more in-depth investigation into the interactions between the two variables.

The Mann-Whitney-U test for gender differences revealed that there were significant variations in which feral cat control methods men or women would likely allow the use on their properties (Table 2). There were no significant differences in gender and attitudes between the two locations. The most significant gender differences were recorded in association with baiting with Eradicat® ($p < 0.001$), Felixer™ grooming traps ($p < 0.001$), padded leg-hold trapping ($p \sim 0.002$), baiting with Curiosity® ($p \sim 0.005$) and shooting ($p \sim 0.013$), where in each men seemed to be more supportive of the use of the method. These results may indicate differences in attitudes around the acceptability of types of cat control methods used, as each method mentioned involves the use of either poison or another technique that could be considered inhumane by some sections of the general public. The methods that do not involve contact or initial harm to the animal, such as cage trapping, detector dogs, Maremma dogs and exclusion fencing did not yield significantly different results for gender, indicating that there was

little difference in attitudes between men and women around these cat control methods, perhaps because these methods were viewed overall as more humane.

Table 2. A Mann-Whitney-U test was run to determine the influence of gender differences, previous knowledge of cat control methods, and location on the likelihood of using particular feral cat management methods on private property on Kangaroo Island, SA and in the Grampians region of Victoria. The results of the test suggest that gender differences and previous knowledge of cat control methods influence the likelihood of using particular methods, but that location does not. Values indicate significance (p) where values < 0.05 are significant.

Feral Cat Management Method	Gender Differences	Previous Knowledge	Location
Baiting with Eradicat®	**< 0.001***	0.464	0.426
Baiting with Curiosity®	**0.005**	**0.003***	0.628
Felixer® Grooming Traps	**< 0.001***	**0.003***	**0.011***
Cage Trapping	0.327	**< 0.001***	0.169
Padded Leg-Hold Trapping	**0.002***	0.139	0.143
Shooting	**0.013***	**< 0.001***	0.169
Detector Dogs	0.356	**< 0.001***	0.085
Maremma Dogs	0.283	**0.025***	0.058
Exclusion Fencing	0.327	**< 0.001***	0.058

Further, where men were more likely to allow the use of most of the cat control methods involved in the study, women were likely to only allow the use of the methods that did not involve the use of poison or involve direct physical contact with the individual cat (Figure 2). Reasons mentioned for this difference in attitude might be because women stated that they did not want to risk the poison baits being picked up by non-target species, pets or children, and men were opposed to having the baits picked up by non-target species. Men were also more likely to mention that they would prefer all methods be used, as feral cats needed to be eradicated as quickly as possible. There also seemed to be evidence of polarisation within the female population itself. Although more than half of women were supportive of the use of padded leg-hold trapping, Maremma

dogs, and exclusion fencing, the percentages of women who would and would not allow the use of these less assertive methods were similar (Figure2).

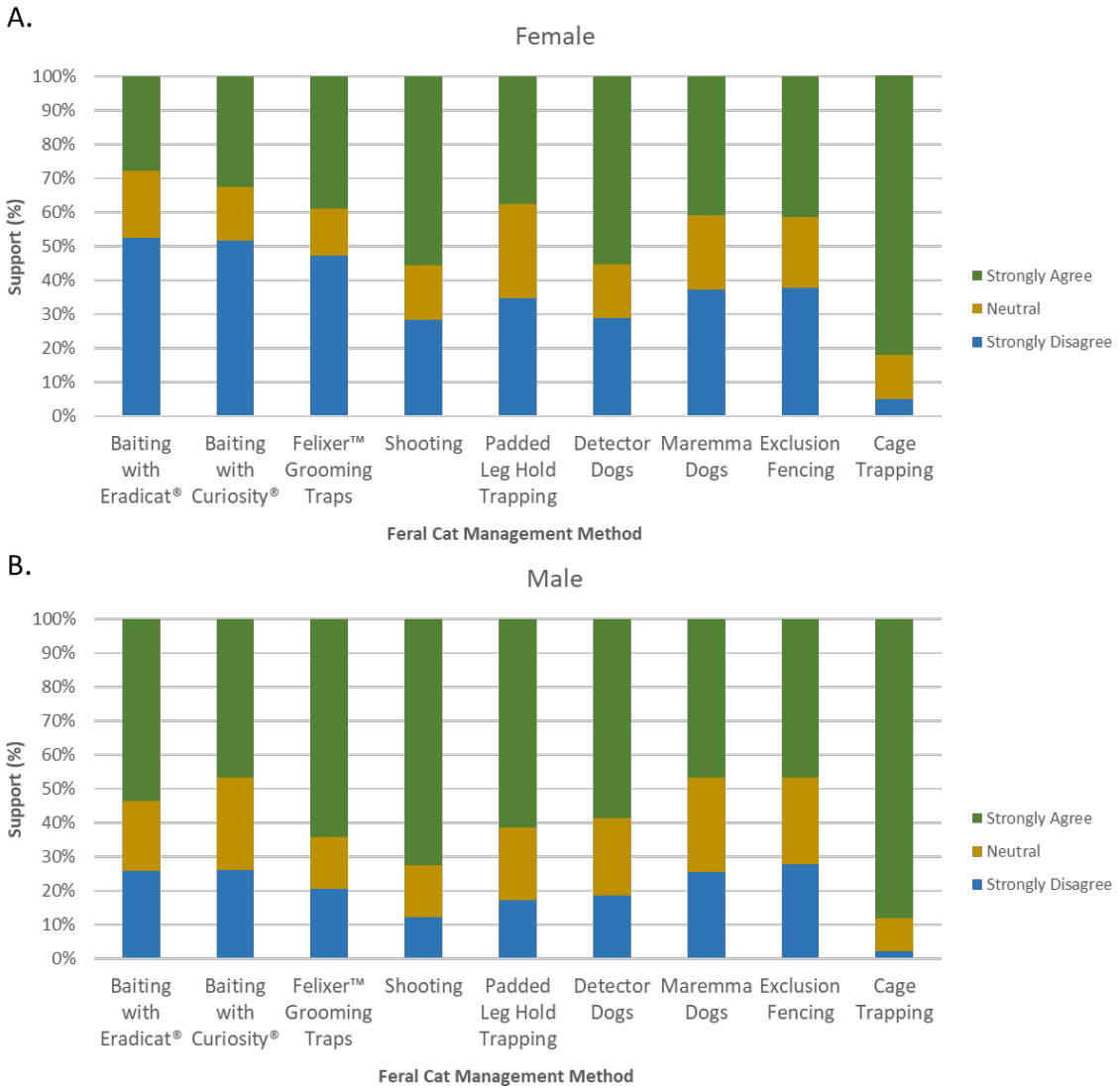

Figure 2. Each plot represents the total number of participants of each gender who responded to the question regarding whether they would be likely to allow the use of different feral cat management methods on their property. Plot A describes the likelihood for females to accept the use of various methods, and plot B describes the likelihood for men to accept the use of the methods. Each colour on the graph represents a level of likelihood that a participant will use a certain cat control method: "Highly Unlikely" (blue), "Neutral" (gold) or "Highly Likely" (green).

4.3.3 Influence of previous knowledge of cat control methods on participant attitudes

After gender differences, previous knowledge was the next most significant factor influencing attitudes around cat control methods and showed strong evidence of polarisation within the dataset. Results of the Mann-Whitney-U test indicate that with the exception of two methods, all methods yielded significant differences depending on whether participants had heard of the cat control method or not, which suggests that effective knowledge and communication within feral cat management could be essential to gaining social license (Table 2). Further, there were significant differences in percentages of people who had heard of the method or not according to location, especially in relation to some of the newer methods (Table 3). Of the people who were unfamiliar with the use of baiting with Eradicat®, 30% were from KI and 70% were from the Grampians. Similarly, 26% of those who were not familiar with Felixer™ grooming traps were from KI, and 74% were from the Grampians. For baiting with Curiosity®, 44% of people who were unfamiliar with the method were from KI, and 56% came from the Grampians.

Table 3. A Mann-Whitney-U test was run to determine the influence of location on previous knowledge of cat control methods between participants on Kangaroo Island, SA and in the Grampians region of Victoria. The results of the test suggest that previous knowledge of some cat control methods is influenced by location. Values indicate significance (p) where values < 0.05 are significant.

Feral Cat Management Method	Previous Knowledge
Baiting with Eradicat®	**<0.001***
Baiting with Curiosity®	**0.011***
Felixer® Grooming Traps	**<0.001***
Cage Trapping	0.117
Padded Leg-Hold Trapping	0.399
Shooting	0.419
Detector Dogs	**<0.001***
Maremma Dogs	0.399
Exclusion Fencing	**< 0.001***

There was strong evidence of polarisation between the results for baiting with Curiosity®, in relation to those who were highly likely to allow the use of the method and those who were not, despite most having not previously heard of the cat control method prior to taking the questionnaire. The results suggest that although people may be willing to allow the use of baiting with Curiosity® if they have not heard of it, there is a greater chance that they would allow the use of this method if they have previously heard of it.

Results indicated that 42% of the participants who had not previously heard of the Felixer grooming trap were highly unlikely to allow its use, compared to the 39% who had not heard of it but were highly likely to allow its use (Figure3). On the other hand, 63% of those who had heard of Felixer™ grooming traps previously were highly likely to allow its use, versus the 26% who had previously heard of it and were highly unlikely to allow its use. These results further suggest that previous knowledge may be essential to gaining social license, as people who have knowledge about a method may be more likely to negotiate its use. Data also suggests that this particular method may not be as well-known as some of the other methods proposed, possibly because it is a relatively new technique still being trialled.

Examination of the survey data on baiting indicated that unlike baiting with Curiosity®, there was no significant difference in the likelihood of allowing the use of baiting with Eradicat® between those who had and those who had not heard of the method (Figure 3). Results suggest that baiting with Eradicat® is one of the more well-known feral cat control methods, and that there must be a reason other than lack of knowledge as to why it is so highly contested amongst the general public and other stakeholders. There is also the possibility that knowledge of target specificity influences attitudes to where Felixer® grooming traps are slightly more acceptable than either method of poison baiting.

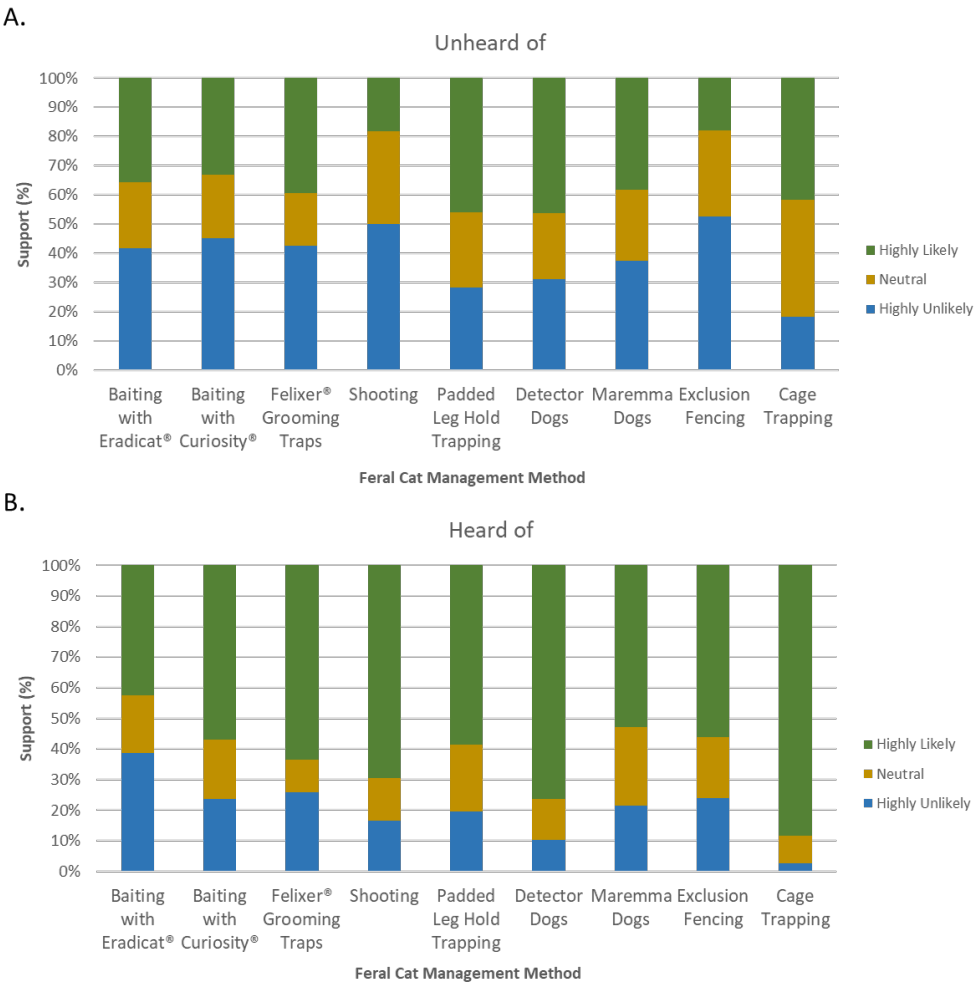

Figure 3. The above plots represent the total number of participants who had and had not previously heard of the various feral cat management methods, and their likelihood of allowing the use of these methods on their properties. Plot A describes the likelihood for those who have not heard of the particular feral cat management method to accept the use of the method in question, and plot B describes the likelihood for those who have heard of it to accept its use. Each colour on the graph represents a level of likelihood that a participant will use a certain cat control method: "Highly Unlikely" (blue), "Neutral" (gold) or "Highly Likely" (green).

4.3.4 Gender differences vs. previous knowledge of methods

In examining the interaction between gender and previous knowledge of cat control methods over acceptance of particular methods, the results of the ordinal logistic regression model (Table 3) suggested that attitudes toward control methods involving the use of baits, or leg hold trapping were influenced more strongly by gender, whereas methods like exclusion fencing, detector dogs, Maremma dogs, and cage trapping were influenced more strongly by previous knowledge of the control method. Shooting and baiting with Curiosity® appeared to be influenced strongly by both gender difference and an individual's previous knowledge of that particular control method (Table 4).

Table 4. An Ordinal Logistic Regression model was used to compare the influence of gender differences and previous knowledge on the likelihood of participants using particular feral cat control methods on Kangaroo Island, SA and in the Grampians region of Victoria. In all cases, at least one of the factors heavily influenced the likelihood of use. Values indicate significance (p) where values < 0.05 are significant.

Feral Cat Management Method	Gender Differences	Previous Knowledge
Baiting with Eradicat®	**< 0.001***	0.732
Baiting with Curiosity®	**0.002***	**0.002***
Felixer® Grooming Traps	**0.004***	0.878
Cage Trapping	0.359	**< 0.001***
Padded Leg-Hold Trapping	**0.002***	0.195
Shooting	**0.021***	**< 0.001***
Detector Dogs	0.695	**<0.001***
Maremma Dogs	0.188	**0.04***
Exclusion Fencing	0.584	**< 0.001***

Data suggests that of the people who were highly unlikely to allow the use of baiting with Eradicat® as a control method (n = 77), the majority, or about 70% were women. Of the women who had not heard of baiting with Eradicat® (n = 39), 56% were highly unlikely to allow the use the method, and only 21% were highly likely to allow its use (Figure 4). While of the men who had not heard of baiting with Eradicat® (n = 28), the majority (57%) were still likely to allow the use of the method, and only 21% were highly unlikely to allow its use. Further, of the women who had heard of baiting with Eradicat® previously (n = 62), 50% were still highly unlikely to allow the use the method,

though 32% were highly likely to allow its use (Figure 4). Fifty-two percent of men who had heard of baiting with Eradicat® (n = 65) were willing to allow the use of the method, and 28% were highly unlikely to allow its use. These findings further underpin that gender strongly influences attitudes towards the use of baiting with Eradicat® ($p < 0.001$) (Table 4).

In relation to allowing the use of Curiosity® baits, the majority (58%) of women who had not previously heard of the method (n = 76) were highly unlikely to allow its use, whereas 26% were highly likely to. In contrast, a large portion of the men who had not heard of the method before (n = 66) were still highly likely to allow its use (41%), whereas 30% were highly unlikely. Of the women who had heard of baiting with Curiosity (n = 25), 32% were highly unlikely to allow the use of the method, but the majority (52%) were highly likely to allow its use. Of the men who had heard of the method previously (n = 26), 62% were highly likely to allow its use and 15% were highly unlikely. In this instance, women seemed to be more strongly biased towards not using Curiosity® baits if they had not previously heard of the method but were more likely to allow its use if they had heard of it, whereas men seemed to be more accepting of the method even if they had not heard of it previously. This suggests that both gender and previous knowledge played an important role in the likelihood of allowing use of Curiosity® baits (Figure 4).

The results for the Felixer™ grooming traps (Figure 4) indicate that of women who had not heard of this method before (n = 59), the majority (56%) would be highly unlikely to allow its use, and 25% would be highly likely to allow its use. Sixty percent of men who had not heard of the method before (n = 40) were highly likely to allow its use, and 22% were highly unlikely to allow its use. Of the women who had heard of Felixer™ grooming traps previously (n = 41), the majority (59%) would be highly likely to allow its use, and 34% were highly unlikely (Figure 4). Similarly, 62% of men who had heard of the method (n = 45) were highly likely to allow its use and 22% were highly unlikely. (Figure 4). Although previous knowledge of the method did not seem to influence

attitudes around the use of Felixer™ grooming traps as much as gender difference, it was apparent that women who had not heard of the method were much more likely to not support its use than men.

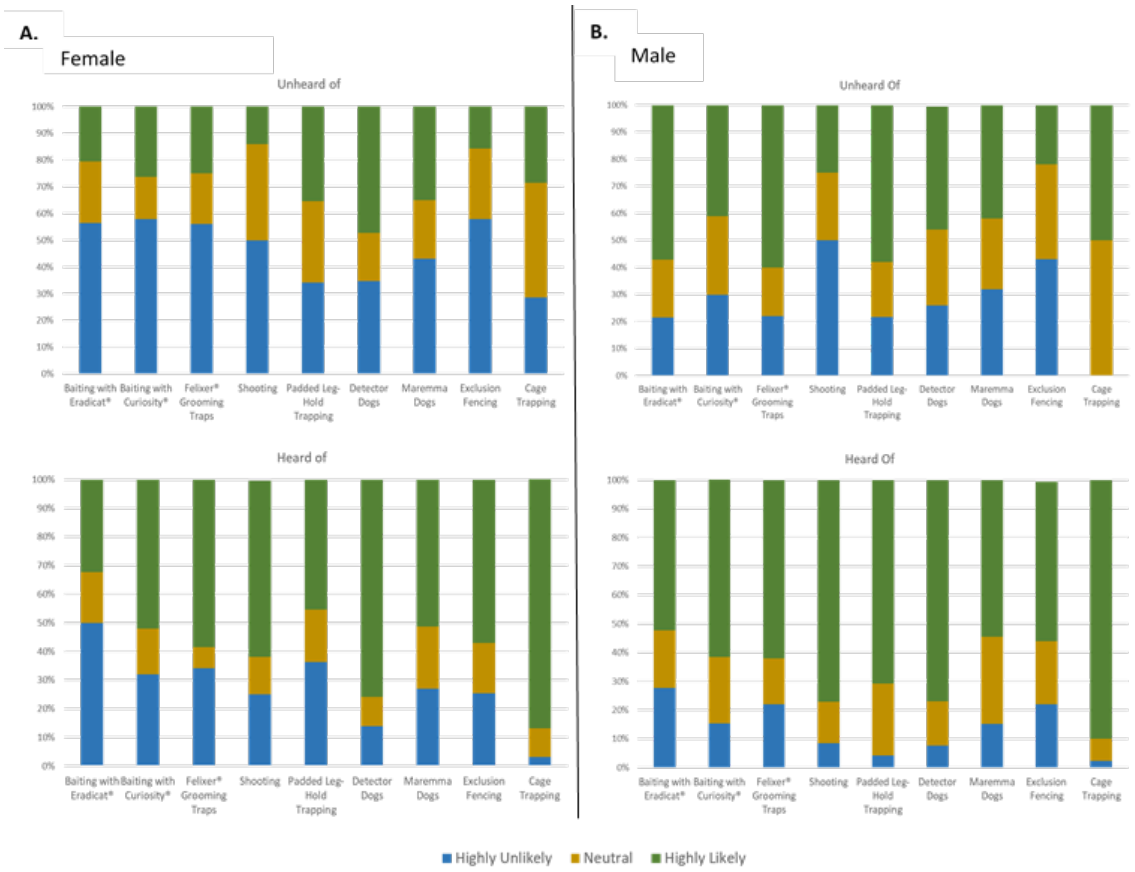

Figure 4. Percentages were calculated to determine the proportions of male and female participants from Kangaroo Island, SA and the Grampians region of Victoria who had and had not previously heard of particular feral cat management methods. Graphs display the breakdown of the relationship between levels of likelihood of allowing the use of feral cat management methods for (A.) women who have heard of these methods and (B.) those who have not heard of these methods previously (C.) men who have heard of these management methods and (D.) those have not. Each colour on the graph represents a level of likelihood that a participant will use a certain cat control method: "Highly Unlikely" (blue), "Neutral" (gold) or "Highly Likely" (green).

Further, we asked respondents whether they believed that there were better ways to manage feral cats than those mentioned in the questionnaire. A total of 14% of women strongly agreed that there were better methods, 46% were neutral or unsure, and 40% strongly disagreed. Of the men who were asked if there were better ways to manage feral cats, 4% strongly agreed that there were better methods, 55% were neutral or unsure, and 52% strongly disagreed. Common themes identified in the

written in responses provided by participants included women suggesting that they would not use poison such as Eradicat® baits due to the potential risk towards humans, pets and children, and men suggesting that they would be against the use of Eradicat® due to the potential risk towards non-target species. Further, exclusion fencing was identified by participants as a method that was expensive and inefficient.

4.4 Discussion

This study supports the argument that interactive effects of gender and previous knowledge of a cat control method play a vital role in explaining people's attitudes towards feral cat management (Dougherty, Fulton, and Anderson 2003; Bremner and Park 2007). Location was also a factor in relation to previous knowledge in this case, as people from KI were more familiar with the lethal methods using poison than those in the Grampians, which indicates perhaps that communication on the island has been effective, but also that many people in the Grampians region may not have been made aware of these methods yet (Barton Laws et al. 2015).

Men were more likely to permit the use of all management methods on their property, including lethal ones, as a way to manage feral cats as quickly as possible, whereas women were more likely to disagree with the use of lethal methods such as poison, preferring the less efficient methods such as cage trapping and shooting. At the same time, women were less likely to support methods that they were not previously familiar with and did not know enough about, suggesting that previous knowledge may play a more significant role in association with gender, rather than just gender effects alone in predicting support for the use of feral cat management methods. This finding is likely to be at least partly explained by the belief that women in general tend to be more risk adverse than men and are likely to avoid activities that they are uncertain about and perceive as high risk (Larkin and Pines 2003; Zinn and Pierce 2002).

The fact that women hesitate to allow methods that they are not completely familiar with to be used on their property may also provide evidence that they are placing

greater emphasis on a range of additional factors in decision-making around feral cat management, such as the potential harm to other animals or people (Larkin and Pines 2003; Zelezny, Chua, and Aldrich 2000). Some of the main reasons mentioned by women for not accepting the use of poison baiting, for instance, were that they did not want the baits to be consumed by pets or wildlife, and they also did not want the baits to be picked up by children. Men who were against baiting with either Eradicat® or Curiosity® also mentioned that it was due to the potential of non-target wildlife species ingesting the poison, but there were less mentions of that issue by men than by women. Further, women were more likely to strongly agree that there are better ways to manage feral cats than the methods mentioned within the questionnaire, while men seemed more confident that the methods that were mentioned within the questionnaire were the best ways to manage feral cats. At the same time, approximately 55% of men were unsure if there actually were better management methods available, and 46% of women felt the same suggesting that further community engagement may improve the confidence in the community around management abilities and methods. Management would also benefit from future in-depth research and education on the ethical considerations surrounding management decisions in relation to gender.

Other responses provided mostly by men about their attitudes towards management inferred that feral cats needed to be eradicated at all costs, which may be the main motivation for the majority choosing to use all of the cat control methods on their property. It is possible, too, that men and women hold different levels of responsibility for any potential harm to either non-target species or people if there allowed the methods to be used (Zinn and Pierce 2002; Zelezny, Chua, and Aldrich 2000). For women, there could be a greater sense of responsibility felt for potential risks and consequences from the direct use of poison, and they may be more cautious in wanting to avoid those consequences if they are not informed enough about the methods (Zinn and Pierce 2002; Fish et al. 2010; Wehrmeyer and McNeil 2000). Further, the consequences of making the choice to allow lethal methods such as poison to be used

may take precedence over the consequences of letting feral cat populations decline very gradually, if at all, in vulnerable environments (Zinn and Pierce 2002; Wehrmeyer and McNeil 2000). Men may feel a different level of responsibility towards potential risks due to their knowledge of feral cat management methods or concern of the impacts of feral cats, or possibly due to the white male effect that provides them with a confidence in any interventions. Men may also be considering the effectiveness of the methods to be more important than the potential negative consequences to non-target individuals, whereas women may consider the opposite (Zelezny, Chua, and Aldrich 2000). Additional research would also benefit from investigating gender differences in this regard in different contexts.

Effectiveness is an important overall factor that needs to be considered in decision-making around invasive species management, because even though the public might be in favour of one method over another, that method might not be very effective, or may be too labour intensive or economically unfeasible to achieve an outcome such as eradication (Doherty and Ritchie 2017; McCarthy, Levine, and Reed 2013). Cage trapping was found to be the most popular method among both men and women in this study. However, cage-trapping is one of the most labour intensive, ineffective and expensive means of attempting to control feral cats, especially because feral cats tend to be wary of traps and are difficult to catch (Phillips et al. 2005). The least popular option for management among the public was baiting with Eradicat®, even though this method is considered the cheapest and most effective method of all those presented (Algar et al. 2011; Dundas, Adams, and Fleming 2014). For example, eradicating cats from Faure Island Western Australia using Eradicat® only cost about $4/ha (Algar et al. 2010), compared to $500/ha for the San Nicolas Island USA cat eradication with its primary requirement to use cage trapping and impoundment on the mainland (Hanson et al. 2015; Fisher et al. 2015). Participants in our study were provided with information about the effectiveness of the method, as well as the cost and the appropriate stages of management in which to use each method prior to answering questions about the

likelihood of use, which may suggest that men are more flexible and willing to compromise on the use of methods than women depending on the effectiveness of the method itself in removing cats from an area (Zinn and Pierce 2002; Zelezny, Chua, and Aldrich 2000; Larkin and Pines 2003). At the same time, additional studies need to be undertaken on the proportion of men and women directly involved in invasive species management, as well as those involved in land management and the roles they fulfill. This may provide further insight into the involvement and experience of both men and women in addressing feral cats, and how these direct experiences may shape attitudes in the future for each gender.

The relationship between gender and previous knowledge of feral cat control methods as detailed in this study provides evidence that cognitive and experiential differences between genders influence decision-making around feral cats, and that effective communication is essential in gaining social licence for feral cat management (Dougherty, Fulton, and Anderson 2003; Loyd and Miller 2010). People who are familiar with feral cat impacts and particular methods are better able to determine where they stand in accepting or rejecting method use, such as was the case for cage trapping and baiting with Eradicat®. Women seem to require a greater amount of information on both feral cat impacts and management techniques if they are to support a method, whereas men seem to require less information prior to providing support for a method. Information provided by management should be clear and engaging, but also targeted to different groups. Clearly to generate broad community support for the use of a lethal method in the landscape there is a need to explain in depth: how it works; how it will affect individual feral cats; its effectiveness in reducing harm; the environmental and economic losses caused by feral cats; and how it may impact non-target species.

4.5 Conclusion

In addressing the issues around attitudes towards particular methods of feral cat management, especially those considered lethal or dangerous to humans and non-target species, it is important for management agencies to create materials or educational

programs that can be used to inform the general public about the feral cat management approaches taking place in the region. It is important for messages to be tailored for a broad audience but could also be targeted across genders in a way that introduces the facts surrounding impacts of feral cats as well as the feral cat management programs. As women tend to disagree more than men with the use of lethal methods and also consider additional factors to practicality in assessing management methods, messages will need to inform while also emphasizing the consideration and compassion taken towards both people and wildlife that might be affected by the methods. Finally, further detailed studies into gender value differences and how they interact with knowledge to influence attitudes towards removing invasive species using appropriate methods need to be conducted for feral cats and other species that have direct, damaging influences on the environment.

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Chapter 5

The influence of land use and location type on landholder attitudes towards feral cat (*Felis catus*) management in south-eastern Australia

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Principal Author

Name of Principal Author (Candidate)	Brooke Deak	
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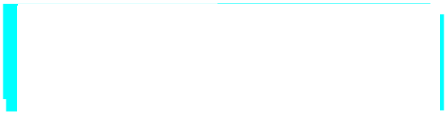
Signature		Date: 11/09/2020

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By signing the Statement of Authorship, each author certifies that:

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iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Bertram Ostendorf	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/9/2020

Name of Co-Author	Douglas Bardsley	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Taggart	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 28/09/2020

Name of Co-Author	David Peacock	
Contribution to the Paper	Conceptualization, methodology, formal analysis, writing – review and editing.	
Signature		Date: 23/09/2020

Abstract

Feral cat management is being undertaken in regions around Australia, including on Kangaroo Island, South Australia and in western Victoria's Grampians National Park and surrounds. Landholder support and participation is essential to the success of feral cat management, and landholders in various locations with particular land use types are affected differently by the presence of feral cats and by the management approach applied to control them. To determine how location and land use influence feral cat management, we used a landholder questionnaire to assess attitudes towards feral cats and levels of acceptance of several feral cat management methods in these locations. We found that respondents from different land use types have different attitudes towards feral cats, and especially the use of particular feral cat management methods. Sheep farmers were found to be the most highly affected by the presence of feral cats and were consistent in their support for the application of all available management methods to control feral cat populations in their regions. Kangaroo Island sheep farmers were more knowledgeable about feral cat impacts and management methods, whereas Grampians sheep farmers were interested in gaining additional information about the topic. The more widespread representation of the hardships that sheep farmers face due to the presence of feral cats could gain more public empathy, raise awareness of the economic impacts that feral cats have on industry, and encourage support for control actions.

5.1 Introduction

The participation of landholders in invasive species management is critical to ensure the efficacy of any landscape scale control program (Glen et al. 2016). Investigating the perceptions and attitudes of landholders towards feral cat management may allow management authorities to understand and address the concerns of potentially affected landholders prior to cat management program implementation (Glen et al. 2016; Niemiec et al. 2016). Attitudes towards invasive species and management methods can vary depending on a number of factors including gender and

location, but may also depend on land use type, as the practicality of certain methods may not be well-suited to all land use types within the area targeted for management (Australian Government Department of the Environment 2015a; Garcia-Llorente et al. 2008). For instance, poison baiting may not be a viable option in areas that experience a high frequency of human traffic, or in areas frequented by working dogs, pets, or vulnerable native wildlife species (Algar et al. 2007; Australian Government Department of the Environment 2015c). Further, a change from one type of land use to another could impact the types of methods that are viable for use on that land, in the process potentially shifting landholder perceptions of management and control methods (Niemiec et al. 2016). For example, in the event that a landholder wanted to clear forested land on their property for intensive agriculture or sheep farming, that landholder may then need to reconsider the types of control methods that they would allow to be used on their land. If the change proved an inconvenience to the landholder, it may also change their willingness to participate in feral cat management programs once the new land use activity is undertaken on their property (Glen et al. 2016; Niemiec et al. 2016).

Landholders with particular land use types are affected differently by different invasive species (Bardsley and Edwards-Jones 2006). For instance, it is likely that sheep farmers may be more heavily impacted by the presence of feral cats (*Felis catus*) on their properties than landowners with other types of farming enterprises or those with urban residences (Natoli et al. 2006; Taggart et al. 2019b). Feral cats can impact the health of livestock due to their ability to transfer diseases to sheep, particularly toxoplasmosis and sarcocystosis (Taggart et al. 2019a; Taggart et al. 2019b). As the primary host, cats can carry *Toxoplasmosa gondii* throughout their life if initially infected with little chance of health consequences to them individually, but the effects of this parasite on sheep can be extreme (Australian Government Department of the Environment 2015c; Recio and Seddon 2013). The disease can be transmitted through physical contact with a cat or its faecal matter and can cause abortion in sheep or weakness in newborn lambs, leading to significant economic losses for sheep farmers (Langham and Charleston 2012; Moon et

al. 2015; Taggart et al. 2020). Sarcocystosis can also impact the health of sheep and cause significant economic loss. If sheep graze on pasture that contains the faeces of a cat that carries *Sarcocystis*, there is a strong chance that the sheep will ingest the parasite's oocysts, which will result in cysts developing in the muscle tissue of the infected sheep, again generating economic losses for the landholder from carcass trimming or rejection at the abattoir (Langham and Charleston 2012; Taggart et al. 2019b).

Although there are studies on the impacts of parasitic diseases on sheep, there is a lack of interdisciplinary research into how, and to what degree, these diseases impact sheep farmers and how significant a role feral cat management plays in improving the situation (Garcia-Llorente et al. 2008; Martinez-Navalon et al. 2012). The financial impact on sheep farmers of diseases spread by feral cats could potentially result in stronger attitudes and support for management from sheep farmers than from other landholder groups (Garcia-Llorente et al. 2008; Martinez-Navalon et al. 2012). At the same time, there may be perception differences within any particular landholder group depending upon location, experience, or knowledge about feral cat impacts and management (Conrad 2010; Moon et al. 2015). Levels of support for feral cat management may also be influenced by the interactions between landholders and government and other management authorities, especially as the information provided to landholders regarding invasive species management may shift perceptions of the species in question, and of the type and quality of the management that takes place (Ramsey 2010; Van de Walle and Bouckaert 2003).

There are rarely general media stories circulated about how feral cats impact landholders, particularly those who may be at higher risk of economic loss such as sheep farmers. In contrast, media attention about feral cats in Australia is largely focused on the significant impacts of feral cats on wildlife and their management (Hollingsworth 2019; Lysaght 2020). Although this information is effective in gaining attention and sparking debate, there is an opportunity to gain further support for feral cat management if the focus of the media shifts to address a human element that is relatable to the

audience, such as how feral cats can impact human health and economic wellbeing (Delgado-Ceballos et al. 2012; Ramsey 2010).

Existing academic investigations of perceptions of invasive species management primarily focus on attitudes of the general public with few addressing the attitudes and perceptions of specific landholders towards different management methods being used on their properties (Niemiec et al. 2016). The general consensus across articles considered about landholder perceptions is that more research is needed in order to better understand collective action and likelihood of landholder participation in management campaigns (Glen et al. 2016; Niemiec et al. 2016; Ramsey 2010). The aims of this study were to determine if land use type influences attitudes towards feral cats and feral cat management among landholders in south-eastern Australia, and to investigate differences that exist between sheep farmers and other landholder groups in relation to feral cat management. It also examined differences in attitudes and perceptions of feral cats between sheep farmers on Kangaroo Island, South Australia and those in the Grampians region of Victoria.

5.1.1 Study areas

This study examined local attitudes towards various feral cat control measures on Kangaroo Island (KI), South Australia and around the Grampians National Park in western Victoria. KI is generally known for its ecotourism and is home to several endemic island wildlife species, such as the KI short-beaked echidna (*Tachyglossus aculeatus multiaculeatus*) and the KI dunnart (*Sminthopsis fuliginosus aitkeni*) (Natural Resource Kangaroo Island 2013). The island also has important sheep-farming and other livestock industries (Authentic Kangaroo Island 2020; Spence 2020). The presence of feral cats on KI greatly threatens the island's native wildlife as well as its sheep farming industry, and as a result planning for a feral cat eradication program was commenced on the island in 2015 (Kangaroo Island Feral Cat Eradication Program 2018; Taggart et al. 2019a).

The Grampians National Park is also well known for its high degree of endemic biodiversity and extensive ecotourism attractions, and for the sheep-farming and livestock industries in the surrounding areas (Parks Victoria 2020). The red fox (*Vulpes vulpes*), an invasive predator long established in this area, poses a significant threat to the region's wildlife and livestock, and as such, is managed across large areas of the national park and surrounding farmland using '1080' poison baiting and predator exclusion fencing (Horner and Platt 1993; Taggart et al. 2015). Feral cats, however, have only recently been declared a feral pest species in Victoria due to their threat to native wildlife and livestock, and as a result, are now being incorporated into pre-existing invasive predator management campaigns (Victoria State Government 2018).

These two locations were chosen partly because of their commonality in regionally critical sheep farming and nature-based tourism, but also to examine the perceptions of landholders during differing stages of feral cat management. Part of that interest links to the fact that the two locations could represent differences in attitudes between an island population and a mainland population. Efforts to control feral cats on KI are more advanced than those in the Grampians region, as the feral cat eradication program was established earlier, with community control efforts going back to the 1990s (Paton 1994; Paton 2003). Differences in the planning and implementation stages of feral cat control programs could provide useful insights into the importance of levels of community awareness of management approaches. By undertaking a comparative study, we sought to develop a better understanding of how location and land use influences landholder willingness to support the development of more effective feral cat management actions.

5.2 Methods

5.2.1 Questionnaire design

To examine the relationships between the land use types of the KI and Grampians communities and their attitudes toward feral cat control, we chose to design an online questionnaire that was then distributed to landholders and other members of the general

public on KI and in and around the Grampians National Park region. An online survey was developed within the program Qualtrics and consisted of several short answer and multiple-choice questions. There were also questions that generated both quantified and qualified answers using Likert scales, and a heat map for participants to select the approximate location of their property as it pertained to the survey. The questionnaire primarily facilitated the collection of quantitative data on perceptions according to a Likert scale rather than just a qualitative assessment of people's thoughts and ideas more typical of focus group assessments or interviews.

Questions were designed to examine participant familiarity with feral cats and associated management methods, as well as investigating the influence that socio-economic and demographic factors have on attitudes towards feral cats and their management. After respondents answered questions relating to their familiarity with different feral cat management methods, the questionnaire then introduced a brief description of each control method (Appendix B). The descriptions of each method were kept short while detailing what was entailed in using each method as well as its cost-effectiveness. The potential risks to non-target species such as native wildlife and also pets were highlighted, so that participants would develop a fuller picture as to the benefits and risks of different methods. The questionnaire was sent to both Grampians Parks Victoria Management and the KI Natural Resource Management Board for initial feedback and was then pre-tested by colleagues in the University of Adelaide Ecology and Evolutionary Biology Department.

The questionnaire was designed to take respondents approximately 15 to 20 minutes to complete. An anonymous link was provided in the mailed-out invitation to participate, and participants were to use this link to access the online platform Qualtrics where the questionnaire was based. Although previous studies have shown that online questionnaires may not be as successful in reaching a full range of landholders as mail-out questionnaires, we decided that mailing out hardcopies of an invitation to the questionnaire would enhance our response rate (Fielke and Bardsley 2014). An

associated hardcopy invitation that required a further level of interaction, involving the person choosing to participate or not, also lowered the risk of participants simply dismissing the survey with the click of a button, as is more probable with an email invitation. Further, to prevent participants taking the questionnaire more than once, a "Prevent Ballot-box Stuffing" option was developed, in which cookies were placed on the participant's browser if they attempted to complete the survey more than once, with a message to say that they had already participated.

Using the Australia Post Unaddressed Mail Service, Participant Information Sheets were sent out to 1,508 addresses on KI and 3,500 post office box addresses in and around the Grampians National Park in western Victoria. A Facebook and Twitter page was also created to promote the questionnaire with the same link that had been included on the Participant Information Sheet, but a different code for entry was created in order to trace back where participants had sourced the information about the questionnaire, whether online or through the mailed-out invitation. A local radio station near the Grampians region (ABC Ballarat) and the local newsletter on Kangaroo Island (The Islander) also provided a means of promoting the questionnaire through brief interviews. Facebook Community groups for the designated localised areas were contacted about potentially promoting the information on their pages, and many agreed. The questionnaire was open from 26th September 2018 to 31st January 2019 in order to allow time for farmers and other landholders to receive the letter or flyer in the mail and to fill out the questionnaire in the case that the season was a busy time for certain farmers or other landholders.

To access the questionnaire on Qualtrics, participants were required to enter a code provided to them on their hardcopy letter of invitation or on the Facebook post to which they were directed, which targeted regional groups on KI and around the Grampians. Participants were then asked whether they were responding for KI or the Grampians region, and their answer determined which version of the questionnaire they could access to complete. Although the two questionnaires were very similar, there were

slight differences according to location. A question had been added to the Grampians version of the survey asking participants whether they believed that feral cats should be managed on private property as well as Crown land because at the time of the announcement about feral cat management in the state it was decided that Victoria would only manage feral cats on Crown land. A region-specific map was provided to participants in both questionnaire versions as a way for them to identify the location of the property for which they had answered the questionnaire.

After the 31st January 2019, results were collected from the online program and analysed in the program R. We had a 5% response rate with a 72% completion rate, receiving back 243 completed questionnaires and 93 partially completed questionnaires. Questionnaires that were only partially completed and did not include information on land use type were removed, leaving about 213 questionnaires available for analysis. The following land use types were observed in the questionnaire: "Grazing land (Sheep)", "Grazing land (Cattle)", "Grazing (other)", "Conservation/Research", "Commercial", "Cropping", "Holiday", "Lifestyle", "Native bushland", "Orchards", "Other farming", "Residential block in a large town", "Residential block in a small town", "Residential rural living", "Viticulture", and "Other". Some participants responded with "Other" but also provided a description for their land use. These descriptions for "Other" were used to filter these land use responses into the best-fit categories for statistical analysis. For instance, some participants mentioned having sheep as well as other animals and so these responses were placed into the "Grazing land (Sheep)" category in order to include all sheep farmers in one category. Others mentioned "Small scale horticulture" or "hobby farming", and so these were placed in the "Other farming" category. To allow for a more comprehensive analysis comparing sheep farmers to other land use types, five distinct categories were created that merged similar land use types into one (Table 1).

Table 1. A breakdown of the land use types provided by participants on Kangaroo Island, South Australia and in the Grampians region of western Victoria who completed a questionnaire that was designed to examine their attitudes towards feral cat management (n=213). Land use type was selected by participants and grouped into five separate categories for analysis.

Land Use Types	Final Category
Grazing land (Sheep)	Sheep Farming
Grazing (Cattle), Grazing (Other), Cropping, Orchards, Other farming, Viticulture	Other Farming
Residential block in a small town, Residential block in a large town	Residential Block
Conservation/Research, Native Bushland	Conservation
Residential rural living, Holiday, Commercial, Lifestyle, Other	Rural Lifestyle

5.3 Results

5.3.1 Overall land use

Of the 213 questionnaires that were analysed, 64 (30%) came from respondents with residential blocks in either small or large towns, 56 (26%) came from respondents with sheep on their land, 32 (15%) were from respondents with various other farming areas, 32 (15%) were from respondents with conservation or native bushland areas, and 29 (14%) were from respondents with rural lifestyle properties. The results of the Kruskal-Wallis tests suggest that there were three significant variables for how participants of the different land use types perceived feral cats and their management (Table 2). Among these differences were the likelihood to adopt a cat as a pet, whether there should be stricter regulations on domestic cats, and whether participants had been financially impacted by the presence of feral cats.

Table 2. A Kruskal-Wallis test was used to determine the influence of land use type on attitudes towards feral cat management by participants in the study. A series of statements regarding feral cats and their management was presented to participants, and they were asked to rate their agreement with each statement using a Likert-type scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). Values in the first five numeric columns indicate means, and values in the last column indicate significance (p) where values < 0.05 are significant. The letters next to the means given for each land use type indicate if there are differences, with like letters meaning no significance and different letters indicating significance.

Question	Sheep Farming	Conservation	Other Farming	Rural Lifestyle	Residential	Kruskal-Wallis P-Value
I would adopt a cat as a pet.	2.2 *a*	2.3 *a*	3.9 *b*	2.2 *a*	3.7 *b*	0.002
There should be stricter regulations on owning domestic cats.	6.2 *a*	6.8 *a*	5.5 *b*	6.6 *a*	5.6 *b*	0.020
My household or business has been financially impacted as a result of feral cat presence in my region.	4.7 *a*	2.8 *b*	2.7 *b*	2.7 *b*	2.8 *b*	<0.001

Although most participants in all land use types strongly disagreed with the idea of adopting a cat as a pet, those with Other Farming or a Residential Block had more polarised views. Of these two land use types, 51% of Residential Block participants said that they would not adopt a cat, whereas 40% agreed strongly that they would. Forty-one percent of Other Farming participants said that they would adopt a cat, as opposed to 41% who said that they would not. Sheep Farming and those with a Rural Lifestyle most strongly disagreed with the idea of adopting a cat, with a mean of 2.2 from a scale of 1 to 7 (Table 2).

Most participants also strongly agreed that there should be stricter regulations on domestic cats. However, a higher percentage of participants in the Residential Block and Other Farming categories either strongly disagreed or were neutral towards this

statement compared to participants with other land use types (Table 2). Those with Conservation land felt the most strongly about stricter regulations being imposed on the ownership of domestic cats with a mean of 6.8 on a scale of 1 to 7, followed by those with a Rural Lifestyle (6.6) and Sheep Farming (6.2). Further, of all participants, sheep farmers suffered the greatest negative financial impact of all land use types due to the presence of feral cats. In fact, participants from all other land use types either strongly disagreed that they had been financially impacted or were neutral.

Attitudes among varying land use types towards using control methods on private property were consistent, with no significant differences in the results of the Kruskal-Wallis test except in the case of shooting ($p > 0.01$). At the same time, those with Conservation land as well as sheep farmers were the most likely participants to use all cat control methods on their property, though baiting was the least popular option. Control methods varied in average responses among participants with different land use types (Table 3), with farming participants who were not sheep farmers seeming the least likely to use the various control methods. Overall, sheep farmers seem to have the most to gain from feral cat control and had strong attitudes against the idea of adopting a cat and in support of imposing stricter regulations on domestic cats. They had also suffered the highest financial impact from feral cats. As a consequence, we examined the demographics of sheep farmers on KI and in the Grampians in greater detail to determine if there were any significant differences based on location.

Table 3. A Kruskal-Wallis test was used to determine the influence of land use type on participant likelihood of using particular cat control methods on private property. Participants were asked to rate the likelihood of using each method using a Likert-type scale ranging from 1 (Highly Unlikely) to 7 (Highly Likely). Values in the first five numeric columns indicate means, and values in the last column indicate significance (p) where values < 0.05 are significant. The letters next to the means given for each land use type indicate if there are differences.

Feral Cat Management Method	Sheep Farming	Conservation	Other Farming	Rural Lifestyle	Residential	Kruskal-Wallis P-Value
Baiting with Eradicat®	4.2 *a*	4.5 *a*	3.6 *a*	3.9 *a*	3.6 *a*	0.411
Baiting with Curiosity®	4.4 *a*	4.3*a*	3.7 *a*	4.0 *a*	3.7 *a*	0.500
Felixer™ Grooming Traps	4.9 *a*	5.4 *a*	3.7 *a*	4.1 *a*	4.1 *a*	0.213
Cage Trapping	6.6 *a*	6.7 *a*	6.2 *a*	6.7 *a*	6.1 *a*	0.213
Padded Leg Hold Trapping	5.0 *a*	5.4 *a*	3.5 *a*	5.0 *a*	4.6 *a*	0.051
Shooting	6.3 *a*	6.1 *ab*	5.7 *b*	4.4 *bc*	4.5 *c*	0.001
Detector Dogs	5.5 *a*	5.7 *a*	4.6 *a*	4.6 *a*	4.9 *a*	0.266
Maremma Dogs	5.0 *a*	4.5 *a*	3.6 *a*	3.7 *a*	4.8 *a*	0.147
Exclusion Fencing	4.5 *a*	4.9 *a*	4.2 *a*	3.3 *a*	4.8 *a*	0.223

5.3.2 Kangaroo Island sheep farmers vs. Grampians sheep farmers

Ages predominantly ranged between 45 and 64 years, with 52% of respondents from KI, and 48% from the Grampians region. Further, of the overall population of sheep farmers who responded to the survey, 54% were female and 43% were male, with 3% identifying as “Other”. A high percentage of sheep farmers in both locations agreed that outdoor domestic cats posed a significant threat to wildlife (Table 4). However, about 14% of sheep farmers on KI strongly disagreed with this statement and another 14% were unsure. In contrast, only 7% of sheep farmers in the Grampians felt unsure, and no participants from this region strongly disagreed with the statement.

Sixty-nine percent of KI sheep farmers strongly agreed that they were familiar with conservation efforts in their region. Thirty-one percent were neutral in their

agreement, and there were no participants who strongly disagreed. In contrast, 48% of Grampians sheep farmers neither strongly agreed nor strongly disagreed that they were familiar with conservation efforts, but instead remained neutral. Only 19% said that they strongly agreed that they were familiar with the conservation efforts in the region, and 33% said that they strongly disagreed. Further, KI sheep farmers were more familiar than those in the Grampians with feral predator management actions taking place in the region, with 59% strongly agreeing with the statement, and 38% unsure and only 3% strongly disagreeing with the statement (Table 4). Forty-eight percent of Grampians sheep farmers indicated they strongly disagreed with the statement, implying that they were not familiar with feral predator management in their region, with 37% unsure, and only 19% strongly agreeing that they were familiar. On this same note, sheep farmers in the Grampians were more likely than those on KI to desire additional information on the potential for reintroducing a native predator species ($p = 0.014$) (Table 4).

Perhaps due to the differences in knowledge around feral predator management, there were also significant differences in levels of confidence in the respective local management authority's ability to control feral cat numbers. Many of the sheep farmers from both KI and the Grampians were unsure or neutral in their levels of confidence in their authority. Sheep farmers from KI felt more confident in management's ability to control feral cats than those from the Grampians. A total of 41% of Grampians sheep farmers felt that they had little to no confidence in the management authority's ability to control feral cat numbers, compared to the 21% of sheep farmers from KI who had little to no confidence.

Table 4. A Mann-Whitney-U test was run to determine the influence of location on attitudes towards feral cats and feral cat management for sheep farmers on Kangaroo Island, South Australia and the Grampians region of Victoria. A series of statements regarding feral cats and their management was presented to participants, and they were asked to rate their agreement with each statement using a Likert-type scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). Values in the first two numeric columns indicate means, and values in the last column indicate significance (p) where values < 0.05 are significant.

Question	Kangaroo Island (n = 29)	The Grampians (n=27)	Grouped Mann-Whitney-U P-Values
Feral cat management would benefit the livestock industry in my region.	6.2	5.4	0.017
I would be interested in learning about the potential for reintroducing native predators into my region to aid in feral cat management.	4.1	5.7	0.014
I am confident in the management authority's ability to control feral cat numbers.	4.2	3.0	0.025
I am familiar with the current feral predator management in my region.	5.6	3.1	< 0.001
I am familiar with conservation efforts in my region.	5.9	3.7	< 0.001
Outdoor domestic cats pose a threat to wildlife.	5.8	6.7	0.046
Feral cats have a negative impact on the livestock industry.	6.3	5.3	0.046
I would be likely to allow the use of exclusion fencing on my property.	5.4	3.6	0.034
I would be likely to allow the use of Maremma dogs on my property.	5.7	4.3	0.034
I would be likely to allow the use of shooting on my property.	6.6	6.0	0.046
I would be likely to allow the use of Felixer® grooming traps on my property.	5.5	4.1	0.034

KI sheep farmers felt more strongly about feral cat impacts on the livestock industry than did Grampians sheep farmers, with 83% of participants strongly agreeing that feral cats negatively impact the industry, 11% felt unsure, and only 7% strongly disagreed with the statement. Of the Grampians sheep farmers, 55% strongly agreed that feral cats impacted the livestock industry, 37% were unsure, and 7% strongly

disagreed. Eighty-three percent of KI sheep farmers felt that feral cat management would benefit the livestock industry in the region, with 14% being unsure, and 3% strongly disagreeing. Fifty-two percent of sheep farmers from the Grampians strongly agreed that feral cat management would benefit the livestock industry in the region, 41% were unsure and 7% strongly disagreed.

Differences in attitudes towards control methods being used on, or around a property, were also evident between locations, especially for exclusion fencing, Felixer™ grooming traps, detector dogs, Maremma dogs and shooting. Most KI sheep farmers (83%) had previously heard of exclusion fencing (Figure 2) and 64% were highly likely to allow the use of this method on their land, while 21% were highly unlikely (Figure 1). For Grampians sheep farmers, 52% had heard of exclusion fencing previously, but only 41% were highly likely to allow the use of it on their land, with the majority (52%) unwilling to use exclusion fencing on their land, and 19% remained unsure.

Felixer™ grooming traps were also contested between the two locations (Figure 1). Most sheep farmer participants (79%) on KI had previously heard of the control method, whereas 21% had not (Figure 2). Seventy-nine percent of KI sheep farmers also said that they would be highly likely to use Felixer™ grooming traps on their land, with 21% being highly unlikely to do so, and 4% remaining unsure. In the Grampians, only 11% of sheep farmers had heard of the control method previously, and 89% had not (Figure 2). The likelihood of sheep farmers using grooming traps in this region was polarised, indicating perhaps that previous knowledge was not a simple decisive factor influencing support for this control method. Forty-one percent said that they would be highly unlikely to use Felixer™ grooming traps on their property, and 37% agreed that they would be highly likely to use them, with 19% unsure.

In all cases, the idea that sheep farmers on KI were more familiar with the different control methods than farmers based in the Grampians suggests that the difference in stages of feral cat management between the two locations may have contributed to attitudes towards management. This is also suggested in the significant difference observed in Grampians sheep farmers who were more unlikely to have heard about feral cat impacts (Table 5) and to request additional information on feral cat management, and those of the KI sheep farmers who felt that they had largely heard of feral cat impacts and were less likely to request additional information ($p = 0.017$).

Table 5. Mann-Whitney-U test was run to determine the influence of location on attitudes towards feral cat management for sheep farmers on Kangaroo Island, South Australia and the Grampians region of Victoria. Yes-or-no questions were asked of participants regarding whether they had previously heard of certain feral cat management methods or impacts of feral cats, where 1 indicated yes and 0 indicated no. The results from the test suggest that there were significant differences between sheep farmers in each location for the questions listed. Values in the first two numeric columns indicate means, and values in the last column indicate significance (p) where values < 0.05 are significant.

Question	Kangaroo Island (n = 29)	The Grampians (n = 27)	Grouped Mann-Whitney-U P-Values
More information on feral cat management requested.	0.8	1.0	0.017
I have previously heard of feral cat impacts.	1.0	0.7	0.006
I have previously heard of exclusion fencing.	0.8	0.5	0.018
I have previously heard of detector dogs.	0.5	0.2	0.006
I have previously heard of Felixer® grooming traps.	0.8	0.1	<0.001

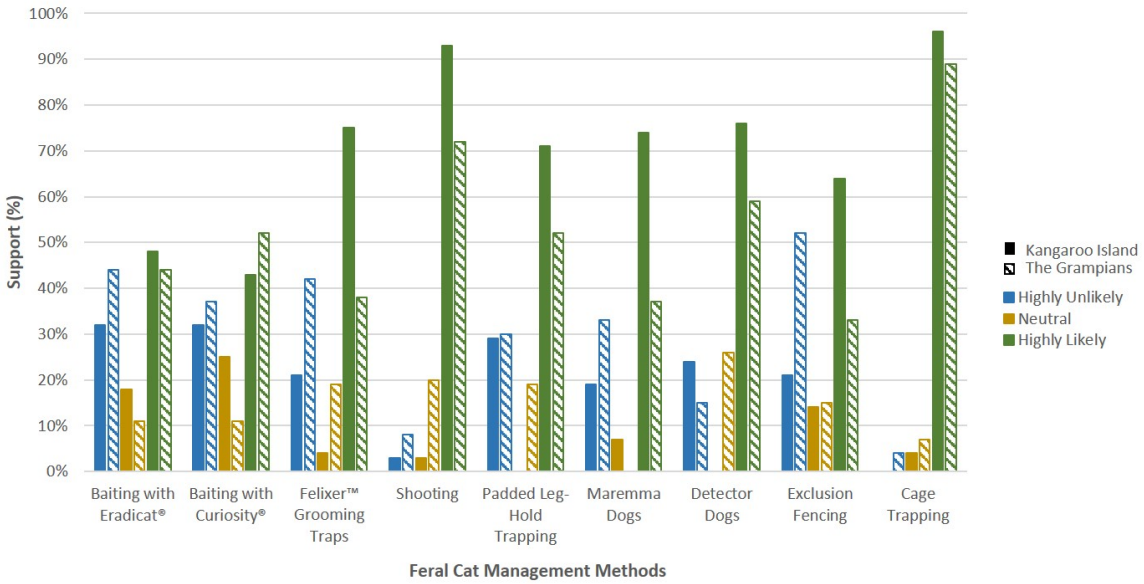

Figure 1. A comparison between the likelihood of sheep farmers on Kangaroo Island, South Australia and in the Grampians region of Victoria using particular feral cat control methods. Each colour on the graph represents a level of likelihood that a participant will use a certain cat control method: 1-2 "Highly Unlikely" (blue), 3-5"Neutral" (gold) or 6-7 "Highly Likely" (green). The total number of participants for each level of likelihood was separated into those from Kangaroo Island (solid bar) and those from the Grampians region (cross hatching).

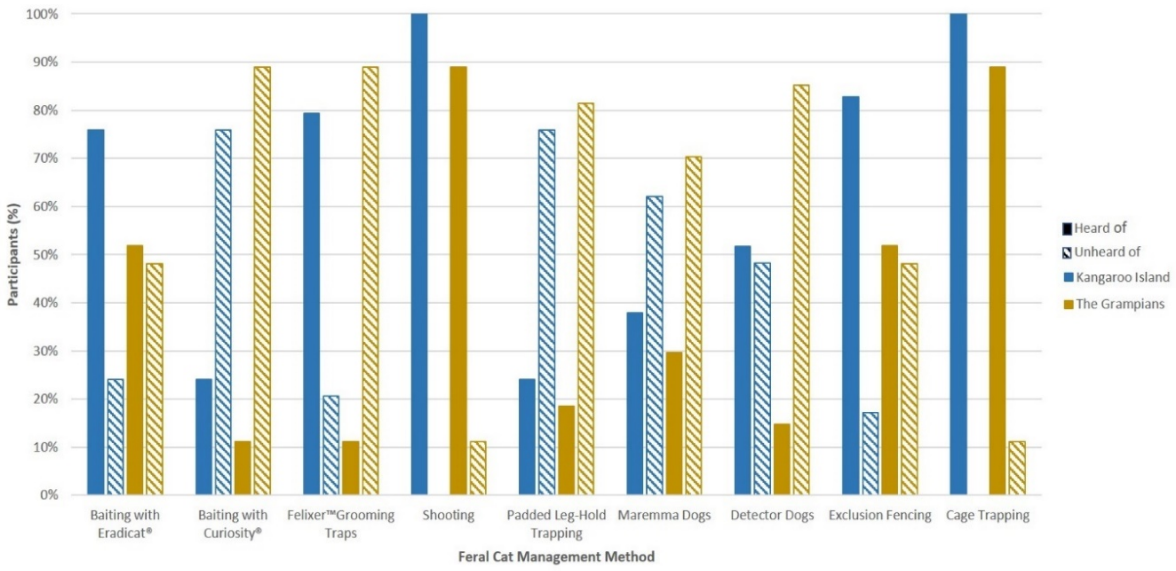

Figure 2. A comparison between sheep farmers on Kangaroo Island, South Australia and in the Grampians region of Victoria who had or had not heard of the control method prior to taking the questionnaire. Both colours on the graph represent a location: Kangaroo Island (blue), and the Grampians region (gold). The total number of participants for each location was separated into those who had heard of the method previously (solid bar) and those who had not (cross hatching).

5.4 Discussion

The results of this study suggest that land use type has a strong influence over landholder perceptions and attitudes towards cats. Those respondents with residential blocks or involved in farming activities outside of sheep farming were more likely to adopt a cat as a pet and were also more in favour of not having stricter regulations on domestic cats than landholders of other land use types. That result further suggests that participants with other land use types, such as sheep farmers, those with conservation blocks or those with rural lifestyle properties may be more aware of the ecological impacts of feral cats (Conrad 2010). Participants with properties in residential areas do not believe as strongly that domestically owned cats themselves pose a threat to wildlife, and this may be because they have not seen or experienced the impacts of feral cats on wildlife. There were no significant differences in how landholders with different land use types viewed the potential use of management methods, except for shooting, and this may be due to the type of property that the participant owned (Conrad 2010; Glen et al. 2016). This implies that although land use type may influence how people perceive feral cat impacts, it may not be the most significant factor in determining what types of feral cat management methods would likely be used on private property.

There was strong evidence of land use influencing respondents' perceptions of the financial impacts of feral cats, with sheep farmers experiencing the most significant financial impacts from feral cats compared to other land users (Martinez-Navalon et al. 2012). Sheep farmers were also the most likely participants of all land use types to use all feral cat management methods on their land, and from this it can be assumed that the financial impact imposed on sheep farmers strengthens their willingness to experiment with different approaches to try and determine the most safe and effective means of management (Gong et al. 2009; Martinez-Navalon et al. 2012). These findings provide further support for the idea that landholders with different land use types are affected differently by the presence of feral cats, and that sheep farmers in particular suffer more

from feral cat impacts than those of other land use types (Gong et al. 2009; Taggart et al. 2019b).

It became clear that although sheep farmers in general had strong opinions about feral cat management, sheep farmers from the two locations in the study held slight differences in attitudes. It is expected that sheep farmers on KI would likely be more familiar with the impacts of feral cats and the different control methods due to the formal application of the regional Feral Cat Eradication Program. A comparative cat control program is yet to be established in the Grampians region of Victoria (Australian Government Department of the Environment 2015c; Kangaroo Island Feral Cat Eradication Program 2018). Sheep farmers in the Grampians region were more eager to gain additional information on feral cats and their management, and were also more interested in learning about native predators that could potentially be reintroduced into the environment as a way to help regulate feral cat abundance (Victoria State Government 2018). For instance, the Tasmanian devil (*Sarcophilus harrisii*) has been shown to compete with feral cats for prey and carcasses and influence their behaviour, and could serve as a radical option for reintroduction into areas such as the Grampians or Kangaroo Island to aid in feral cat management (Hunter et al. 2015; Thalmann et al. 2016). Sheep farmers on KI were less likely to request additional information, probably due to the large amount of information they had received previously from management authorities about the impacts of feral cats and management methods in their region (Natural Resource Kangaroo Island 2013).

In the Grampians area, sheep farmers were also less certain about the threat feral cats posed to the livestock industry than the sheep farmers on KI, and this could be due to both the current stage of feral cat management in the state, where information regarding feral cat impacts has not yet been widely disseminated, and the likely much lower incidence of toxoplasmosis and sarcocystosis (Taggart et al. 2020; Taggart et al. 2019b). Also, recent research has shown that there is much greater abundance of feral cats and incidence of toxoplasmosis and sarcocystosis on KI than on the neighbouring

South Australian mainland (Taggart et al. 2019a; Taggart et al. 2019b), and the disproportionate regional impacts of the diseases may be influencing KI sheep farmer attitudes of the direct threat that feral cats pose to their livestock industry.

Results also suggest that people who have been made aware of the feral predator management and conservation efforts in their localised area are more likely to feel confident in their regional management authority's ability to control predator numbers (Holmes et al. 2015; Van de Walle and Bouckaert 2003). Sheep farmers on KI were more likely to feel confident in their management authority's ability to control cat numbers than sheep farmers in the Grampians, and this is likely due to the amount of information provided to sheep farmers in each location (Kangaroo Island Feral Cat Eradication Program 2018; Natural Resource Kangaroo Island 2013). Landholders are more likely to trust government if they have been properly informed of the actions taking place, and that trust can then produce a stronger sense of support for management, especially if the information is provided on a face-to-face basis as opposed to in an email (Ramsey 2010; Van de Walle and Bouckaert 2003). As time progresses and to garner additional support for interventions, management authorities in the Grampians region may see value in focusing on further educating communities about the impacts of feral cats and their options for management (Holmes et al. 2015; Howard et al. 2018).

This study also suggests that the presence of feral cats has a significant influence on the wellbeing of sheep farmers, and that this is an issue that needs to be addressed on a wider scale due to the considerable regional economic, social and welfare implications (Langham and Charleston 2012; Martinez-Navalon et al. 2012). There is a clear opportunity for the media to present a stronger case for feral cat management to the public by focusing on the human aspects of the issue, and the hardship faced by sheep farmers due to the presence of feral cats (Fukano and Soga 2019; Martinez-Navalon et al. 2012). Further research into the tangible costs associated with the loss of, and impacts on, livestock in Australia due to toxoplasmosis and sarcocystosis as spread by feral cats, should be considered (Martinez-Navalon et al. 2012). Providing this information to the

public may illicit a sense of empathy for the wellbeing of sheep, sheep farmers and other people living in rural locations and may strengthen support for effective feral cat management (Hwong et al. 2017; Loyd and Miller 2010a). It may also aid in connecting the public, including those stakeholders from different land use types, to the problems generated by feral cats in a direct and relatable way, which in turn, could shift perceptions of feral cats to generate further support for management (Conrad 2010).

Not all key stakeholder groups have an equal influence over decisions regarding the management of invasive species. In the regions studied, sheep farmers may have a larger influence on feral cat policy than other landholder groups, based on the direct economic impacts they experience and the associated pressure that places on government to fix the problem (Stokes et al. 2006; Taggart et al. 2019b). Likewise, inland fisheries in Australia may make a greater contribution to decision-making around carp management than other groups because they are more directly affected, while conservation groups in northern Australia may have more to say regarding cane toad invasions due to the scientific evidence available of the threat they pose to their regional wildlife (Alleyway et al. 2016; Southwell et al. 2017). The disproportionate pressure these groups place on government may cause other groups to feel that they are marginalised from the decision-making processes, which may lead to additional friction when it comes to public debate around management (Hummel 2011; Stokes et al. 2006). It may also undermine the less influential stakeholders' trust in government, which in turn could influence participation and support for the management of other environmental issues if people feel their views are not being incorporated into deliberations (Frewer 1999; Liu and Cook 2016). Even if there is an urgent need to address the concerns of particular stakeholders who are being highly impacted by feral cats, there is also a need to ensure that the positions of other stakeholder groups have been integrated into the decision-making process so as not to alienate them or marginalise them from future actions.

5.5 Conclusion

While land use type may be useful in determining the likelihood of people adopting or owning a cat, it is not entirely useful in determining the types of methods that could potentially be used on private property. At the same time, the financial impacts and direct experiences with feral cats of landholders with different land use types could encourage strong additional support for feral cat management, especially among sheep farming and livestock communities. If an increase in information about the impacts of feral cats on humans and livestock were presented to the public alongside the ecological impacts, it may yield increased support for feral cat management and encourage community engagement among stakeholders within each region. Reporting on the hardship that sheep farmers face due to the presence of feral cats could present an opportunity to gain empathy from the public, bring awareness of the welfare and economic impacts that feral cats have on the sheep industry, and encourage the need for action. Further, it is important to acknowledge the level of familiarity landholders may have with feral cats and their management, and to continue to provide information and gauge perceptions as needed to garner ongoing support. To encourage people to engage actively with control programs when they occur, management authorities should aim to ensure that their communities are well-informed of any impacts or management actions that may occur.

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Chapter 6

Discussion

6.1 Overview

Feral cat management is undertaken worldwide, but the urgency with which it is met is different depending on the country, its socio-ecological context, and the groups of individuals that are invested in the issue. This can greatly impact the implementation and success of feral cat management campaigns, as a lack of urgency can lead to a lack of government intervention and support for management, such as is the case within the USA, Canada, and the UK. These countries instead depend on individuals and animal welfare groups to manage feral cat populations, which is often not a successful solution due to limited resources and lack of funding (Pets4Homes 2020). There is also concern around the fact that these groups prefer the use of non-lethal methods for feral cat control, such as trap-neuter-release (TNR), as opposed to lethal methods that may be more practical in quickly depleting the populations and effective for open populations (Freberg 2019; Hatley 2003). Further, because these invested groups are the ones predominantly sharing information about the welfare and impacts of feral cats and the options for feral cat management in these areas, the surrounding public may have a skewed idea about how deleterious feral cats can be to humans, wildlife, and also to livestock industries. They may also not be aware of options other than TNR for managing feral cats. For these reasons, the feral cat populations within these countries can face issues of either incredibly slow decline, stagnation, or even population increase if cats are not found quickly enough to neuter or spay prior to having another litter, and hence this is not an option for countries where the threat of feral cat impacts is heavily felt.

Instead, feral cat management in countries such as Australia and New Zealand is considered a highly urgent matter across all levels of government, mainly due to the severe threat that feral cats pose to native wildlife species, as well as the negative impacts they impose on humans and livestock. A combination of lethal as well as non-lethal methods is considered the best approach to management, with government funding and resources as well as strong public support being essential to success (Australian Government Department of the Environment 2015a). The leading authorities on feral cat

management including the scientists and management officials play a significant role in communicating and interacting with the public about the different aspects of feral cat management, and this aids in gaining support for management campaigns (Freberg 2019). However, some particular management methods that have been proposed for feral cat management in certain regions of Australia are not incredibly well-known to the public, and this provides opportunity to certain groups and individuals to make claims against these methods that might negate support for management.

The following findings from the study suggest that approaching the public regarding feral cat management must be taken into consideration in a regional context, and that different demographic factors such as gender, land use and location, should be taken into account when discussing management options. It is important to ensure that the community within any locality of planned feral cat management are aware of the scientific facts around the methods being proposed for use, and that these individuals are able to make educated decisions on the methods that they would be willing to allow the use of in their regional areas. Management campaigns should carefully consider all possible cat management methods and select those that suit both the ecological and social requirements of the specific regional localities.

6.2 Key findings

There is no well-grounded universal definition of a feral cat.

The literature review portion of this thesis (chapter 2) concludes that there is no consensus about how a feral cat should be defined. Definition is dependent on how people within a country interact with the feral cats in their area, as well as their proximity to them, and the need for management based on the amount of perceived threat that the cats pose to wildlife, humans, and livestock. In countries such as the USA, Canada, and parts of Europe, the general perceived threat of feral cats is not very high, and the difference between a feral cat and a stray cat or an outdoor domestic cat is barely

recognised (Natoli et al. 1999; Pets4Homes 2020). Definition changes by state and by city and is often synonymous with the definition of an outdoor domestic or stray cat, making cat management more of an all-inclusive task that seemingly does not require heavy government intervention to control populations (Farnworth et al. 2011; Natoli 2014). Instead, government regulation focuses on the act of outdoor cat ownership, and regulations in this regard tend to be vague and to depend on the regional definition of each category of cat. Therefore, feral cat management in these countries can be considered lax as a result of a generally low level of perceived threat, causing flexible definitions of a feral cat that cannot be used to plan a nationwide approach to feral cat management.

In Australia, feral cats are acknowledged as their own category of cat apart from stray cats or outdoor domestic cats. Reasons for this include the fact that Australia's natural environment did not evolve with the presence of native felids, and so the direct presence of cats as an exotic species in the landscape has created devastating impacts on local ecosystems across the country (Australian Government Department of the Environment 2015b; Recio and Seddon 2013). As a result, feral cats are now considered a primary threat to the environmental wellbeing of the country and are strongly defined, leading to more feasible approaches to management (Australian Government Department of the Environment and Energy 2019). According to the Australian Government's Department of Agriculture, Water and Environment, a feral cat is one who is born or breeds in the wild, lives away from human habitation, and does not rely on humans for food or shelter (Australian Government Department of Agriculture 2020). As well as being avid hunters, feral cats can carry infectious diseases and pose a considerable threat to native populations of small birds and mammals, people, and livestock (Australian Government Department of the Environment 2015b). Though each state may approach feral cat management differently according to what best suits their landscapes, the definition of a feral cat and the urgency felt to remove the animal from the area remains generally the same.

The social aspects that influence public attitudes around feral cats, and the levels of perceived threat felt in different countries based on factors including interactions with these cats, warrant closer observation as they directly impact the management of feral cats worldwide. The lack of a universal definition provides the opportunity for the other key findings to establish why varying definitions exist based on cultural perceptions and narratives, and how this can be addressed for feral cat management in the future.

Public attitudes around feral cat management as presented on social media differ by country and are thought to be influenced by the narrative associated with that country, which is contributed to greatly by predominant groups.

In examining the Twitter discourse around feral cats in Chapter 3, it was clear that the differences in definition as found in the literature review seemed to permeate the social media narrative, and that the dialogue around feral cat management differed greatly by country and by group depending on how feral cats were defined and perceived. The groups that predominantly shared information on Twitter about feral cats from countries such as the USA, Canada and the UK between the years of 2015 and 2019 consisted of animal welfare organisations and individuals who were unaffiliated with any other group, and who proclaimed themselves to be animal lovers. These groups contributed greatly to the narrative around feral cats by sharing sentimental stories and using emotive words that would evoke an emotional reaction from the interested parties who were reading the posts (Freberg 2019). Due to the lack of scientific information being adequately shared about the impacts of these animals, especially within the USA, the individuals reading these posts could easily underestimate the danger that feral cats pose to humans, native wildlife, and livestock and instead be led to believe that their management is non-essential, or that TNR is a sufficient enough management method to control cat populations.

At the same time, though these groups may have dominated the Twitter discourse around feral cats in their respective countries, their influence did not seem to extend to other countries even in an online environment where information can be shared around the globe. The groups that greatly influenced the Twitter discourse on feral cats in Australia, for instance, were government organisations and scientists, as well as individuals who were not formally affiliated with any other group and did not proclaim themselves animal lovers. Feral cats were addressed by these groups as an exotic pest, and information was presented as factual with little to no emotive language used. Though they are the same species as domestic cats that are kept as pets, feral cats are often addressed as a separate animal altogether, likely for management purposes.

There were distinctive differences in the ways in which each different country presented information around feral cats, and how the dominant groups within these countries intended to approach the public regarding management. Along with the differing definitions of a feral cat depending on region, this suggests that feral cat management be addressed at a national or regional level (Gosling et al. 2013). The observed lack of governmental or scientific authority presented in the USA's Twitter narrative around feral cats further reiterates the lack of interest or urgency around cat management in that country. This seemed to create an opportunity for other groups that are invested in the issue to share information around the topic that may not be scientifically accurate and may damage any attempt at appropriate feral cat management procedures taking place in the future. On the other hand, the strong evidence of governmental and scientific support for feral cat management in Australia, and the sharing of factual information about feral cats with the public in this country, suggests that the issue is taken seriously and requires public awareness and support to address the problem efficiently (Australian Government Department of the Environment 2015b; Denny 2010).

Different priorities and level of urgency within these countries may rely on the evolutionary history of each and how resilient the landscapes are to the presence of feral

cats, but it may also rely on the values associated with each culture. For instance, Australians may value their natural environment more than Americans value theirs, in which case the threat of the feral cat presents more of a drive for management in Australia than it ever would in the USA, even if the USA faced a similar amount of threat (Eom et al. 2016; Litina et al. 2016). The same would apply to other countries in relation to their environmental values, likely reflective of the extent of urbanisation and loss of the natural environment, which further supports idea that there cannot be an international approach to managing feral cats, and that feral cat management needs to be approached on a regional scale.

Regional public attitudes around feral cats are similar, but there are differences in attitudes about feral cat management depending on demographic features as well as an individual's familiarity with feral cats and feral cat management.

Later chapters 4 and 5 focused on addressing regional attitudes around feral cats and management in south-eastern states of Australia, and though it was found that there was a general consensus among participants in the study areas that feral cats did need to be controlled and eradicated wherever possible, there were noticeable differences in how this should be approached, which depended on a person's gender, land use type, and familiarity with feral cat management methods.

The studies conducted on Kangaroo Island in South Australia and the Grampians National Park region of western Victoria first found that gender was a prominent factor in how people responded to lethal versus non-lethal feral cat management methods. This study supported previous research suggesting that women were more cautious in taking environmental risks than men, and that they were more hesitant than men to accept the use of methods that they were not previously familiar with (Barton Laws et al. 2015; Larkin and Pines 2003). Theory suggests that reasons for avoiding environmental risks

include the idea that women identify with nature through being oppressed by men, just as nature is oppressed by industrial innovations (Wehrmeyer and McNeil 2000). Other theories suggest that women are taught a compassionate nature through culture, and that this is why they are adverse to harming the environment, where men are taught a more independent and domineering nature through culture, leaving them less concerned about environmental consequences (Fish et al. 2010; Zinn and Pierce 2002). Women both on Kangaroo Island and in the Grampians region were more likely to support the use of non-lethal methods such as cage trapping than the use of lethal methods such as baiting with poison, due to the alleged cruel nature of the lethal methods and the potential impacts that they may have on non-target species. This strongly supports previous theory of risk-aversion (Fish et al. 2010; Larkin and Pines 2003) while also suggesting that women may have been more concerned with the welfare of the feral cats than they were about the potential consequences to native wildlife if the cats were not removed using more efficient methods including those involving poison (chapter 4).

On the other hand, men were more likely to support the use of all methods including those that involved the use of poison, suggesting that they may be more concerned with the efficiency of the management methods than women, and that they may also have been less concerned than women with the consequences that the methods may have on non-target species. It was also clear that men who were not familiar with a feral cat management method were still likely to allow its use, whereas women were highly unlikely to allow its use if they were not familiar with it (Dougherty et al. 2003; Zinn and Pierce 2002).

Further it was discovered that there were differences in previous knowledge depending on location. Overall, participants in the Grampians region were less familiar with the methods suggested than participants on Kangaroo Island and were also more likely to request additional information on the feral cat management methods that were being planned for use in the area. This suggests that gender alone is not enough on which to base an individual's response to management methods, but that previous knowledge

also plays a significant role and should be taken into consideration by management authorities planning to approach the public regarding support for management.

Chapter 5 highlights the further demographic findings of land use as a significant factor in public acceptance towards the use of various feral cat management methods on private property. Though there were differences between participants with several types of land use, those that were highly impacted by the presence of feral cats were the participants who were most likely to allow the use of all cat management methods on their property. Of all of the land use types presented, sheep farmers were found to be the only group who were significantly impacted financially by the presence of feral cats due to the diseases transmitted from cats to sheep that resulted in impacts on livestock production (Spence 2020). Slight differences in attitudes towards feral cat management between sheep farmers on Kangaroo Island and those in the Grampians region were thought to be the result of the differences in familiarity with the feral cat issue, as well as differences in evidence of feral cat impact. On Kangaroo Island as a small island community with limited area, impacts of feral cats on sheep proved more noticeable than in the Grampians where farms are more spread out and feral cats have additional area to roam. Also, sheep farmers on Kangaroo Island would have been engaged at least three years earlier in 2015 regarding feral cat management than those in the Grampians National Park region because of the differences in timelines for planning each region's management program, leading to a better sense of familiarity with the feral cat management issue for those on Kangaroo Island. Further, the dynamic of the communities in each region may have led to more widespread discussion about the impact of feral cats among those on Kangaroo Island than those in the Grampians, creating an additional dimension of potential research into the dynamics of an island community versus a mainland community in relation to invasive species management.

6.3 Significance and broader implications

Throughout the process of my PhD, people have consistently asked "what's the answer to the feral cat issue?" Unfortunately, as this thesis shows, the issue is not black and white, and there is no single answer that can be used to fix the problem. Without local public support, feral cat management in any specified location is likely to fail, but in order to gain that support, many factors need to be taken into consideration. For instance, each country examined in this thesis holds its own views on feral cats and how to appropriately approach feral cat management, and this can be at least partly attributed to the cultural values of that country, and the environmental values held by that culture. It can also be attributed to the beliefs of the individuals within the country itself, which are influenced by the media and the sense of urgency for the topic that is expressed through media sources. The USA and Australia were two countries with incredibly different attitudes towards and approaches for feral cat management, and at the same time highlight the requirements for what would need to happen to adequately approach feral cat management.

In reviewing differences between the USA and other countries, it is clear that an immense effort would be required to readdress the feral cat issue to significantly reduce feral cat populations within the USA. The current state of feral cat management, the resources available and the attitudes towards management from both high levels of government and the public on a national level, is not enough to adequately reduce feral cat numbers or to have an impact on lessening the threat they pose to humans and wildlife. However, if it were treated as a high priority by local governments, there is a chance that feral cat management in certain localities throughout the country could begin to reduce cat numbers down to manageable populations to where TNR might be effective in the long run. This would require examining the issue from a scientific perspective and confirming a stronger definition of what a feral cat is compared to other categories of cat. It would also require disseminating information to local communities about the direct effects that feral cats and feral cat colonies might be having on the local

wildlife and ecosystems, and the consequences to human and pet health. Further, the long-running discourse around feral cats that assumes that they are defenceless and in need of human intervention would need to be addressed fully, as this would have continually influenced the beliefs of individuals and their attitudes towards feral cats over the previous years. Feral cat management methods other than TNR would need to be proposed and introduced to the public, and education and awareness programs would need to be set up on the community level for the public to engage and aid in the decision-making around these additional methods being used. Unfortunately, with current environmental values and outlooks, acknowledging the feral cat issue as a high priority for any level of government in the USA may not occur until a significant amount of damage has already been done as a result of feral cat presence.

Australia, which views feral cat management with a greater sense of urgency than other countries noted in this thesis (with the exception of New Zealand), is in a situation where it has a firm national stance on the issue, as well as a firm national definition of a feral cat, and can concentrate on planning and implementing management in its different states. With governmental organisations and scientists effectively disseminating factual information on feral cats on social media and moving forward to propose management methods, the focus falls to local community engagement to gain public support. As discussed previously, cultural values and environmental values contribute to attitudes around feral cats and their management. This extends to community culture, and subcultures within each community as well. For instance, Kangaroo Island and the Grampians region each hold their own separate cultures. Kangaroo Island is relatively compact in area and there is a strong sense of community culture on the island that is different from that of mainland communities. There are also different subcultures within each community, depending on occupation, beliefs and demographics. For this reason, while most Australians in both regions suggested that they would be in favour of controlling and eradicating feral cats wherever possible, there were different opinions regarding how to approach management. Sheep farmers that

participated in the study from both regions, for instance, have certain cultural and environmental values that may differ to those with plots of land that are dedicated solely to conservation, or to those with residential properties who may not consider the state of the environment as closely. Sheep farmers may have also been more familiar with the feral cat impacts than others, and this would have influenced their views on a cultural level. This is one example of the many different subcultures that need to be addressed attentively in management. Further, there is the way in which communication occurs that needs to be considered for different demographics and subcultures. Farmers who work long hours and shift jobs depending on seasons may not have the time, knowledge or interest to engage online with other stakeholders as often as those in other occupations. At the same time, others who live out in the countryside and have no or limited access to the internet may also be less able to engage in online discussions and may require other means of engagement such as community forums.

Therefore, while Australia as a country is in a good position to approach feral cat management, it is important to regard management in each regional setting and to acknowledge the different subcultures of stakeholders involved in the decision-making processes. Between the several lethal and non-lethal method options for use in management campaigns within in this country, there will likely never be an approach that everyone in the community will agree on. However, taking differences in demographics, as well as cultural and subcultural views and beliefs into account, and educating based on associated familiarity presents an opportunity for being a step closer to amiable discussion and compromise on the management methods proposed for use.

Other implications of this research include the need for an overall better approach to communicating about environmental issues such as invasive species. Though culture and locality seem to dictate public opinion and governmental regulation on such topics as well as the urgency with which they are met, the ways in which these topics are discussed, by whom, and how the information is shared through various platforms contribute to the overall perceptions of the issues themselves by different

groups, including the public and invested stakeholders. By examining the discourse around certain environmental issues such as feral cats in further depth, we are able to better determine the factors that influence the flow of communication and how this communication then shapes the perceptions of each group regarding the topic, prior to these perceptions influencing management. With this in mind, we may be able to develop a more efficient means of communication that will help to inform and engage all parties equally, which could result in individuals better understanding the topic, and scientists and government better understanding public perceptions.

6.4 Future research and general recommendations

Further research into the interactions between the public, government authorities, scientists and other stakeholders would benefit feral cat management in local and regional areas. A comparison between the actual threat of feral cats versus the perceived threat as influenced by different groups would provide insight into the amount of influence that different groups have on public opinion in different regions and may allow an opportunity to address any misinformation or disinformation that circulates through communities.

There is additional opportunity to investigate the inner workings of management and associated communication processes to determine how different management departments view the success of their campaigns and their interaction with the public, and to compare these beliefs with the views of the public. This could provide insight into the amount of information that is disseminated to the public by these departments, the method used for dissemination, and how soon after receiving the information that it is shared with the public and other stakeholders. It could then be compared to the beliefs that the public have about government dissemination and their trust in the information provided by the different departments. Further, investigating in detail the levels of trust between the public and government versus other stakeholders would allow opportunity to link to the research on information provided by the government at various times.

Also, it would be beneficial to examine legislation around different management methods in various countries to determine why a certain method may be accepted for use in some countries while it is banned in others, such as in the case of certain poisons. An opportunity to establish differences in social license around various methods by country may aid in determining what demographic or cultural values appear to influence the acceptability of different methods, and how these values compare internationally in relation to invasive species and feral predator management. For instance, investigating intercultural differences by country in the acceptability of various feral cat management methods based on gender, age, location and also land use type may provide additional insight into the reasoning behind the use of certain methods in those countries as opposed to others.

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Appendix A

The list below includes the words that were added to the hash_sentiment_huliu lexicon key in sentiment for Chapter 3, and the sentiment score next to each word indicates if the word has been given a negative connotation (-1), a neutral connotation (0), or a positive connotation (1) in relation to feral cats.

Word Added	**Sentiment**
Abuse	-1
Adopt	1
Adopting	1
Adoption	1
Alley	1
Awareness	1
Aww	1
Awww	1
Baits	-1
Biodiversity	-1
Birds	-1
Breed	-1
Breeding	-1
Care	1
Caregiver	1
Caretaker	1
Caring	1
Clinic	1
Clinics	1
Colonies	1
Colony	1
Communitycats	1
Control	-1
Controlled	-1
Controlling	-1

Cull	-1
Culled	-1
Culling	-1
Desex	1
Donate	1
Donating	1
Donations	1
Ecology	-1
Endangered	-1
Euthanise	-1
Euthanize	-1
Extinction	-1
Feed	1
Feeding	1
Feralcommunity	1
Foster	1
Fund	1
Funds	1
Humane	1
Hunt	-1
Impact	-1
Impacts	-1
Inside	1
Invasive	-1
Kill	-1
Kitties	1

Kitty	1
Manage	0
Managed	0
Management	0
Managing	0
Native	-1
Network	1
Neuter	1
Neutered	1
Nokill	1
Outdoor	-1
Outside	-1
Panther	-1
Pest	-1
Pests	-1
Pet	1
Predator	-1
Predators	-1
Raise	1
Remove	-1
Rescue	1
Rescuers	1
Rescuing	1

RSPCA	1
Sarcocystis	-1
Semiferal	-1
Shelter	1
Shelters	1
Spay	1
Spayed	1
Spayneuter	1
Sterilize	1
Stomach	-1
Stomachs	-1
Streets	-1
Tame	1
Taming	1
TNR	1
Toxoplasmosis	-1
Trap	-1
Trapneuterrelease	1
Trapneuterreturn	1
Volunteers	1
Welfare	1
Wildlife	-1

Appendix B

This Appendix presents the questionnaire used in Chapters 4 and 5 for Kangaroo Island (KI). The questionnaire for the Grampians region was similar but included one additional question about feral cats being managed on private land as well as Crown land, along with a map of the Grampians region rather than of KI.

PARTICIPANT INFORMATION SHEET

PROJECT TITLE: The Significance of Public Relations in Planning and Implementing Successful Strategies for Feral Predator and Feral Cat Management
HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H-2018-159
PRINCIPAL INVESTIGATOR: Dr. Bertram Ostendorf
STUDENT RESEARCHER: Brooke Patricia Deak
STUDENT'S DEGREE: Ph.D in Sciences

Dear Resident,

There have been recent changes in invasive species management in Australia, with feral cat management becoming a high priority throughout most of the country. Continuing debate around feral cats and the methods used to manage their numbers has sparked a serious interest in what you and your fellow community members on Kangaroo Island and in the Grampians region think about the topic. We're looking to gather a sense of how you feel about feral cats as a species, and what management techniques (if any) you feel would be acceptable to use on in your local region, and possibly even in your own backyard.

What is the project about?
The aim of this project will be to determine how the public feels about feral predator and feral cat management, and also to inform about the different techniques that may be used in such a way that you will be able to make educated decisions about whether or not they would be acceptable for use in your region, or on your land. This information can then later be used to inform management authorities about what techniques are deemed acceptable by the public.

An anonymous questionnaire has been prepared for you and other landholders or members of general public in areas throughout Kangaroo Island and the Grampians to gather a sense of how individuals and local communities feel about feral cats as a species, and how they view current and potential future management. Within this questionnaire, you will be informed about different management techniques that are commonly used in feral cat management will then be asked to indicate how likely you would be to allow use of these techniques in your region and on your land. You will also be asked to rate your approval of current management conducted in their area, and what sources you feel are most trustworthy when receiving information about feral cats and feral cat management.

Who is undertaking the project?
This project is being conducted by Brooke Deak, and will form the basis for the degree of Ph.D in Sciences at the University of Adelaide under the supervision of Dr. Bertram Ostendorf, Dr. David Taggart, Dr. Douglas Bardsley and Dr. David Peacock.

Why am I being invited to participate?
You are being invited to participate in this research because you either own, rent or manage property on Kangaroo Island or in the Grampians region, where feral cat management is either currently taking place, or is soon to take place.

What am I being invited to do?
You are being invited to participate in an online questionnaire about feral cats and feral cat management.

How much time will my involvement in the project take?
The questionnaire should take between 15 – 20 minutes to complete.

Are there any risks associated with participating in this project?
There is a risk of inconvenience in taking time to participate in the questionnaire. Participants should also be aware that the content of the questionnaire may be upsetting to some, as it details several strategies that are commonly used to remove feral cats from the landscape.

What are the potential benefits of the research project?
The benefits of this project include the opportunity for individuals within the community to engage in the management of feral cats by providing feedback on the management techniques that may be used in the future, which will aid in informing management authorities on what is deemed acceptable by the public in each location. Other benefits include the opportunity to express views around current and future management, and to potentially improve the communication between the management authorities and the public.

Can I withdraw from the project?
Participation in this project is completely voluntary, and completion and submission of questionnaire will indicate consent. Due to the anonymous nature of the study, it may not be possible to withdraw you from the study once the questionnaire has been submitted.

What will happen to my information?
Your information will be private, and no personal identifiers will be used when reporting results. The information provided will be transcribed into electronic files that will be password protected. Any notes or hardcopies of information will be stored in a secure location in a locked storage filing cabinet for the duration of the study, and will remain in a secure location within the university for at least seven years.

Once complete, the results of the study will be submitted for publication, and will be used to complete a Ph.D thesis. They may also be presented in conference papers or presentations. No participants will be identified in any publications or conference papers or presentations.

A summary of the findings will be created, and if you wish to receive feedback on the project, you are welcome to contact the research team or to indicate your interest on the separate sign-up sheet included with the questionnaire.

Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.

Who do I contact if I have questions about the project?
Primary Contact:
Dr. Bertram Ostendorf
Email: Bertram.ostendorf@adelaide.edu.au
Phone: (08) 8313 7317

Ph.D Student Researcher:
Brooke Deak
Email: Brooke.deak@adelaide.edu.au
Phone: (08) 8313 2792

What if I have a complaint or any concerns?
The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2018-159). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research (2007). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:
Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000
Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If I want to participate, what do I do?
If you wish to participate in this study, please continue on and complete the questionnaire attached, and then send it back using the self-addressed envelope that has been included.

Your feedback may aid in improving the future of feral cat management within your community, and across the country. We appreciate your time and look forward to receiving your response!

Yours sincerely,
Dr. Bertram Ostendorf
Ms. Brooke Deak
Dr. David Taggart
Dr. Douglas Bardsley
Dr. David Peacock

In this first section, we will be exploring questions about your experience with cats to get a sense of how you view them. Please circle your answers for each of the following questions.

1. How many cats do you own?

   ○ 0
   ○ 1
   ○ 2
   ○ 3 +

2. On a scale of 1-7 with 1 meaning "Strongly Disagree" and 7 meaning "Strongly Agree", please circle the number you feel best indicates your level of agreement with each of the following statements:

	Strongly Disagree			Neutral			Strongly Agree
Cats make good pets.	1	2	3	4	5	6	7
I would adopt a cat as a pet.	1	2	3	4	5	6	7
Feral cats are a natural part of Australia's wildlife.	1	2	3	4	5	6	7
In general, feral cats should be controlled.	1	2	3	4	5	6	7
Feral cats should be eradicated wherever possible.	1	2	3	4	5	6	7
Feral cats are genetically different from domestic cats.	1	2	3	4	5	6	7
People should not feed stray cats.	1	2	3	4	5	6	7
There should be stricter regulations on owning domestic cats.	1	2	3	4	5	6	7
Domestic cats should be allowed to roam freely outside of short periods of time.	1	2	3	4	5	6	7
Feral cats have a negative impact on the livestock industry.	1	2	3	4	5	6	7
Feral cats pose a threat to wildlife.	1	2	3	4	5	6	7
Feral cats have a negative impact on the tourism industry.	1	2	3	4	5	6	7
Protecting biodiversity is important to me.	1	2	3	4	5	6	7
I do not want cats on my property that are not my own.	1	2	3	4	5	6	7
I frequently notice cats roaming freely outdoors.	1	2	3	4	5	6	7
Outdoor domestic cats pose a threat to wildlife.	1	2	3	4	5	6	7
Feral cats have a negative impact on human health.	1	2	3	4	5	6	7
Indoor domestic cats pose a threat to wildlife.	1	2	3	4	5	6	7
Domestic cats should be allowed to roam freely outside for long periods of time.	1	2	3	4	5	6	7
Outdoor domestic cats do not have the same impact on wildlife that feral cats have.	1	2	3	4	5	6	7
The feral cat topic is very important to me.	1	2	3	4	5	6	7

Now we will be taking a look at some of the techniques commonly used in feral cat management, and how you feel about them potentially being used in your region, and also on your property.

When completing this portion of the questionnaire, we ask that you please only consider your most relevant property even if you reside in, own or manage multiple properties in the region.

3. Have you previously heard of any of the following techniques that are commonly used in feral cat management? Please check the box next to all of the answers that apply.

☐	Baiting using Eradicat® (1080 poison)
☐	Baiting using Curiosity™ (PAPP poison)
☐	Cage trapping
☐	Padded leg-hold trapping
☐	Felixer® grooming traps (1080 poison)
☐	Shooting
☐	Detector dogs
☐	Maremma dogs
☐	Exclusion fencing

Please continue on the next page.

Below you will find a brief description of the techniques that have been used in feral cat management programs in the past, and that may be used in the feral cat management within your area. Please read through them carefully, as they will help you in completing the questions on the following pages.

Baiting using Eradicat® (1080 poison)	The Eradicat bait comes in the form of small minced-meat chipolatas. These chipolatas contain the poison 1080, which is a natural chemical found in some plants within Australia, but is highly toxic to both cats and dogs. Native animals generally have a tolerance to 1080, and the dosage used in these baits aims to minimise potential harm to native species. These baits are distributed on the ground either manually or aerially. When the cat consumes the bait, its respiratory system fails and it exhibits noticeable symptoms of disorientation and lethargy prior to death.
Baiting using Curiosity™ (PAPP poison)	The Curiosity bait also comes in the form of a minced meat chipolata, but contains the poison para-aminopropiophenone (PAPP). When consumed, PAPP disrupts the transport of oxygen to the heart and brain, resulting in a quick loss of consciousness. PAPP is normally considered a more humane option than 1080, as it produces faster results with less obvious symptoms. Curiosity contains a cat-specific dose of PAPP within each bait, but it still may pose a risk to certain native species such as the goanna.
Cage Trapping	Cages are strategically set up and baited by management authorities to catch cats alive. They can also be borrowed by landholders to catch cats on their property. Traps must be checked every 24 hours, and captured cats are first scanned for microchips, and if they are found to be feral, they are quickly and humanely euthanised. If a landholder catches a cat on their property, they must report it to an authorised animal management officer within 12 hours.
Padded Leg Hold Trapping	These mechanisms are rubber-lined, jawed spring-operated traps that are designed to capture individuals of the target species by the foot or lower leg, and include a spring to reduce potential for injury. Traps are checked within less than 24 hours, and cats caught within 1 km of a township are scanned for microchips. This technique is often used in conjunction with shooting, and traps should only be used in areas where the animal can be humanely destroyed while still held in the trap. Leg hold traps may be more effective for catching feral cats who are wary of cage traps.
Felixer® Grooming Traps (1080 poison)	These traps are designed to lure cats in using different sounds, and laser sensors and cameras detect the animal as it passes by. When a cat is detected passing by, the trap sprays a cat-specific amount of toxic gel containing 1080 onto its fur. Once it has been sprayed, the cat will lick to clean the fur and will ingest the poison into its system, leading to its death.
Shooting	This technique requires the use of trained shooters who have a proper license for the appropriate firearms and ammunition, and who are skilled in proper shot placement. Cats are shot humanely, usually at night using a spotlight to detect them and a whistle to attract them. Shooting can be costly in terms of time and money, and is best deployed when cat numbers have already declined significantly.
Detector Dogs	Detector dogs are trained specifically to track cats in various landscapes. The dogs are accompanied by their handlers, and they are sent to locate feral cats in a landscape. The cats are then caught and humanely euthanised. The dogs are not used to catch or kill cats, only to locate them.
Maremma Dogs	Maremma dogs bond with a flock of sheep, and protect them by scaring away cats and other predators. A certain number of dogs will be kept on a property, according to the size of the property and the number of sheep within a flock. The presence of Maremma dogs is likely to deter cats, making it easier to predict cat movements and control their numbers.
Exclusion Fencing	Exclusion fences are usually about 1.8 metres high and often include a large overhang on top to deflect cats and keep them jumping over into the restricted areas. At times they include electric wires to deter cats from climbing up. These fences are often accompanied by an electric grid if they are located near a road, to allow for cars to pass through while still abating the threat of cats entering the restricted area.

4. On a scale of 1-7 with 1 meaning "Strongly Disagree" and 7 meaning "Strongly Agree", please circle the number you feel best indicates your level of agreement for each of the following statements:

	Strongly Disagree			Neutral			Strongly Agree
I am familiar with the conservation efforts taking place in my region.	1	2	3	4	5	6	7
I am knowledgeable about different native predator species within Australia (e.g. Quoll, Tasmanian devil, Barn owl).	1	2	3	4	5	6	7
Feral cat management is necessary in my region.	1	2	3	4	5	6	7
I am familiar with the current feral predator management in my region.	1	2	3	4	5	6	7
I approve of the current feral predator management taking place in my region.	1	2	3	4	5	6	7
I would like to be informed of other new technologies that might be developed and used in feral cat management.	1	2	3	4	5	6	7
I am confident in the management authority's ability to control feral cat numbers.	1	2	3	4	5	6	7
I am confident that the management authority has the appropriate resources to control feral cats.	1	2	3	4	5	6	7
I would be interested in learning about the potential for reintroducing a native predator species (Quoll, Tasmanian devil) into my region to aid in feral cat management.	1	2	3	4	5	6	7
I approve of the current conservation efforts taking place in my region.	1	2	3	4	5	6	7
The management techniques presented in this questionnaire contain ethical and humane ways to control feral cat numbers.	1	2	3	4	5	6	7
There should be more information and communication provided around what management authorities plan to do.	1	2	3	4	5	6	7
There are better and more ethical ways to control feral cat numbers than the techniques presented in this questionnaire.	1	2	3	4	5	6	7
The information presented in this questionnaire improves my confidence in the upcoming feral cat management in my region.	1	2	3	4	5	6	7
My household or business has been financially impacted as a result of feral cat presence in my region.	1	2	3	4	5	6	7
Feral cat management is a worthwhile investment.	1	2	3	4	5	6	7
Feral cat management would benefit the livestock industry in my region.	1	2	3	4	5	6	7
I am comfortable with feral cat management taking place on my property.	1	2	3	4	5	6	7

5. On a scale of 1-7 with 1 meaning "Highly Unlikely" and 7 meaning "Highly Likely", please circle the number you feel best indicates how likely you would be to allow the use of the following techniques on your land:

	Highly Unlikely			Neutral			Highly Likely
Baiting using Eradicat® (1080 poison)	1	2	3	4	5	6	7
Baiting using Curiosity™ (PAPP poison)	1	2	3	4	5	6	7
Cage trapping	1	2	3	4	5	6	7
Padded leg-hold trapping	1	2	3	4	5	6	7
Felixer ® grooming traps (1080 poison)	1	2	3	4	5	6	7
Shooting	1	2	3	4	5	6	7
Detector dogs	1	2	3	4	5	6	7
Maremma dogs	1	2	3	4	5	6	7
Exclusion fencing	1	2	3	4	5	6	7

6. Please indicate any reasoning you may have for your answers to the previous question in the box below.

7. On a scale of 1-7, with 1 being "Not Responsible" and 7 being "Highly Responsible," please circle the number you feel best indicates how responsible you believe each of the following parties is for funding feral cat management in your region.

	Not Responsible			Neutral			Highly Responsible
Landholders	1	2	3	4	5	6	7
Cat owners	1	2	3	4	5	6	7
Environmental not-for-profit organisations	1	2	3	4	5	6	7
National Park Authorities	1	2	3	4	5	6	7
Natural Resource Management Authorities	1	2	3	4	5	6	7
Local Council	1	2	3	4	5	6	7
State Government	1	2	3	4	5	6	7
Federal Government	1	2	3	4	5	6	7

We're almost done! We just need a bit of information about you to complete the survey.

8a . Have you previously come across information regarding feral cat impacts or feral cat management?

- O Yes
- O No

8b. If so, then on a scale of 1-7 with 1 meaning "Not Useful" and 7 meaning "Very Useful," how useful have the following sources been in learning about these topics? If you do not use the source listed, please select "N/A."

	Not Useful			Neutral			Very Useful
Online news sites or organisation webpages	1	2	3	4	5	6	7
Social media	1	2	3	4	5	6	7
Word of mouth	1	2	3	4	5	6	7
Workshop or community event	1	2	3	4	5	6	7
Blogs	1	2	3	4	5	6	7
Newspaper	1	2	3	4	5	6	7
Pamphlets	1	2	3	4	5	6	7
Television or Radio	1	2	3	4	5	6	7
Scientific journal articles	1	2	3	4	5	6	7
This questionnaire	1	2	3	4	5	6	7

9. Would you prefer information to be more readily available regarding these topics?

- O Yes
- O No

10. Did the information presented in this questionnaire increase your interest in learning about feral cats or feral cat management?

- O Yes
- O No

11. On a scale of 1-7, with 1 meaning "Highly Unlikely" and 7 meaning "Highly Likely," please circle the number you feel best indicates how likely you are to trust articles and information from the following sources. Please also provide any reasoning you may have in the box provided.

	Highly Unlikely			Neutral			Highly Likely
Government Agencies	1	2	3	4	5	6	7
Research and Science Facilities (e.g. CSIRO)	1	2	3	4	5	6	7
Not-for-profit Organisations (e.g. WWF)	1	2	3	4	5	6	7
Animal Welfare Groups	1	2	3	4	5	6	7
News Broadcasting Stations	1	2	3	4	5	6	7
Landcare Groups and Facilitators	1	2	3	4	5	6	7
Reasons:							

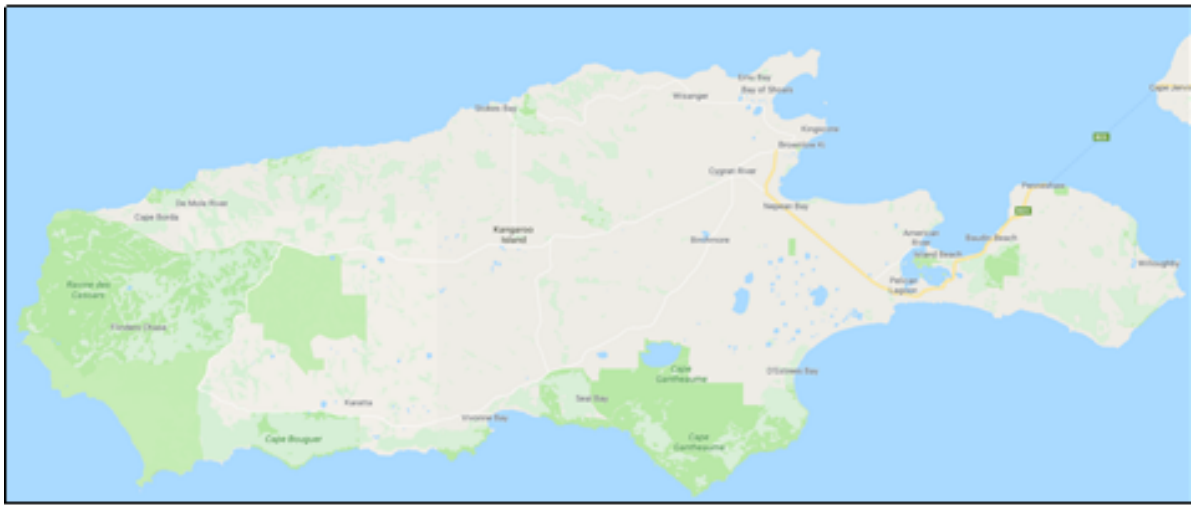
12. Please select your age range.

18-24	25-34	35-44	45-54	55-64	65-74	75+
○	○	○	○	○	○	○

13. Please select your gender.

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to disclose.

14. Please mark the location of your property by circling the approximate location. If you reside in, manage or own more than one property, mark the location of each property, and place an X on the one that is **most relevant** to your answers in this questionnaire.



15. How many years have you resided in, owned or managed this property?

0-4	5-9	10-14	15-19	20+
○	○	○	○	○

16. How would you best describe your property?

- ○ House on a residential sized block (<2 ha)
- ○ House on a larger sized block (2-5 ha)
- ○ House on a smaller acreage (6-10 ha)
- ○ House on a larger acreage block (>10ha)
- ○ Unit/Apartment
- ○ Other: _____

17. How would you best describe the land use on your property?

- ○ Residential block in a large town
- ○ Residential block in a small town
- ○ Grazing land (Sheep)
- ○ Grazing land (Cattle)
- ○ Viticulture
- ○ Cropping
- ○ Orchards
- ○ Other: _____

18. Please quantify in dollars per annum the negative financial impact, if any, that your household or business has experienced as a result of the feral cat issue.

19. What is the highest level of education you have completed?

- ○ Secondary School Certificate
- ○ Certificates I-IV
- ○ Associate Degree
- ○ Bachelor's Degree
- ○ Higher Degree

20. Would you be open to allowing your land to be used as a potential location to trial new techniques?

- ○ Yes
- ○ Possibly; It depends on the technique
- ○ No

21. Would you like to receive feedback on the results of this study, once it has been concluded?

- ○ Yes
- ○ No

If you have responded "Yes" or "Possibly" to question 20, or "Yes" to question 21, please take a moment to record your contact details on the separate Sign Up sheet that has been provided.

22. How did you hear about this study?

- ○ Letter in the mail
- ○ Word of mouth
- ○ Online newsletter
- ○ Social media
- ○ Other:

23. Are there any additional comments you would like to make regarding the topics within this questionnaire?

Thank you for participating. We greatly appreciate your time and consideration. If you have any additional questions or concerns about the topics covered in this questionnaire, or about the questionnaire itself, please contact Brooke Deak at brooke.deak@adelaide.edu.au. Further information on what is currently being done in your region can also be provided by your local environmental management authorities.

Please return the completed survey using the self-addressed envelope supplied.

Trial Participation and Feedback Sign Up Sheet

Would you be open to allowing your land to be used as a potential location to trial new techniques?

- ○ Yes
- ○ Possibly; It depends on the technique
- ○ No

Would you like to receive feedback on the results of this study, once it has been concluded?

- ○ Yes
- ○ No

Please record your address, email address and/or phone number in the box below so that we will be able to contact you for further information, or provide feedback following the conclusion of the project.

Address: Email address: Phone: