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**A Modern Cat-tas-trophe? The Relationships and Impacts between Feral Cat Management  
and Sustainable Urban Development: A Literature Review**

Gage Mofield

A thesis submitted to the University Honors Program in partial fulfillment of the requirements  
for the Honors Certificate with a Thesis

Approved by

Dr. Julie Weinert

Southern Illinois University Carbondale

April 29 2020

## INTRODUCTION

Throughout the history of time, feral cats have been revered for their ability to kill perceived human nuisances such as rodents and venomous snakes. These animals held negative connotations, as they were able to contaminate and consume the food that was supposed to be utilized for human consumption. Because of their importance, it is believed to be the original reason that cats were domesticated (Langton 1940). Most likely originating in Ancient Egypt (Figure 1) following domestication, these cats were then distributed and brought to different continents such as Europe, Asia, and Australia to maintain and control local rat and rodent populations from then on and throughout the 1600s and 1700s (Hu et al. 2014). As domesticated cats began to spread across the world, they began to form feral populations, as their offspring began to avoid human conflict in any way, shape, or form (Dickman 1996). As time went on, these newly formed cat populations began to pick up the moniker “community” or “free-roaming” cats, or what they are more commonly referred to today as the “feral” cat.



*Figure 1: A Cat mummy located in the Department of Egyptian Antiquities of the Louvre (Greudin 2002).*

While many definitions exist for the phenomenon, a feral cat is one that is unsocialized with the surrounding human population, and often live in groups known as “colonies” where

they share basic amenities such as food sources and shelter (LaCroix et al. 2006). Most feral cats tend to originate from an unneutered male cat. It is important to note that the term “feral” is more a behavior characteristic rather than a biological one, as there are many factors such as age, amount of exposure to humans, and individual personality that determine the odds for a cat to be feral. Also, a cat can be feral and not feral at different points in their life, and may vary in terms of the degrees of how feral a cat can be (Dauphine et al. 2009). As one can tell, there is a lot of gray area that still exists in defining feral cats, as variation exists between different countries and animal experts. In the United States (where most of this analysis and review will be looking into), many veterinarians and animal rescues have much more broad definitions for characterizing feral cats and use tactics such as observation of cats social behavior in response to human contact or even just an inanimate object (Slater et al. 2010). With all these open-ended questions still being present in regards to feral cats in general, more than enough questions and concerns in regards to how to manage their populations, as well as the different impacts that they can have on the environment, especially in urban areas.

For this literature review, I will be reviewing the impacts that feral populations have on sustainable development, specifically in urban environments, and doing an intensive analysis of the economic, social, and most significant, environmental impacts that feral cats have on the respective urban environment. Following this, I will then be reviewing the different management strategies that currently are in place for managing feral cat populations, specifically lethal methods of feral cat management, and then analyzing a non-lethal feral cat management program known as “TNR”, which stands for Trap-Neuter-Return, and seeing which methodology is the best suited for managing urban feral cats, and debating the pros and cons between lethal

and non-lethal methods. Finally, I will then demonstrate what my overall opinion on the subject matter is based on the data that I have gathered, and what actions I believe should be implemented in regards to management plans and possible future research endeavors.

### **DEFINING URBAN SUSTAINABILITY AND URBAN WILDLIFE**

When it comes to discussing the different aspects of urban sustainability and what is regarded as urban wildlife, it is important to know the respective definitions of each term. While there are broad definitions that exist for defining the term sustainable development, the most common definition is the one utilized by the Brundtland Report, which states “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Emas 2015). When taking into account how this works in an urban environment, which usually has the common perception of being a unsustainable “habitat”, sustainable urban development seeks to create cities that still manages and improves the overall health of the planet and the economic, social, and ecological systems of a city (Wheeler 2012). Urban environments are continuing to grow and expand in size, and as urban growth continues to lead into deep structural changes in the composition and dynamics of the surrounding landscape and human populations continue to grow, cities and urban environments as a whole will need to be able sustainably manage and develop without harming the economic, social, and ecological processes. Since urban environments are artificially created/man-made environments and are relatively new to the overall ecosystems of the planet, there has been only a small amount of the research on the impacts that urbanization and habitat fragmentation have on the local and overall environment, especially on what impacts occur on the nearby wildlife that now finds themselves in this concrete urban jungle.

While wildlife is regarded as the local fauna of an environment, urban wildlife are the animal species that can thrive and utilize a human-dominated ecosystem. Although these urban species vary in their utilization and exploitation of these human manipulated environments, they all come into contact with the humans who live in the urban environment, whether that be in the respective city or the woodland-urban interface (Shochat et al. 2006). It is important to note however that while feral cats tend to live outside human homes and exhibit “wild” behavior, they are not considered a form of urban wildlife or wildlife in general (Heezik 2010). This is because while most forms of urban wildlife tend to utilize human-created food sources (Figure 2), feral cats are almost entirely dependent on them. Few feral cats can survive on hunting alone, as most tend to rely on human-caused food sources, such as a caretaker or a neighbor providing daily cat food, or a dumpster left open behind the supermarket just to name a few examples. Because feral cats are not able to thrive on their own accord, they are looked at more so as an invasive species, or an animal species that causes or is likely to cause ecological or economic harm or endanger human health in the respective environment that it is not native to (Loyd et al. 2010). As feral cats continue to expand their range, they will continue to have negative impacts in relation to sustainable urban development, especially concerning the environmental sustainability of an urban area.



*Figure 2: The most common food source for a feral cat tends to come from a direct human source (DiLonardo 2019)*

## **FERAL CATS AND ECOLOGICAL SUSTAINABILITY**

To begin, one of the main arguments about the impacts that feral cats have on an urban ecosystem is through their relation to biodiversity levels. Biodiversity is correlated to the overall sustainability of an ecosystem, as the greater the biodiversity value of an area is, the more sustainable that area is as well, as high biodiversity in an environment means there is a greater variety of species and genes that allows said ecosystem to thrive (Barton et al. 2017). The value of biodiversity is extremely important to the environment as each species plays an important role in their respective ecosystem, and altering this environment can lead to devastating impacts for the surrounding areas as well as the planet as a whole. Since urban ecosystems already tend to have lower biodiversity levels than most ecosystems due to the high amounts of habitat destruction and fragmentation that has already been implemented to cater to the increasing human population, the issue is not helped by the increase of feral cats across the area.

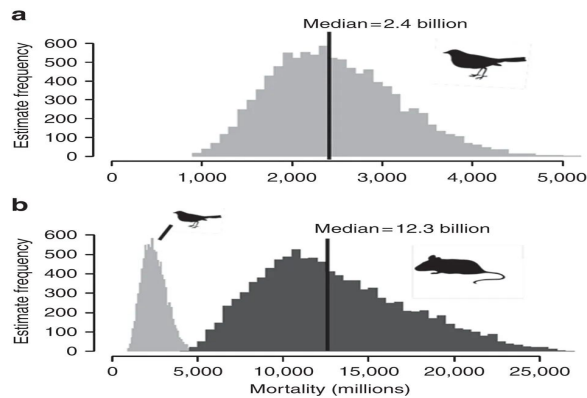
Biodiversity levels within an ecosystem correlate to the number of species and overall species richness of an area, and feral cats are considered significant predators to a vast number of species within the city environment. Some common/example species that feral cats decrease the

overall species number of include the California Quail, Killdeer, and Ovenbirds, which are bird species that tend to nest on or near the ground, which makes them more susceptible to the feral cats hunting strategies (Dauphine et al. 2009). On top of that, feral cats can cause serious damage to animals within populations that contain a plethora of rare and endangered species, especially in urban environments where not only there is already a smaller amount of these species that help promote urban biodiversity levels. But because feral cats in urban environments form dense social groups that have small home sizes, causing these human-supported feral cat colonies concentrated of large group numbers to form within the range of a respective at-risk species (Winter et al. 2006).

While the specific area has not been the most researched as of late since this is a new and developing subject matter about urban areas, feral cats have been shown to kill billions of different small mammals and birds each year since their introduction as a predator species (Kitts-Morgan 2015). With such a significant number of animals being predated and having their abundance decreased by these feral cats populations, they are considered the largest human-influenced source of mortality for birds and small mammals (Figure 3) in the United States (Loss et al. 2013). Because of these cats being grouped as subsidized predators within these human manipulated environments, meaning that they tend to receive food and care from the nearby human populations, there are many arguments and concerns about the presence of cats within these environments, and whether the respective small mammal and bird populations can be sustainable in this predator-prey dynamic within the local, let alone just urban, ecosystem. Within these predator-prey dynamics being altered by the presence of feral cats in the urban environment, they also alter local food chains and have the ability to cause a trophic cascade.



This can be seen as one of the two most common animals that are preyed upon by feral cats are the bird species listed before as well as bats, which are the two main predators for many human perceived insect pests such as mosquitoes. Because of this, insect populations have the ability to increase in size, as well as in the spread of common animal to animal transitional diseases (Jessup 2004). Despite feral cats not fully relying on hunting the city wildlife as a food resource since mostly rely on humans as the primary food resource, they still have a significant impact on the respective animal populations as these cats continue to saturate the urban landscape.



*Figure 3: A probability distribution of estimated bird mortality caused by feral cats in mainland areas of the contiguous United States. This graph above demonstrates the overall mortality rate per million that are caused to terrestrial vertebrates by feral cat presence (Loss et al. 2013.)*

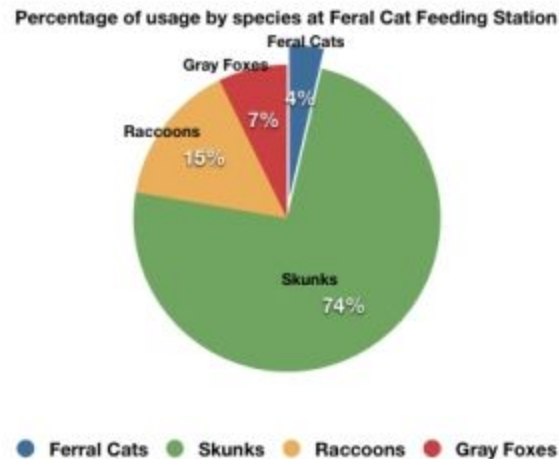
## **FERAL CATS AND ECONOMIC SUSTAINABILITY**

Within the three pillars of sustainable urban development, one of the main focal points revolves around having a sustainable and self-sufficient economy. As feral cats continue to increase in population numbers, studies have shown that they have a significantly negative impact on the economy of the respective urban city, especially if cities continue to expand into the future. First off, in urban areas, feral cats tend to form dense social groups with small home

range sizes, in comparison to rural feral cats which tend to be more solitary and have larger home ranges (Normand et al. 2018). While still understudied and overall needs to be researched more in the near future, feral cats will reproduce in larger quantities and in quicker succession if they are densely grouped in their respective colonies to survive and thrive in the urban environment. Because of this behavior that occurs within the urban setting, there is more economic harm that takes place due to this feral cat adaptation to living in the urban landscape. While there is not specific dollar amount for the financial loss that feral cats have caused for cities, a study conducted by the University of Nebraska demonstrated that feral cats and their predation on birds alone had an economic impact of more than \$17 billion per year in the United States (Hildreth et al. 2010). They were able to calculate this by estimating the cost of a bird to be approximately \$30, as previous literature has stated that bird watchers spend 40 cents per bird observed, hunters spend \$216 per birds shot, and bird rearers tend to spend approximately \$800 per bird released (Hildreth et al. 2010).

As stated before, one of the common characteristics of feral cats is that their most common food source comes from the surrounding human populations feeding them. These food resources can come from a sole individual providing their own food to a feral cat colony, or even the commonly utilized “feeding stations”, which are maintained by private citizens or volunteers to provide multiple pounds of cat food each day. However, many studies have shown that these feeding stations are inefficient and overall a waste financially, as a vast majority of the food provided would be eaten by the local raccoon and skunk populations (Figure 4), while feral cats would arrive to an empty in a vast majority of the encounters during the experiment conducted

by the Urban Wildlife Research Project within the Santa Clara Valley in California (Woestijne et al. 2013).



*Figure 4: Data collected on the wildlife usage of feral cat feeding station in Santa Clara, California (Woestijne et al. 2013)*

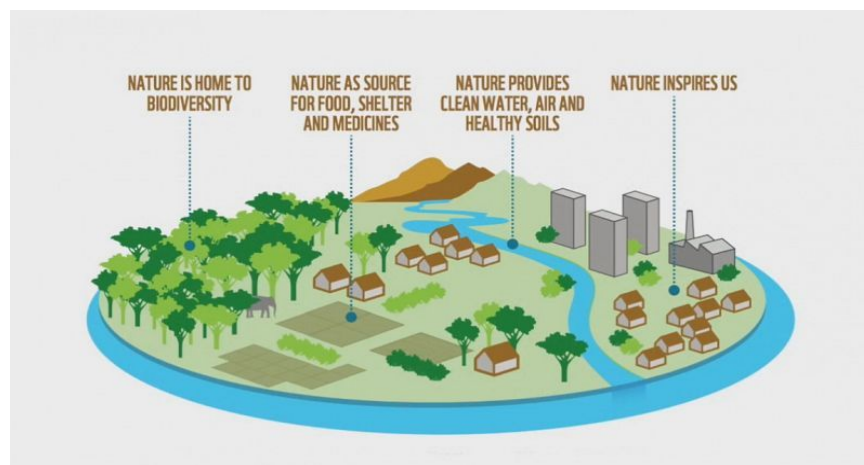
In New Orleans, feeding stations were seen being manipulated and taken advantage of by the nocturnal urban rat populations. This is significant from an economic sustainability perspective as this ample amount of food leads directly into the poor management of waste, in this case specifically food waste, in cities and urban environments as a whole, as urban rats have amassed over a billion of dollars in property damage due to their prevalence (Wundram 1986). While there are laws in some cities that make it illegal for people to leave these kinds of food sources out overnight, it still has left a direct impact on the urban environment from an ecological standpoint, as well as an even more massive and inadvertent economic impact as well. While many more feeding station studies need to be conducted in a variety of different urban environments as one feeding station does not speak for the rest of the feeding stations that have

already been implemented, it is important to know if feeding stations are being efficiently utilized from an economically sustainable standpoint, but also make sure one is not inadvertently harming the urban wildlife now utilizing these feral cat feeding stations.

### **FERAL CATS AND SOCIAL SUSTAINABILITY**

Finally, regarding the three pillars of sustainable development, there is the social aspect. The social pillar of sustainable development usually refers to social issues concerning a wide array of public policies that focus on the importance of human wellbeing. As stated before in the environmental sustainability aspect of sustainable urban development, biodiversity is extremely important for the overall health of a respective ecosystem. Not only is biodiversity important from an ecological perspective, but it is also from a social sustainability perspective (Figure 5). For example, a loss in biodiversity has negative impacts not only on the surrounding ecosystem, but also on mental health levels for the local human populations. Humans use ecosystem services, or the contributions of ecosystems provided to individuals living within their respective cities (Atiqul et al. 2011), for not only basic needs such as food, water, and clean air, but also indirect benefits such as mental health and cognitive development (Sala et al. 2009), and urban biodiversity levels help provide these attributes. One study, conducted by Richard Fuller, has shown that the psychological benefits that humans gain from utilizing urban green spaces in cities is correlated to the amount of species richness/biodiversity in an urban area, depending on the taxonomic group (Fuller et al. 2017). This can be seen due to the human need for obtaining some form of physical activity that is in a natural environment, which urban environments tend to lack when they do not have access to some form of green space. Fuller states that his results indicate that urban environments should continue to emphasize the ecological complexities that

exist within them to not only enhance human well-being, but also conserve biodiversity levels in urban ecosystems (Fuller et al. 2017). Based on the previously mentioned study, geographic location makes a significant impact for the person utilizing the cities ecosystem services that are related to biodiversity levels, as the closer a person is in proximity to one, the more one benefits from its availability. In another study conducted by A. Chiesura, who conducted studies in the cities of Amsterdam and Paris, also confirmed that the experience of a natural setting with higher biodiversity levels in an urban environment is not only “a source of positive feeling and beneficial services” for human well-being, but also a vital tool for maintaining sustainability within the respective community (Chiesura et al. 2004). With the increasing presence of feral cats that continues to alter the biodiversity levels in urban environments, it is important to remember how important biodiversity is to people when thinking about the relationships between feral cats and sustainable urban development.



***Figure 5: A infographic showing how the importance of urban biodiversity to environmental and social sustainability (Fisher et al. 2019)***

Another factor that can impact already low biodiversity levels within the urban environment (as well as fit into the environmental sustainability pillar for sustainable urban

development) is the presence of certain diseases that can come from the transmission of feral cats to local wildlife. Feral cats can serve as a vector for several diseases, including zoonoses, or diseases that can be transmitted to humans, including rabies, toxoplasmosis, bartonellosis, and salmonellosis just to name a few (Cornell University College of Veterinary Medicine). Rabies in particular, which is commonly transmitted through bite wounds, has identified feral cats as being responsible for a significant amount of cases of human exposure to disease. According to a study based in New York state, despite feral cats making up only 2.7% of total animals reported to be infected with the disease, they were reportedly responsible for approximately 33% of the recorded human exposure incidents (Edison et al. 2010). With Toxoplasmosis, cats are the primary host of the parasite *Toxoplasma gondii*, which is what causes the respective disease, and can be transmitted to humans easily through the contact or consumption of food, water or soil contaminated with cat feces carrying *Toxoplasma gondii* eggs (Dabritz et al. 2010). On top of all this, humans provide potential mechanisms for the transmission of diseases from feral cats acting as vectors to themselves respectively. As stated before, it is becoming more and more common for individuals or groups to leave out feeding stations for nearby feral cat colonies. When humans implement these outdoor feeding stations for feral cat populations to utilize, then the nearby colonies create and increase the chance of high-risk disease transmission from cats to people in regards to the number of unvaccinated cats now using that feeding station as a reliable food source and the proximity of the human population, especially within the more densely populated urban environment (Gerhold et al. 2012). Overall, feral cats play a huge role in the transfer of zoonotic diseases to not only other surrounding forms of wildlife, but also to humans as well, which plays a significant role in the social aspect of sustainable urban development.

In order to know how to manage feral cats and what impacts they do have on sustainable urban development from a social perspective, data must be collected in regards to how humans perceive feral cats in regards to not only how they should be managed, but also in regards to their overall well-being. Studying the values, attitudes, and orientations that humans hold to feral cats, also known as the human dimensions, is integral to studying the relationship between feral cats and the welfare of the species. While few studies have been conducted in the United States, there have been a few public opinion surveys conducted in other countries regarding the perceptions of urban feral cats. In this specific survey conducted in Brisbane, Australia, surveys showed that few respondents believed that urban feral cats had a good life, that cat owners were more likely to say that “seeing and feeding a healthy stray cat” would make them feel happy in comparison to non-cat owners, and that males and older participants were more likely to express more disagreement with the question listed previously than did females or younger respondents (Rand et al. 2019). In a global assessment of the social perceptions of feral cats, the study showed that 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 (Deak et al. 2019). Some countries seem to also take more of an issue with the presence of urban feral cats than others. For example, Australians tend to consider feral cats a threat to society, as many citizens are aware that they are nuisances for the highly valued native fauna (Trigger et al. 2007). In a Danish study, they found that a majority of the population (60%) did not have a problem with feral cats roaming around, and within that majority, a majority of those respondents were even non-cat owners (Sandøe et al. 2018). In regards to the social pillar of sustainable urban development, it is important to consider the plethora of stakeholders that can

impact feral cat management, but the most important may be that of the general public when deciding what strategy may be the most effective to implement.

### **FERAL CATS MANAGEMENT STRATEGIES: LETHAL METHODOLOGY**

While into the importance of individual attitudes and perceptions of urban feral cats, one must also take into account the public opinion on what is the best way to manage their population size and overall impacts. One of the most common and in turn most simple methods to deal with them is through lethal methods such as trap and kill and euthanasia. With trap and kill (Figure 6), which is the most common method currently in managing feral cats, is a seemingly direct, simple, and immediate method, which involves trapping the cat and then soon after euthanizing the animal (LaCroix et al. 2006). With the method being optimal and efficient in regards to how quickly it reduces the population numbers of the invasive species known as feral cats. Another efficient method of reducing feral cat populations is one that gives full responsibility to the individual, and that is outright shooting and killing the cat. This would involve utilizing a shotgun or a .22 caliber rifle and aiming the shot between the eyes or in the heart/lung so that a humane death is still ensured (Hildreth et al. 2010).





*Figure 6: An example of a trap commonly utilized in the trap & kill feral cat management strategy (Trapping Protocols 2019).*

With the previously discussed lethal methods that are utilized to manage feral cats, there are many different forms of evidence to support its use. For example, studies have shown that trap-kill/euthanize methods have proven effective at reducing cat populations and mitigating adverse effects on wildlife in several locations, especially when the feral cat colony had a population greater than fifty (Nogales et al. 2004). On top of that, the implementation of these lethal methods has immediate benefits for the persistence of prey populations that are being impacted by the presence of feral cats, as well as increasing the odds of preserving urban biodiversity levels (Loyd et al. 2010). As stated before, this is the supported methodology for many wildlife, especially bird advocacy groups, as they believe that feral cats are one of (if not the biggest) factor in declining bird populations (LaCroix et al. 2006). While there is not a wide variety of ways to lethally reduce feral cat populations in a humane manner, the ones that are present maximize efficiency and are straight to the point.

While there are many benefits to utilizing these lethal methods on urban feral cats, there are many drawbacks in its implementation within society. For example, the shooting method as a way to manage feral cat populations would probably see little success in urban areas. This is due to shootings being considered sensitive subject matter within the urban environment, and in most places, shooting is avoided within city limits unless an animal poses a significant threat to public safety and health (Hildreth et al. 2010). There is a negative stigma that is associated with the euthanization of an animal with such high charisma, or animal that has widespread popular appeal, such as the domestic cat. In a survey where respondents were asked which management method they thought for urban feral cats was more humane: euthanization or leaving the stray cat within the environment. The majority of respondents stated that the latter was a more humane option, even after they were presented with the information that most feral cats die within 2 years because they were hit by a car (Rand et al. 2019). Another negative to the utilization of lethal methods in feral cat management is the error of euthanizing a cat that already had an owner, which can occur if the cat was not microchipped and possibly slipped its collar after escaping. On top of that, trap and kill and many other euthanization strategies are vehemently opposed by many cat advocacy groups, with groups raising millions of dollars promoting “feral cat rights” and objecting the method until feral cat populations are so high they are a risk they are a serious public health risk to the human population (Ash and Adams 2003). If the option is available, cat advocacy groups tend to advocate for the method of lethal injection with sodium pentobarbital, which is considered a more humane method of euthanasia (LaCroix et al. 2006). Overall, while lethal strategies may have positive impacts with regards to how efficient they are, they may not

be the most socially accepted, and for a management strategy to be successfully implemented, it must have some sort of approval across various stakeholders.

### **FERAL CAT MANAGEMENT; NON-LETHAL METHODS/TRAP-NEUTER-RETURN**

As an alternative for the different lethal feral cat management strategies, many different non-lethal methods began to form, specifically the strategy and program known as Trap-Neuter-Return. Trap-Neuter-Return, also known as Trap-Neuter-Release, and by the simple acronym TNR, first became popular in the 1990s, and formed as a rejection to the norm that was traditionally the “trap and kill” method described in the last section. Overall, TNR believes that it is unethical to euthanize feral cats whose existence is a result of human behavior and increased urbanization (LaCroix et al. 2006). With TNR, the cats are typically trapped, spayed or neutered, and vaccinated against the zoonotic diseases previously discussed in the paper that can negatively impact both local wildlife and human populations (LaCroix et al. 2006). During its capture, feral cats will be chipped by the organization/groups utilizing this method, then have their ears “clipped” to show that they have been spayed/neutered (Figure 7), and then are returned/released back to their respective cat colony (Longcore et al. 2009). Since its implementation, there has been an increase in the utilization of this method in the United States (Spehar and Wolf 2017). With this method being widespread and currently being utilized in many cities, different citizen science programs have been implemented so that the general public can gather data on feral cat colony populations, and overall dynamics. One smartphone app, called Cat Tracker, allows individuals to report sightings of these cats so that researchers can try to understand their population sizes and distributions as well as how effective TNR may

be (Roetman et al. 2018). Because of this, there are a lot of positives with the implementation of TNR.



*Figure 7: The cat pictured has had his left ear “Clipped” to show that he has been spayed or neutered by a local TNR program (Ear-Tip: Identifying Community Cats).*

As stated before, there are many different positives to the implementation of the Trap-Neuter-Return strategy when managing urban feral cats. For example, because it is a non-lethal method, there is more acceptance of its use among the general public. As stated before, while there has been little research done in regards to social perceptions of urban feral cats and management strategies, a few of the surveys that have been conducted have shown that when presented with various management strategies, specifically when measuring preference between lethal vs non-lethal methods, resulted in most respondents (79%) choosing TNR as their preferred management strategy (Rand et al. 2019). In regards to the overall amount of feral cats that are still present in the urban environment, while there is not as quick as a reduction to the

population in comparison to the lethal methodology, studies have shown that TNR can be successful at reducing population numbers for feral cats after a significant amount of time has passed, especially in colonies that were smaller than fifty cats (Loyd et al. 2010). Supporters of TNR also point out that the removal of feral cats through lethal measures from the environment is pointless, as it results in a natural phenomenon known as the “vacuum effect”. The vacuum effect occurs when individual cats are removed from their habitats, but their food source remains available and no longer protected. This then causes feral cats from the surrounding areas to immigrate and claim the food source, and thus there is no reduction in the number of feral cats in the colony. Conversely, proponents say, in a managed colony altered cats remain to protect their food source, yet they do not reproduce since they have been spayed/neutered. Therefore, a closely-monitored colony will become smaller over time (LaCroix et al. 2006). Overall, there are a lot of positives based on many different areas of research that showcase why TNR should be utilized more often than the lethal alternatives.

However, despite these previously discussed pros to utilize TNR, there are still cons in regards to comparing this feral cat management strategy in comparison to the previously discussed lethal methods. One of the biggest negatives that comes from utilizing TNR as a feral cat management method is that since it is a relatively new strategy, there is still little data in regards to how effective the strategy may be. A big reason for this is that in a research study conducted in Florida, the data showed that while the feral cat colony that was managed with TNR methods did decrease in overall numbers, illegal dumping of unwanted cats into the urban environment as well as the attraction of stray cats to the provisioned food offset reductions in cat numbers caused by death and adoption (Castillo and Clarke 2003). This study, as well as others,

have shown that there are many inconsistencies in the data used in TNR research, as some studies show success in its implementation, while there are others that showcase the management strategy is not the most efficient (Winter 2004). One area of research that has been consistent however is that TNR has been shown to not be effective for feral cat colonies that are greater than 50, and at that point are a concern not only of the surrounding urban wildlife, but also the public health of the human population (Schmidt et al. 2009). Another reason is that even though the feral cats that go through TNR based management no longer have the ability to reproduce after being spayed/neutered, they are still released back into the urban environment, allowing them to still predate the local wildlife, causing impacts on predator-prey dynamics as well as the nearby human population (Gutilla and Stapp 2010). Because of these factors, TNR has been seen as an unsuccessful management method for ornithologists and many bird advocates, which is the animal that has seen the largest impact of population decline due to feral cat predation. Overall, while there is a high appeal amongst the general public, how effective the management method may be still needs to be researched more thoroughly.

## **DISCUSSION & CONCLUSION**

Along with the public opinions and perceptions of urban feral cats, different stakeholder groups often hold their own views on feral cats and can play a more significant role in which management method will be utilized more often than the other. Two stakeholder groups that have been at constant odds with one another in regards to which management needs to be utilized more than the other are the bird advocate/wildlife experts, who tend to be more in favor of lethal methods for management of feral cats, and cat advocates/veterinary experts, who tend to be more in favor of non-lethal methods, more specifically trap-neuter-return/release programs. As stated

before, bird advocates tend to prefer the more lethal methods of feral cat management as it outright removes feral cats, which are considered by ornithologists and general wildlife biologists to be an invasive species, from the urban environment, allowing for urban biodiversity levels to be preserved and for birds and other terrestrial vertebrates to not be predated by the species (Kitts-Morgan 2015). Also previously mentioned, the main argument used by cat advocates that prefer TNR is that it is seen as a more humane way to handle this sensitive issue, as well as TNR having more appeal as a management method to the general public (Rand et al. 2019). These arguments combined with the pros and cons of lethal and non-lethal feral cat management strategies demonstrate the many values and overall importance of incorporating sustainable urban development in the decision-making process.

In regards to the environmental pillar of sustainable urban development, the lethal methodology would have more of a positive impact on the urban environment in comparison to non-lethal/TNR management strategies. This can be seen since as stated before, studies have shown that outright removing feral cats from the urban environment is the best way to help out the local wildlife populations and biodiversity levels for the area, while TNR strategies that release feral cats back into the environment (even though they are now vaccinated and sterilized), will continue to predate the nearby terrestrial vertebrates. While cat advocates state that implementing lethal strategies on feral cat colonies will result in a “vacuum effect” that makes lethal strategies redundant and pointless, however, this phenomenon assumes that no consistent source of new, unsterilized cats exists, and studies have shown that feral cats will travel long distances regardless of their location for food sources (Guttilla and Stapp 2010). Overall, the environmental aspect of this issue is the one that should be most considered in the

decision-making process for the issue, as it is the pillar that is currently experiencing the most drastic and negative impacts from the presence of urban feral cats.

In regards to the economic pillar of sustainable urban development, while it has been shown that the presence of urban feral cats does have negative impacts concerning a city being economically sustainable, there is currently not a significant amount of research conducted on which strategy may be more economically viable between lethal methods such as trap and kill/euthanasia practices, or non-lethal programs, including TNR, with many recent studies even stating that more economic research needs to be done on the subject matter (Crawford et al. 2019). While there are a few studies that state that TNR is a much more cost-friendly and overall more economically viable strategy than lethal alternatives, many of these have either been conducted by cat advocacy groups and therefore there is a viable chance that the data and results published are showcasing inadvertent advocacy. Inadvertent advocacy occurs when a researcher unintentionally expresses personal policy preferences or ethical judgments in a way that is nearly indistinguishable from scientific judgments, as a researcher may be well-intentioned and intellectually honest but still inadvertently engage in policy advocacy (Wilhere 2012). However, since it has been shown that urban feral cats do negatively impact economic sustainability because of their impacts on the environment and surrounding wildlife, this factor should be taken in future decisions about the subject matter. Overall, more research must be conducted in relation to the economic pillar of sustainable urban development to determine which feral cat management strategy will be more economically sufficient.

With the social pillar of sustainable urban development and how that factors into determining the most optimal feral cat management strategy, there are a plethora of factors that



are both for and against lethal and non-lethal methods. For example, as stated before, the general public that live in urban environments tend to prefer non-lethal/TNR management strategies in comparison to lethal strategies such as trap and kill and euthanasia. There are a wide variety of factors that play into why this may be, including that, the overall perception that TNR is seen as the most humane way to handle the issue (Rand et al. 2019). With cats having such high popularity amongst, most individuals will tend to pick the option that will mean the least harm to the creatures involved. However, individuals who live in an urban environment may be less exposed to natural settings which in turn may correlate to less knowledge about the impacts that feral cats have on wildlife (Heezik 2010). On top of that, since feral cats are still being released back into the environment, they will continue to decrease already low urban biodiversity levels, which are important from a social perspective as well as an environmental viewpoint (Fuller et al. 2017). Concerning the perceptions that individuals may have about the subject matter, there is still debate between bird advocates and cat advocates about how to handle the issue and what would be the most effective way. Since individuals such as ornithologists and veterinarians are highly regarded stakeholders for how to manage urban feral cats, they play a significant role in the decision and law-making process. To make sure that fair and impartial decision making is taking, there must not be allocation towards a specific group that one may prefer, as certain animal-related groups will allocate millions of dollars to see their preferred management method be utilized over the other, regardless of the negative impacts (Loyd et al. 2010). Overall, there are a wide variety of pros and cons for the implementation of lethal and non-lethal management strategies for urban feral cats in relation to the social pillar of sustainable urban development, but

the most important factor to take into account is the general well-being and public opinion of the city population.

While there are positives and negatives to utilizing the previously discussed, the best option may be to implement whichever management strategy is most fit based on the current situation regarding the respective feral cat colony. For example, after researching the pros and cons of each management method, a big factor in the success of a feral cat management strategy seems to be population size. For example, research studies have shown that TNR/non-lethal management strategies are effective when the feral cat colony is less than fifty, while colonies with greater than fifty are most effectively managed by lethal measures including euthanasia (Schmidt et al. 2009). This is significant because as the most commonly accepted management method amongst the general public is TNR, which can be utilized until experts determine that the feral cat colony has grown to a point where it is causing significant harm to the health of the environment, surrounding urban wildlife, and local human population. As discussed at the beginning of the paper, while not always the case, most cats become feral to a point of no return after they hit a certain age in development. One way to reduce the amounts of feral cats in the urban environment is using the kittens that are still open to socialization, putting them up for adoption to be raised as common household pets, and still having them go through the proper spay/neuter surgery to ensure that if they do end up outdoors again they will not be able to reproduce (Loyd et al. 2010). On top of everything, a big point of contingency lies in the fault that there are few cat-specific laws regarding who is responsible for the predation caused by feral cat colonies. For example, while the common law insulates cat owners from liability for their cats, endangered species laws tend to ignore the question of ownership altogether, instead

focusing on the cause and effect relationship of individual actions as to a protected species (LaCroix et al. 2006). For sustainable urban development to occur within this feral cat management issue, proper guidelines, restrictions, and punishments must be detailed and enforced properly if any substantial progress can be made. Finally, for proper progress to be made in regards to determining which management strategy is best, educating the public on the subject matter is one of, if not the significant factor that has little research put towards it. For example, studies have shown that while city/urban inhabitants may be more supporting non-lethal management strategies over lethal strategies because they are unaware of the impacts that feral cats can have on both wildlife and overall biodiversity levels (Deak et al. 2019). An educational campaign might help urban residents understand this important issue created by the presence of feral cats, and possibly alter their beliefs as to the optimal decision for their communities when now educated enough on the subject matter to have a proper opinion.

To wrap it all up, in my personal and humble opinion, even though there have been many available research studies that have been conducted regarding which feral cat management strategy would be the most optimal for achieving sustainable urban development, more research must be done in the near future to demonstrate how to effectively balance all the factors that play a role in the issue. The idea of feral cat management is extremely interdisciplinary, as it combines many different facets of wildlife conservation, human dimensions, environmental sustainability, animal welfare, and many more. As stated before, there have been few research studies conducted on lethal vs nonlethal feral cat management strategies and how they relate to economic sustainability, and the few that have been conducted concerning the social pillar of sustainable urban development, have been conducted internationally in countries such as

Australia. These questions should have more research conducted that is related to them as society continues into the future, and especially at a national level and within states that have diverse wildlife and urban biodiversity levels including Hawaii, California, and Florida, respectively. While the environmental pillar is at the utmost concern at present, a city can not achieve sustainable urban development if the other two pillars are not being researched as thoroughly as well. Overall, feral cats do play a significant role in deterring a city from sustainable urban development, and the management strategy that is determined to be the most optimal, whether that be one full time or utilizing both management strategies depending on the various factors about the respective feral cat colony, will be integral in helping achieve this goal in the near future.

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