

Cats, Colonies, and Cities: A Geospatial Analysis of Feral Domestic
Cats in Lawrence, Kansas

By
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Abstract

Feral cat colonies are a widespread spatial phenomenon that attract controversy for treading the physical and cultural line between invasive urban wildlife and domesticated pets. These feral cats are constantly negotiating their place outside the home and choosing their own habitats in urban environments. The objective of this research is to explore what environmental variables of the human landscape in Lawrence, Kansas influence where feral cats congregate and reproduce to create colonies, trying to better understand the complexities of feral cat habitats using a mixed methodology of participant observation, collaborative research, and GIS analysis. The results of this research should be considered exploratory, but they reveal links or ecological connections between human population densities and cat colony locations. Different architectural structures and site characteristics provide anthropogenic food sources that are important environmental variables influencing where feral cats make their homes. Some evidence suggests feral cat colonies prefer residential areas over other types of land use. Overall, my results suggest feral cat colonies have reoccurring environmental variables that influence their choice of habitat, while maintaining each colony unique in its physical and cultural context.

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Preface

I arrived at my topic of feral cat colonies through a combination of personal interest, coincidence, and the valuable guidance of my advisor Peter Herlihy. I arrived at the University of Kansas for a master's degree because Lawrence was close to home and had a number of human geographers that I could learn from. I wanted to utilize my prior knowledge in GIS while exploring my interest in human geography and Dr. Herlihy's research included both of these themes. In my first semester at KU, I discovered the subdiscipline of animal geography which managed to combine my professional interests in geography with a lifelong personal love of animals. Coincidentally, Dr. Herlihy's master's research and Sauerian lineage fit my newly acquired research interest well.

After I decided I wanted to focus on animal geography and became intrigued by urban wildlife, Dr. Herlihy came across an article online discussing the upcoming Trap Neuter Return (TNR) program being implemented by the Lawrence Humane Society (LHS) in Lawrence. I decided almost immediately after reading that article that I wanted this to be my thesis topic. This research did not require grants or travel, was perfectly fitted to my research interests, and utilized skills I already had in GIS and cat behavior. I was lucky enough to volunteer with the TNR team at LHS several times and have acquired much of my feral cat knowledge from the other volunteers. What struck me about feral cats was their incredible ability to adjust and thrive in almost any environment by using all of the resources at their disposal. This behavior struck me as similar to urban wildlife behavioral adjustments and inspired my desire to better understand the spatial nature of feral cat colonies.

Introduction

Cats have been the companions of humans for thousands of years (Zeuner 1963). They are yet another example of the vast interface between humans and animals. However, unlike the dog, the cat retains many of its wild behavioral traits despite being domesticated. Most notably, domesticated cats are capable of surviving in a multitude of different environments without human assistance. This ability has led to large numbers of feral cat colonies in urban and suburban areas. The term feral means species, in this case *Felis catus*, that have been domesticated, reverting back to wild behavioral patterns, especially reproduction. What constitutes a feral cat has not been universally agreed upon. This is most likely because cat behavior and socialization to humans occurs on a spectrum without clear boundaries or definitions. I have created a basic figure to illustrate the spectrum of cat socialization (Figure 1). A highly socialized cat is friendly to humans and is successful living in the human home. A semi-socialized cat is comfortable enough with humans to interact but would be uncomfortable living solely in the human home. An unsocialized cat is considered feral, may live in a colony, and avoids humans as much as possible (Figure 1).

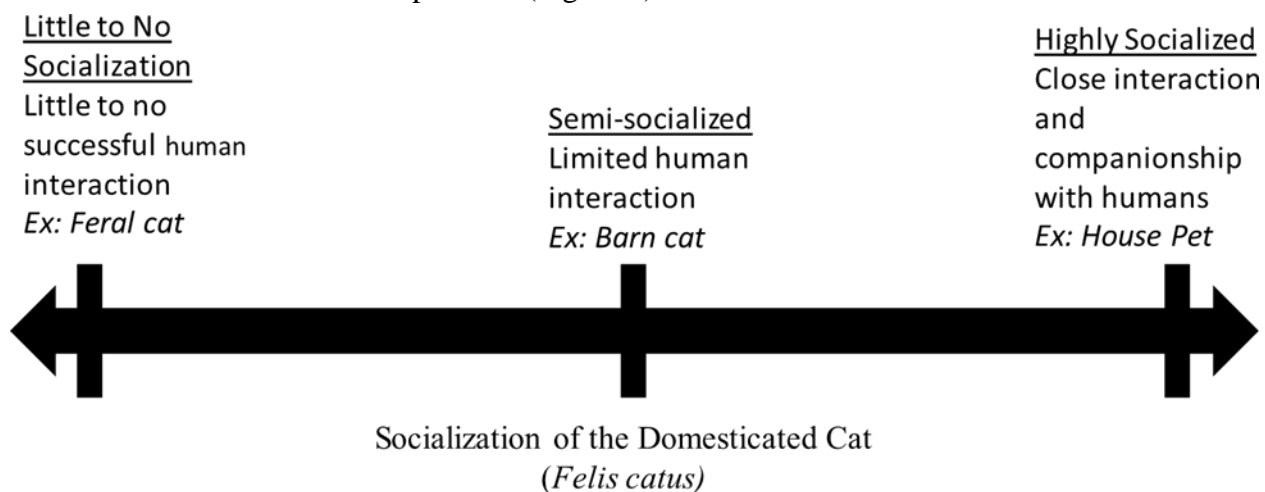


Figure 1: Spectrum of socialization for *Felis catus*

However, there are basic characteristics of feral cats, agreed upon by the professionals who work with them, that can provide a working definition of a feral cat. These characteristics include: a lack of socialization to humans, avoidance of humans, and ability to survive without being under direct human control (Gosling, Stavisky, and Dean 2013). Often feral cats fitting this description are descendants of pets or barn cats that have escaped human control. For the purposes of this thesis, I will define feral cats as cats with little to no socialization to humans that live outside of the human home, often in colonies. There are many terms used in this thesis that have specific definitions in the context of this research and thus I have created a definition guide to be used as a reference throughout this thesis (Figure 2).

Definition Guide
<u>Urban Wildlife</u> - undomesticated species that have populations that cohabitate with human populations (Adams 2016, pg 16) (Smith 2022).
<u>Synanthropes</u> - undomesticated plant or animal species that have changed their behavior to suit the anthropogenic environmental changes (Gade 2010) (Smith 2022).
<u>Domesticated</u> - Species that humans have successfully gained a level of control over through selective breeding (Urbanik and Johnston 2017, 108) (Smith 2022).
<u>Wild</u> - Species that have never been domesticated (Urbanik and Johnston 2017, 351) (Smith 2022).
<u>Feral</u> - Species that have been domesticated reverting back to wild behavioral patterns (Urbanik and Johnston 2017, 352) (Smith 2022).
<u>Spectrum of socialization (to humans)</u> - the willingness of an animal to interact with humans of their own volition (Kessler and Turner 1999) (Smith 2022).
<u>Commensalism</u> - a biological relationship between organisms where one organism benefits and one organism sees no benefit or harm (Hulme-Beaman et al. 2016) (Smith 2022).
<u>Mutualism</u> - a biological relationship between organisms where both organisms benefit (Boucher, James, and Keeler 1982) (Smith 2022)
<u>Cat Colony</u> - A cohesive loosely familial social group associated with a central place of habitation that distinguishes them from other groups of cats or individual cats in the general vicinity (Smith 2022).

Figure 2: Guide to terminology used throughout the thesis.

There is no set definition or parameters for what makes a feral cat colony because the colonies can be fluid in nature, cats coming and leaving, and feral cats are difficult to count due to their avoidance of humans (Fieseler 2021). Based on my experience in the field and the available literature, I will be defining a feral cat colony as a cohesive loosely familial social group associated with a central place of habitation that distinguishes them from other groups of cats or individual cats in the general vicinity. These colonies are generally based on related adult females and their children with less numerous, more nomadic adult males (Fieseler 2021).

The treatment and place of feral cats within human society continues to be a controversial subject for local governments, citizens, volunteers, and non-governmental organization groups. In this thesis I examine the spatial relationship between feral cats and humans in Lawrence, Kansas as a case example of urban cats and their colonies in similar urban/suburban settings across the United States. My research focuses specifically on what environmental variables determine the locations of feral cat colonies. In 2019, I began volunteering at the Humane Society of Lawrence and was introduced to this topic through their newly created “Trap, Neuter, and Return” or “TNR” program. In order to investigate the locations of cat colonies and how they interact with the human-made environment, I performed an ArcGIS analysis and in-person investigation with the data provided to me by Lawrence Humane Society.

Background

The City of Lawrence first implemented a Trap, Neuter, and Return (TNR) program in 2019 to manage its feral cat population. The feral cat population of Lawrence is considered problematic because of the burden feral cat colonies place on the Lawrence Humane Society (LHS), the potential of the colonies to grow exponentially, the nuisance behaviors of the cats, and the threat to the bird population. Feral cats place a large burden on LHS because they can

only be adopted out as barn cats due to their lack of socialization. The demand for barn cats is far outstripped by the large numbers of feral cats taken in by LHS each year. Thus, the feral cats sit in the shelter for long periods of time and become a major strain on the resources of LHS: \$568,175 in 2017 alone (Lawrence City Commission, 2018). The burden on LHS is worsened by the ability of feral cat colonies to grow exponentially due to large litters and frequent pregnancies. Colonies are also often bothersome to community members because of nuisance behaviors such as loud vocalizations at night, defecation, and spreading garbage (Turner and Bateson 2014). Lastly, cats living outdoors are a threat to the local ecosystem as an invasive species. In Lawrence, many community members expressed concern that the colonies were reducing the local bird population (Lawrence City Commission, 2019).

The TNR program was settled on as the feral cat management technique for Lawrence as a result of the advocacy of the LHS, changes in local law, and a survey of Lawrence citizens. LHS advocated for TNR as a management strategy to reduce the feral cat population of Lawrence, and therefore the burden placed on LHS, over time in a humane way. They presented the outline of the TNR program to the city council after which a survey was posted on the city website to gauge public opinion (Lawrence City Commission, 2018). The majority of those surveyed were in favor of implementing the TNR program and thus the city council passed ordinance 9615 (Lawrence City Commission, 2019). The passing of ordinance 9615 allowed for the TNR program to be operated legally as it allowed community cats, defined by the ordinance as an unsocialized cat with their ear tipped as evidence of sterilization, to be exempt from the restrictions on free roaming animals (City of Lawrence, 2019). LHS was assisted in creating a viable program by Topeka Community Cat Fix which also provided an example of a productive program in neighboring Topeka, Kansas (Lawrence City Commission, 2018).

The TNR program involves the citizens of Lawrence trapping the feral cats on a voluntary basis and bringing them to the Lawrence Humane Society to be neutered or spayed. Citizens can do this on an individual basis for smaller numbers of cats or allow the team of designated volunteers from the Humane Society to organize a larger scale trapping event. The volunteer TNR team, led by a humane society employee, also performs door to door canvassing, based on messages sent to the team's email address that is dedicated to public outreach and to determine if a particular colony is present and ask for permission to neuter any feral cats present. After they have been neutered or spayed, they are released back into the community by the Humane Society with a corner of their ear removed to identify them as already neutered. The process of TNR can be an involved one for volunteers and thus there are likely a higher population of feral cats present in Lawrence than are recorded by the Lawrence Humane Society. The Lawrence Humane Society has based their program on an existing one in Topeka, Kansas. The Topeka Community Cat Fix is a cat population control program that has been utilizing the TNR system since 2014. The Community Cat Fix works in collaboration with local Topeka veterinarians and Kansas State University College of Veterinary Medicine's Shelter Medicine Program to vaccinate and neuter stray cat populations (Topeka Community Cat Fix 2021). The Topeka program conducted training for volunteers from the Lawrence Humane Society on the TNR process, serving as an operational model for their TNR team.

The Lawrence Humane Society anticipates that some individuals in the community will take on informal roles of guardians or caretakers of the feral cats for feeding and emergency veterinary care. These caretakers go undocumented, as feeding feral animals is illegal in some cities, but are identifiable by food placed out in the open around which the colony will revolve. TNR is a departure from previous, more conventional programs, of attempting to adopt out or

euthanize, by injection, trapped cats. The arguments for TNR programs are that it is more humane than euthanasia and should reduce the feral cat population over time. The claim that TNR reduces colonies over time is unconfirmed and controversial (Deak et al. 2019). The arguments against TNR programs are that TNR is ineffective in reducing the feral cat population and that feral cats are invasive species that are detrimental to native species and could now be considered nuisance animals or “pests” that are subject to less humane methods of euthanasia (Deak et al. 2019). The literature on TNR is currently split on the effectiveness of TNR. The major reason for the divide is the difficulty in measuring the success of a TNR program. There are a number of variables involved in the success of a TNR program such as community engagement, funding, size of the colony, trapping methods etc. that make success or failure difficult to evaluate (Turner and Bateson 2014). Nonetheless TNR is a rapidly growing management strategy for feral cat colonies. Lawrence is only the most recent in a line of smaller cities in Kansas to implement the TNR program that has been previously practiced on a volunteer basis there and in the greater Kansas City area. The trend of government sanction is a recent movement. There has been a trend of local governments legalizing the feeding of unowned or outdoor cats. TNR represents a new method for managing feral cat populations for the Lawrence Humane Society, but feral cats in Lawrence have generally been the responsibility of LHS in collaboration with the City of Lawrence’s Animal Control prior to the start of the TNR program.

The Lawrence Humane Society has compiled a body of spatial data regarding feral cats through recording the location of each stray cat prior to being brought into the shelter. This data predates the TNR program and has continued after its implementation. The locations of where the cats are picked up are recorded in either a street-intersection format or an actual address

within the City of Lawrence. The existence of this data on the pickup locations of the feral cats allows for spatial analysis using Geographical Information System (GIS). This database of locations can be plotted on large-scale base maps of Lawrence to produce an accurate snapshot of the feral cat population in 2019. The frequency of a single pickup location also allows for the differentiation between colony groups, multiple cats generally picked up at one time or within a small-time frame of one another as part of the TNR program, and single stray cats brought in over larger periods of time. This is an important distinction because the purpose of this research is to understand the place characteristics preferred by a group of feral cats instead of the range of a single stray cat. In order to understand the place of feral cats within geography and the broader context of the spatial aspects of human-animal relationships it is important to consider my research within the existing literature.

Literature Review

History of Animal Geography

I situate my research within the context of the animal geography literature, providing a brief chronological review of the history of animal geography. The most straightforward way of analyzing the history of animal geography is through the delineation of three, possibly four, different waves or time periods in which the dominant focus of research shifted. The concept of the three waves was initially proposed by Wolch, Emel, and Wilbert in 2003 (Wolch et al. 2003) and then further explored by Julie Urbanik in her 2012 book *Placing Animals: An Introduction to the Geography of Human-Animal Relations*. The first wave covers the early 20th Century, the second wave covers the mid-20th Century, and the third wave begins in the 1990s. A fourth wave has been proposed recently to encompass the most recent 21st century research (Colombino

2020; Hovorka 2018). However, the waves are not completely defined by their time periods but philosophical change within the field of what is now called animal geography.

First Wave: Zoogeography

The first wave of animal geography is often referred to as Zoogeography (Urbanik 2012). Zoogeography was a prominent field of research within geography during the early 20th century. The hallmark of zoogeography is the exploration of spatial distribution of wild animals. The focus on spatial distribution was common in this period of regional geography for plants, soils, climates, etc. and thus animals were a logical next step. This early body of animal geography research generally focused on the quantifiable attributes of animal geography (Wolch et al. 2003). Bartholomew, Clarke, and Grimshaw authored one of the most prominent early geographical works with animals as its major subject in 1911. Their work, *Atlas of Zoogeography*, was a series of maps depicting the spatial distribution of various species around the world; they cataloged animals based on their regions to further explore the environmental determinants affecting species diversity. This was accomplished by dividing the world into zoological regions and listing the species present in those regions with a brief description (Urbanik 2012). Marion Newbigin followed soon after with *Animal Geography* in 1913, rooted her work in spatial distribution and catalogs but emphasized the need to integrate fauna with flora and focus on animal adaptations (Wolch et al. 2003).

W.C. Allee and Karl P. Schmidt began the transition into the second wave with *Ecological Animal Geography* in 1937, which was based on *Tiergeographie auf ökologischer*, by Richard Hesse, published in German in 1924. Hesse provided the basis for *Ecological Animal Geography* by cataloging animals based on their biomes in a similar manner to Newbigin, Bartholomew, Clarke, and Grimshaw. Subsequently, Allee and Schmidt built on this research by

adding material that analyzed animals' interactions with their environment and the effects of those interactions (Hesse et al. 1937; Urbanik 2012). Allee and Schmidt also penned a book chapter in *Ecological Animal Geography* entitled, "The Effect of Man on the Distribution of Animals," that went beyond the previous focus of zoogeographers and helped paved the way for the second wave of animal geography by beginning an examination of human involvement in the spatial distribution of animals (Hesse et al. 1937; Urbanik 2012). "The Effect of Man on the Distribution of Animals" explored how humans affect other species around them by altering their shared environment. The addition of the human element to Allee and Schmidt's work can be seen as predecessor to the second wave of animal geography's greater emphasis on human-animal relations.

Second Wave

The second wave, called cultural animal geography by Charles Bennett, took shape in the mid-20th century by building on Carl O. Sauer's original concept of "cultural landscapes." Sauer studied how cultural landscapes were produced from cultures altering the physical landscape (Sauer 1925). Sauer focused on cultural landscapes, and he recognized animals and the domestication of animals as vital components of how landscapes are transformed (Sauer 1969; Wolch et al. 2003). The inclusion of domesticated animals, and by default human-animal interactions, separated the second wave of animal geography from the first which focused on other areas. Geographers interested in animals began to build on Sauer's theoretical foundation by researching the domestication processes of individual animals, comparing spatial domestication differences, and generally investigating how human-animal interactions shape the cultural landscape (Wolch et al. 2003).

Some prominent examples of second wave animal geography researchers following in Sauer's footsteps include Daniel Gade, Charles Bennett, Robin Donkin, Frederick Zeuner, G.S. Cansdale, James Baldwin, and Frederick and Elizabeth Simoons. In 1960, Charles Bennett called for a "cultural animal geography." Bennett was influential among scholars of the second wave of animal geography having views that aligned with those of Carl Sauer. Bennett (1960, 14) proposed that the study of the cultural and physical relationships of animals and humans with their environment should be the domain of geography as opposed to zoology, ecology, etc. (Bennett 1960). Bennett was not calling for more zoogeography but a reinvigoration of the spatial considerations of zoogeography combined with the new focus of the role of humans in the cultural landscape (Bennett 1960; Wolch et al. 2003). Daniel Gade explored the domestication of the guinea pig in the New World. This was key research on New World domestication and how it differed from the more plentiful Old-World domestication. Gade found that the guinea pig was used as a part of the traditional cultural practices such as serving as ritual sacrifices and pets as well as a means of sustenance (Gade 1967). Robin Donkin also looked at domestication in the New World where he researched the muscovy duck and the peccary. Donkin and Gade researched the muscovy duck as the one of the few animals, along with llamas and alpacas, to be domesticated in the Americas and the only bird domesticated in South America (Gade 2000a; Gade 2000b; Donkin 1985). As for the peccary, Donkin asserts it was most likely on its way to domestication at the time of European contact (Donkin 1985, 100). Donkin attributes domestication in the New World to cultural practices and preferable animal characteristics foremost with the economic benefits of domestication occurring as a consequence after the fact (Donkin 1985; Wolch et al. 2003). Prior to the research and writing of Sauer, domestication was seen as an economic process, primarily used to increase the availability of animal resources for

the community with the cultural significance coming after the economic significance. Donkin refuted this by arguing that domestication took place first for religious and cultural reasons and the economic benefits came as a beneficial side effect (Donkin 1985; Wolch et al. 2003). Pet-keeping practices, however, acted as a conduit that is both social and economic in traditional societies when a forest species raised as a “pet” becomes “food” to meet a need.

Frederick and Elizabeth Simoons (1968) studied the mithan, a domesticated ox-like bovine ungulate in India. They found the mithan was used for ceremonial and religious purposes separate from the economic purposes previously thought to be at the heart of the domestication process. Animal products that were necessary for the functioning of the human population, such as food and tools, are economic benefits of domestication but not always the sole reason an animal became domesticated. The role of animals in cultural practices can be a more significant catalyst in the domestication process with the economic benefits coming after. The Simoons’ research on the mithan supports Donkin’s (1985, 102) conclusions on the significance of cultural components of domestication over domestication as an adaptation for survival (Wolch et al. 2003). Frederick Simoons worked with James Baldwin on an article exploring the role of human breastfeeding in the process of domestication. Both considered human females suckling orphaned animals as a major consideration in the domestication of certain species (Simoons and Baldwin 1982). James Baldwin is also known for researching domestication in Australia prior to colonial contact as well as identifying major themes involved in 20th century animal geography (Baldwin 1983). Baldwin’s theme structure was based on a previous work by Frederick Simoons and further delineated areas of research within animal geography (Baldwin 1987; Simoons 1974).

Frederick Zeuner furthered interest in the domestication of animals with his 1963 publication *A History of Domesticated Animals*. Zeuner's book serves as a collection of prior research on domestication and gives theoretical insight on the modes of domestication. Zeuner saw domestication as part of increasing human control over the natural landscape and thus his research fits well with Sauerian views of human-animal interaction (Zeuner 1963). G.S.

Cansdale was one of the few second wave geographers to move beyond animal domestication in a rural setting into research on human-animal interactions in a contemporary setting (Cansdale 1952). In *Animals and Man*, Cansdale explores many settings in which human-animal interaction takes place. Notably, Cansdale's research includes human-animal interaction that does not require a live animal, such as the use of animals as symbolism (Cansdale 1952). Although Cansdale was a relatively early second wave geographer, *Animals and Man* was published in 1952, his expansion of the cultural and physical settings in which geographic research regarding animals can take place was to become a hallmark of third wave animal geography (Urbanik 2012).

Third Wave

The third phase, known as animal geography, began in the mid to late 1990s (Urbanik 2012). Prior to the publication of "Bringing the Animals Back In" by Jennifer Wolch and Jody Emel in 1995, animal geography had become less prominent within the larger discipline of geography. Wolch and Emel (1995) challenged the anthropocentrism of the previous wave of animal geography as well as the social sciences as a whole. "Bringing the Animals Back In" was a first proposal of the concept of transspecies social theory as theorized by Wolch and Emel that was later expanded upon with their publication of *Animal Geographies* in 1998. The focus of *Animal Geographies* was deconstructing the previous dual society/nature approach of the

previous animal geographers and updating the theoretical basis of animal geography (Wolch and Emel 1998). Wolch and Emel proposed a more nuanced view of human and animal relations by viewing these relations as a network of both human and non-human interconnected actors as opposed to separate, often opposing entities (Wolch and Emel 1998; Wolch et al. 2003). Their new vision of animal geography shows the influence of actor-network-theory, webs of actors with each having the ability to influence or change the cultural and physical landscape, which was being applied to the social sciences in the late 1990s.

Actor-network-theory contributes significantly to this wave by introducing the concept of agency, which is then applied to animals (Colombino 2020). The introduction of animal agency adds complexity, and rejects second wave culture/nature binaries, to the field of animal geography by questioning the concept of humans as the sole actors in human-animal relations (Urbanik 2012). Jonathan Murdoch (1997) helped bring actor-network-theory to animal geography by stating that animals are their own actors with agency apart from their interactions with humans, also raising concerns on the dualistic nature of the previous schools of thought regarding the nature/society divide. Adding in the consideration of animal will and preference allows for a more nuanced analysis of the role of place in human-animal interactions (Murdoch 1997), that has been important in my research on feral cats.

Another major contribution to third wave geography was made by Chris Philo and Chris Wilbert with the publication of *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations* in 2000. Philo and Wilbert introduced the concepts of “animal places” and “beastly spaces” as a way of understanding how animals and humans navigate their physical and cultural landscapes as well as interact with one another in their spatial contexts (Philo and Wilbert 2000). “Animal places” are the places created by humans for animals, places humans

deem appropriate for animal habitation (Philo and Wilbert 2000). These “animal spaces” can be different for different species and vary depending on culture. A dog’s “animal space” may be in the home, a rat’s “animal space” may be in the laboratory, or a cow’s “animal space” may be in a slaughterhouse (Urbanik 2012; Colombino 2020). By contrast “beastly places” are the spaces animals choose to reside in and may be created or altered by their habitation (Philo and Wilbert 2000). These “beastly places” are often outside of the “animal spaces” that humans would deem appropriate. A dog may be living in abandoned human settlements, a rat may become an unwanted guest in an occupied human home or business, or a cow may make its way onto a highway (Urbanik 2012; Colombino 2020; Philo and Wilbert 2000). By showing how humans create arbitrary boundaries for animals and acknowledging that animals can show agency by transgressing these boundaries, Philo and Wilbert (2000) revitalized animal geography by bringing in the human geography concepts of space and place that would be further developed in the fourth wave.

Fourth Wave

The currently developing fourth wave of animal geography is defined by an increasing emphasis on “beastly places” and greater hybridization with other disciplines (Colombino 2020). Researchers who characterize the fourth wave are attempting to further the third wave research goal of centering animals more than humans (Hodgetts and Lorimer 2015). While the third wave focused on how humans interact with animals (“animal spaces”) the fourth wave seeks to understand the geography of animals in the animals’ context, “beastly places,” namely through methodologies focused on the lived experience of animals (Hodgetts and Lorimer 2015; Colombino 2020; Philo and Wilbert 2000). This new research perspective has been given the name “animals’ geographies” by Hodgetts and Lorimer to further emphasize that animals, not

humans, are the center of the study (Hodgetts and Lorimer 2015). A greater hybridization of animal geography with other disciplines, both social and physical, could aid the “beastly places” research goal by encouraging more holistic approaches to studying the geography of animals’ lived experiences (Colombino 2020; Hovorka 2018).

My research derives its theoretical basis from second and third wave animal geographers by applying their concepts to the feral cat colonies in Lawrence, Kansas. The second wave of animal geography, particularly the works of Sauer and Gade, has provided the basis of my research through their work on domestication as well as contributing a theoretical foundation in Sauer’s concept of cultural landscapes. Domestication is broadly important whenever animals or the cultural landscape are discussed because it has significantly contributed to the nature of modern cultural landscapes. Sauer and other second wave animal geographers studied domestication because they understood its role in how humans and animals interact with their environment and each other. The cultural landscape of Lawrence and the feral cat colonies that reside there have been directly influenced by the history of cat domestication as well as domestication as a whole. The particular history of the domestication of the cat and how that process allows for feral cat colonies in the modern day will be explored below in the literature review.

Sauer’s concept of the cultural landscape lays the foundation for exploring how cats and humans interact with their environment. In the cultural landscape of Lawrence, cat colonies determine where they reside based on physical alterations humans have made to the cultural landscape: alterations like adding buildings or sheds that the colonies use for shelter, and food sources such as open refuse or laid out cat food. It is these kinds of physical alterations of the cultural landscape that allow particular areas of Lawrence to become habitats for feral cats which

in turn influence the cultural landscape of Lawrence through their presence. The framework of physical alterations to the cultural landscape is a major contributor to the development of “places” of feral cats within the physical and cultural landscape of Lawrence. This is the basis my study attempts to build on and quantify.

The third wave of animal geography provides the other half of the conceptual basis of my research. The major concepts used in my research from the third wave include the focus on animals in the urban setting, animal agency, and human-animal negotiation of space and place in their shared habitat. The setting of my research, Lawrence, KS, follows in third wave geographers such as Wolch and Emel’s footsteps by studying animals as a part of the urban environment. The history of the domesticated cat is inextricably linked to the presence of human populations and urban areas continue to be the preferred environment for feral cat colonies. Studying feral cats in their chosen urban habitat is key to understanding the environmental characteristics that influence where they congregate.

Animal agency is a cornerstone of my thesis. My study adopts the perspective of cats choosing habitats for themselves instead of assuming humans are the only actors influencing the locations of feral cat colonies. Philo and Wilbert’s concept of “animal spaces and beastly places” is relevant to my thesis because it provides a framework for addressing how humans and feral cats negotiate space in Lawrence. The “animal spaces” for cats in Lawrence are in the home, in the barn, or in the Lawrence Humane Society. Feral cat colonies inhabit the “beastly places” of Lawrence including behind bars, in mobile home parks, in sheds next to businesses, and wherever they can find enough food and shelter to sustain themselves. The dichotomy of these “animal spaces and beastly places” in Lawrence creates controversy but is not necessarily negative for the actors involved. Many residents express fondness for their community cats and

act as invested caretakers. Other members of the community find cohabitating with feral cat colonies problematic for a myriad of justifiable reasons like threats to wildlife, noise complaints, etc. Negative, positive, and neutral interactions between feral cat colonies and humans are connected to the negotiation of cultural, biological, and physical boundaries in Lawrence.

I have situated my research within the broad context of second and third wave animal geographers to add complexity to my exploration of why feral cat colonies thrive in specific areas of Lawrence. The concepts of cat domestication, pet-keeping, urban wildlife, and TNR will be discussed in the following sections to fill in the details to this broad framework and further contextualize my study.

Cat Domestication

The domestication process of *Felis catus* was influential in determining the place of cats within human societies and continues to play a vital role in how cats interact with humans as well as their environment. *Felis catus* is descendant of *Felis silvestris lybica*, the African wildcat, which was the only sub-species to be tamed out of the *Felis silvestris* species group and shares many behavioral characteristics with *Felis catus* (Ottoni et al. 2017). Recent research has found that cats were domesticated in two separate waves in two areas within the Fertile Crescent, Egypt and Mesopotamia around 10,000 years ago (Ottoni et al. 2017, 4; Ahmad et al. 2020, 4; Geigl and Grange 2019, 12). The domestication of the cat coincided with the Neolithic period due to the establishment of permanent human settlements and the rise of agriculture (Ottoni et al. 2017, 4). Permanent agricultural settlements meant that large amounts of grain were being stored for future use by the inhabitants.

The grain stores attracted rats as an abundant food source (Geigl and Grange 2019, 9). Thus, rats became pests to the human settlements by eating the grain and spreading disease (Ahmad et al. 2020, 4). Wild cats in the areas surrounding the settlements were the predators of these rats and began to change their behavior, overcome some wariness of humans, to access the large concentration of rats in the grain storage areas (Driscoll et al. 2007, 523; Geigl and Grange 2019, 3). The wild cats' predation on the rats in the grain storage areas initiated the commensal domestication pathway that created a bond with humans that increased over time due to the cats' behavioral instincts and abilities to become pest exterminators for the human settlements (Ahmad et al. 2020, 4; Driscoll et al. 2007, 519; Geigl and Grange 2018, 9). The cats gained easier access to prey and the humans avoided the disease and grain loss attributed to large rat populations (Geigl and Grange 2019, 9).

The mutually beneficial relationship between cats and permanent human settlements served to increase the bond between humans and cats over time (Geigl and Grange 2019, 13). The cat-human bond grew and diffused geographically, often when cats were transported to the rest of the world outside the Fertile Crescent on ships where they served as vital crew members used to guard against rats (Ottoni et al. 2017, 5; Geigl and Grange 2019, 12). Cats eventually began to be seen by humans, as evidenced in Egyptian art, as desirable domestic companions as well as a means of pest control (Ottoni et al. 2017, 4; Geigl and Grange 2019, 4). In Ancient Egyptian art, there is no discernable physical difference between cats pictured hunting and cats pictured lounging with their owners, implying the same cats could have occupied both roles simultaneously (Ottoni et al. 2017, 4; Geigl and Grange 2019, 5).

Unlike dogs, domestication in cats is marked by behavioral rather than physical changes, because cats were already perfectly suited to their task as exterminators of what is part of their

natural prey (Geigl and Grange 2019, 12). Selecting for spotted coats did not occur until the 13th century in Southwest Asia and the distinctive cat breeds we know today are only a product of the 19th century (Ottoni et al. 2017, 5; Geigl and Grange 2019, 12). Domesticated cats have largely been able to retain the hunting skills of their ancestors because of this lack of selecting for physical traits by humans and therefore can continue as exterminators as well as companions (Geigl and Grange 2019, 12). The dual nature of cats as both working animals, due to their behavioral instincts as opposed to trained animals, and companionship animals has been a reoccurring factor in cat-human relationships for thousands of years and continues to add nuance to how cats navigate human landscapes in the present day (Geigl and Grange 2019, 5). While historically cats were considered useful working animals as well as companions, today cats are often seen only as companions and consistently rank as one of the most common pets in many countries worldwide (Turner and Bateson 2014, 4). Even as a domesticated companion animal, cats can be seen as pests by local human populations. Cats can become seen as pests when their populations outside the human home grow too large and develop into feral cat colonies. Feral cat colonies can threaten native wildlife populations, spread disease, and display nuisance behaviors such as loud vocalizations at night (Turner and Bateson 2014, 217-218). Large cat populations can become problematic anywhere but inhabitants of locations with endangered species or fragile ecosystems are particularly likely to view cats as pests outside the home.

Pet-keeping Practices

The popular perception of cats as companion animals, also known as pets, has an important influence on the relationship between humans and feral cats. Cats that live outside of human homes are often managed differently than other animals that cohabitate with humans due to their domesticated pet status (Turner and Bateson 2014). This section of the literature review

focuses on human-animal relationships within the home, also known as pet-keeping. Pet-keeping was an important research topic for animal geographers of the third wave of animal geography as a part of their broader research in domestication. The first step in a discussion of pet-keeping is the definition of a pet or companion animal. The most basic definition is that of an animal that can be domesticated or tamed that serves as a companion and is allowed into the human habitat. Pets can be undomesticated species that have been tamed enough to bring into the human habitat such as snakes, fish, turtles or even deer, or, more popularly, domesticated animals such as cats and dogs. Humans have been domesticating animals as pets for over ten thousand years, selecting for particular appearance or behavior and manipulating their genes over time (Tuan 1984). Pets bridge the human-nature divide by allowing a controlled, domesticated animal into the “safe space” of the home (Elder et al. 1998). However, the place of pets in society is constantly being negotiated and re-negotiated by different groups.

Two geographers that attempt to understand the power dynamics in pet-human relationships are Yi-Fu Tuan and Emma Power. Geographer Tuan sees pet-keeping as an attempt by humanity to control part of the wild or animal domain. Tuan refers to the way humans physically manage their pets through individual alteration, like clipping a dog’s ears, to genetic alteration, like breeding for traits. Through these actions humans assert their power over the non-human arena (Tuan 1984, 95; Urbanik 2012). However, Tuan acknowledges that dominance is not the only way that humans and pets interact. Humans are often extremely affectionate towards their pets and truly love them. In fact, dogs are becoming ever more present in homes in the United States. Dogs are becoming so much a part of the modern home that they are replacing children, for a period of time if not permanently, for younger members of society (Power 2012). The pet-human relationship is representative of the relationship between nature and society. In

Western thought nature and society are dualistic forces that can be harmonious or conflictual. So too can human relationships with pets span the spectrum from admiration and control (Tuan 1984).

While humans go to great lengths to manage and control pets, pets also negotiate their own place in human society. It is important to remember that all animals, not least of all cats and dogs, are living things with their own agency. Dogs are often considered a part of the family and they certainly interact with families of their own accord. Dogs will often beg for treats, ask to be let out, and move their toys about the house. This shows agency on the part of the dogs as they are exerting influence on their human owners and surrounding environment (Power 2012). Similarly, any cat owner knows that domesticated cats are notorious for asserting their agency. Cats will often wake up their owner in the middle of the night to be fed, petted, or just because they want attention. Domesticated cats also visibly show agency through the dominance of their homes. They will routinely sleep wherever and whenever they want despite the protests of their human counterparts. In these ways both cats and dogs, the most common animals for pet-keeping, negotiate their human relationships (Power 2008). Feral cats are unique in that they transcend the cultural and psychological boundaries between pets and urban wildlife. While socialized indoor cats fit firmly in the pet-keeping arena which was discussed above, feral cats could almost be considered urban wildlife, which will be discussed below, due to being unsocialized and living outdoors outside human control.

Urban Wildlife

Animals that truly bridge the gap between wild and human spaces are considered to be urban wildlife, undomesticated animals with populations that cohabit with human populations (Adams 2016, 16). Synanthropes are undomesticated plant or animal species that have changed

their behavior to suit the anthropogenic environmental changes (Klegarth 2017; Gade 2010). Synanthropes are unrelated to domestication and evolution because their changes are behavioral, not biological (Hulme-Beaman et al. 2016). While the hallmark of synanthropes is their behavioral adjustments to human altered landscapes, the animal-human contact for those behavioral changes is not always initiated by the animals. Synanthropic animals do not have to enter the human domain of their own volition in order to adjust to it. House sparrows (*Passer domesticus*) are a notable example of a synanthropic species that were deliberately brought into the cultural landscape by humans that later adjusted their behavior to thrive outside of direct human control in a human environment (Johnston 2001).

We tend to think of many synanthropic species as pests, but they fall under the category of wildlife because they are undomesticated and unwelcome in the human home (Wolch, West, and Gaines 1995). Different societies and even individuals within those societies interact with synanthropic animals in varying ways. These interactions can be negative, where the human perceives this as an invasion of their safe space, or positive, where the human perceives this as a chance to interact with nature. Accordingly, animals will have different experiences as well. One human may feed them, a positive interaction for the animal, and another may try to injure the animal, a negative interaction (Wolch, West, and Gaines 1995).

One example of urban wildlife that experiences both positive and negative interactions is the opossum. Emma Power (2009) explored the relationship between humans and brushtail opossums in Australia. The opossums have adapted to the human population by scavenging for food in urban areas. Some of the urban residents rejected this bridging of human-animal domains and attempted to trap the opossums. Other residents recognized that brushtail opossums are native to Australia and were proud to live with them. Clearly humans' perceptions of animals can

depend on their individual and cultural preferences as well as physical landscape (Power 2009, 34). Another example of this porous urban border relationship, this time with domesticated animals, is the feral cats of the United Kingdom (Griffiths et al. 2000). Feral cats have a unique place when it comes to the borders between human and animal spaces. As domesticated cats, they are traditionally seen as pets and therefore belonging in the human home. However, when they lack a place in the human home, they begin to occupy a similar space to urban animals as pests by breeding, creating disturbances such as loud fights, leaving behind waste, and generally living outside direct human control. Even though they become pests outside the home, the perception of them as pets still remains. Humans take care of feral animals that belong to domesticated species more frequently than undomesticated urban wildlife. Residents will take time and effort to set out food, water, or even provide veterinary services. Although their place has changed, the cats are still perceived and therefore treated differently than urban wildlife pests (Griffiths et al. 2000). The following literature review will examine human relationships with urban wildlife at three different scales: at the national level, the state level, and the local level.

Urban Wildlife in the United States

Much of the research on urban wildlife in the United States goes beyond superficial characterizations of human-animal conflict. While urban wildlife includes significant numbers of non-mammalian animals, mammals are by far the most commonly studied (Urbanik 2012). The popularity of mammals is not restricted to urban wildlife studies but is a reoccurring pattern throughout animal studies as a whole (Urbanik 2012). The research discussed here concerns foxes, owls, crows, rats, coyotes, opossums, foxes, and deer. We see many of the same species discussed in the more-limited geographical scope of Kansas and Lawrence, perhaps surprising given the diversity of climate types and ecosystems across the country. This recurrence of

species suggests that many of these species could be considered synanthropes, animals that have implemented behavioral changes in response to living with humans in urban or suburban settings.

Foxes, opossums, squirrels, coyotes, gulls, crows, and rats were among the species singled out for research on their behavioral adjustments to life in urban environments. Foxes have adjusted to urban environments to the point that urban habitats are now considered to be quality habitats in contrast to popular belief that cities are inadequate habitats for animals (Handler, Lonsdorf, and Ardia 2019). The urban environment is considered acceptable as long as there is enough green space for the foxes to utilize. Foxes are able to capitalize on urban environments because of their omnivorous diet and scavenging abilities. The main benefit for foxes living near humans is the increased access to large amounts of food, usually in the form of accessible garbage (Handler, Lonsdorf, and Ardia 2019). Opossums also benefit from the increased food security in the form of human refuse (Meier 1983). The city and suburban settlement areas also offers the added bonus of a lower chance of predation. Opossums have adapted to the city by making their dens within human made structures the majority of the time over other natural options. While benefiting from the food and den availability, opossums still require at least some green space to thrive in the urban environment (Meier 1983). This green space is necessary for cover and travel as well as being somewhat of an unexplained preference for opossums (Meier 1983).

Like the fox and opossum, squirrels thrive in the urban environment. Fox squirrels (*Sciurus niger*) experience significantly less predation in the city than they do in rural environments, with their survival rates slightly higher in cities (McCleery et al. 2008, 135). These survival rates would be more significant if not for the large number of vehicular fatalities

(McCleery et al. 2008, 135). All three of these species of foxes, opossums, and squirrels have changed their behavioral patterns to the urban environment with the results being neutral or beneficial in the long term.

Coyotes have changed their travel behavioral patterns, spatially and temporally, to avoid human movements in urban environments. Coyotes have learned to avoid commercial areas in general and especially during daylight due to the likelihood of conflict with humans. Thus, coyotes travel through those areas, if necessary, at night and staying in areas of lower human density such as parks or residential areas during the day (Grubbs and Krausman 2009). When coyotes inhabit urban and semi-urban spaces, they retain their natural diurnal characteristics by preferring to spend the daytime in areas of lower human population density but have adjusted to using night cover to scavenge and travel through areas of higher human population density if food is unavailable elsewhere (Grubbs and Krausman 2009). This behavioral adjustment has proved beneficial because it allows them to traverse human space and take advantage of lower travel distances to food sources without incurring excessive human conflict.

Western gulls have changed their behavioral patterns to suit an urban environment by switching their food source to human trash from their traditionally eaten fish. Gulls with their roosts located in the urban parts of their native range have adapted to human presence by relying on human refuse as their main food source (Pierotti and Annett 2001). Gulls in more rural areas continue to depend on more traditional sources of food such as fish. However, this behavioral change regarding their food source is proving detrimental to the health of the gulls (Pierotti and Annett 2001). Western gulls who have become dependent on human trash as a food source have been shown to have an inferior reproductive performance compared to the gulls that have continued their traditional fish diet (Pierotti and Annett 2001). Western gull populations could

see a decrease in their population in the future if their reproductive decline continues from consuming human trash (Pierotti and Annett 2001). Thus, while the western gulls have changed their behavior to suit urban life, these changes have not been so beneficial to their species.

While western gulls switch their food sources based on their roost locations, crows will move the location of their roosts in response to anthropogenic habitat fragmentation. While moving roosts allows for habitat flexibility, it has not prevented crows from coming into conflict with humans. Prior to widespread urbanization, crows came into conflict with humans in rural areas as crop pests. Gade (2010) explained that as urbanization spread the rural habitats of crows became fragmented which forced them to adapt their roosts to urban locations. While successfully navigating the transition, they are once again in conflict with human populations due to their unwanted presence in cities. Gorenzel and colleagues (Gorenzel et al. 2000) documented an increase in crow population attributable to their expansion into urban habitats. Responses on when the crow populations started to grow and move into urban areas to roost vary by location but generally began in the span of the 1970s to 1990s. Gorenzel's study shows behavioral changes in crows across the United States which could indicate crows' increasing ability as synanthropes. While birds are common urban wildlife animals, there are also many mammals that have altered their behavior to suit the urban landscape.

Common urban wildlife species such as coyotes and rats have been the subject of studies investigating their location, distributions, and human attempts to control both. Grindler and Krausman (2001) identify the coyote's preference for greenery within urban areas. Being nocturnal, their behavior characteristic of moving at night serves them well in an urban setting. Several other urban wildlife species such as raccoons and opossums also benefit from being nocturnal. Coyotes prefer green spaces within the urban environment such as parks and lawns.

These can be relatively small green spaces as long as they are within reach of one night's travel, approximately 1 – 6 km, for the coyote (Grinder and Krausman 2001). The coyotes actually seem to prefer the human made green spaces of urban areas over the natural spaces for the majority of the time. This preference justifies their continued classification as urban wildlife. However, they still avoid dense commercial areas that lack the green space they require (Grinder and Krausman 2001).

Rats also display a tendency to congregate in certain areas based on the human-made landscape. The place characteristics most significant for rat populations are the presence of subway lines that allow for movement with limited human contact and public property. Other place characteristics associated with rat populations are multi-family housing, older housing, unmaintained or abandoned properties, and open trash (Johnson et al. 2016, 22; Walsh 2014, 8). Indeed, social-demographic patterns of the human population have been correlated to the rat population and sightings. Neighborhoods with lower income and lower education were consistently found to have larger rat populations. Presumably, this is due to a lack of financial resources for rat population management and for building maintenance (Johnson et al. 2016, 22; Walsh 2014, 12).

Deer, rats, and crows have all been the subjects of studies researching how their populations can be managed. A major factor in the need to manage their populations is their ability to live with or near relatively dense human populations. In Missouri, an attempt was made to manage deer populations by translocation (Beringer et al. 2002). The effort was made as an experiment in the most cost-effective techniques to control deer populations which can grow large in a short amount of time. Too large of a deer population in urban areas can become problematic for the populace due to an increased risk of vehicular accidents, health concerns due

to the diseases insects on deer can carry, as well as damage to local gardens. The translocation proved to be too expensive with too high of a mortality rate to continue but was another example of the ongoing negotiation of space between humans and urban wildlife (Beringer et al. 2002).

Similarly to deer, rats have also been the subjects of various control methods. However, management methods cannot be standardized across the board due to differences in the animal's behavior, biology, etc. Rat movements have been studied as an avenue for developing more effective human controls of their populations in urban areas. Rats are of interest to those studying urban areas, as well as to human health officials, due to the diseases that rats can carry and their ability to thrive among large human populations. Multiple studies (Byers et al. 2019) in the last 50 years have determined that rats generally stay within their home ranges unless change in their environment takes place. In urban areas this means that rat populations will be most likely to move based on the availability of food and the structure of the human-built environment around them. While more knowledge on rat behavior is needed, this information is valuable for controlling rat populations. These studies suggest that human environmental intervention is already responsible for the location of rat colonies and therefore could also be utilized to control those colonies (Byers et al. 2019).

Urban Wildlife in Kansas

To provide specific contextual information on urban wildlife for my research, I explored the common urban wildlife species in Kansas. Much of the story concerning urban wildlife can be gleaned from local media outlets. While several studies exist on urban wildlife in Kansas (Durbin and Brodsky 2019; Wait and Ahlers 2020; Maccarone and Janzen 2005), there are common urban wildlife species that lack scholarly attention and there remains much to learn about the presence of these urban wildlife species – coyotes, rabbits, foxes, and skunks. The

state-level scale of analysis allows a more regional and specific analysis of urban wildlife, while giving greater context for urban wildlife in Lawrence, Kansas (discussed below). The major concern about coyotes that popular news sources address is their tendency to prey on small animals, including pets. Their diet places coyotes into conflict with humans in urban or suburban settings because they prey on unaccompanied pets like small dogs or chickens (Campbell 2020). Foxes earn similar complaints due to their similar predation patterns. Their behavioral characteristics, similarity to coyotes, push them into cities and suburbs due to competition with coyotes for prey (rodents, birds) in rural areas (Glick 2011). While too small to regularly prey on small dogs, foxes commonly invade chicken coops. Additionally, there are many mostly unfounded concerns for human health and safety such as attacks on children and communicable diseases when foxes are spotted by urban residents thus creating a disturbance based only on their appearance (Glick 2011).

Other species noted for their disruptive habits are skunks and rabbits. Skunks owe much of their disruptive reputation to the odor they emit as a defensive mechanism. The odor can be a serious nuisance due to its lingering qualities (K-State Extension Wildlife Management 2018). Rabbits can provide general disturbances like nesting under porches and decks or on lawn edges, also for eating plants from local gardens, being notorious for their voracious appetites. They pose the biggest threat to human-built environments in the form of gardens. Gardens act as a buffet-like source of fresh produce for rabbits whose populations can grow rapidly given an abundance of food (Keyser 2015). While articles from most news sources do not have the in-depth analysis that a scholarly work does, they can still be a valuable resource for examining urban wildlife species relationships with humans.

The major themes that are common to academic studies regarding urban wildlife involve investigating the species' level of adaptation to urban environments, the location of species, as well as how their location can be managed, and their population studies. Some species that have been formally studied in Kansas include opossums, owls, red foxes, fox squirrels, cats, raccoons, and deer. All of these animals were subjects of Durbin and Brodsky's 2019 study on how human population density affects species richness. The results were based on photos from motion-capture cameras set up in four different location types in Pittsburg, KS (Durbin and Brodsky 2019). The four location categories were rural, semi-rural, semi-urban, and urban. The deer, opossums, coyotes, and raccoons preferred to locate themselves in areas with less human density in comparison to the cats and red foxes who preferred locations with higher human density. The fox squirrels stood out as the only species that seemed to frequent a location without regard for the human population density (Durbin and Brodsky 2019). The urban and rural locations saw the greatest number of different species. The pictures taken in the urban location were predominantly cats as opposed to the rural location where cats appeared less often (Durbin and Brodsky 2019).

Additionally, opossums and owls were the focus of individual studies regarding location and adaptation as well. While opossums were noted to have populations in both rural and urban locations, they were shown to prefer urban locations with higher human population density over rural areas with lower human population density. This may be due to the fact that their survival rates are significantly higher in urban areas than in rural areas. The exact reason for the higher rate of survival in urban areas is unknown but may be connected to smaller predator populations and larger amounts of food available. This indicates a notable level of behavioral changes to suit urban areas such as using human garbage as a food source and buildings as habitats (Wait and Ahlers 2020). One study by Maccarone and Janzen (2005) that looked at owl pellets in an urban

roost in comparison to more common, rural roosts, indicated that the long-eared owls adapt their diet slightly based on location. The owls consume a larger percentage of house mice in comparison to their rural counterparts who prey on a larger variety of mice. The larger presence of house mice in the owl's diets is likely due to the house mice's own preference for urban environments.

Urban Wildlife in Lawrence, Kansas

An assessment of urban wildlife at a local scale is essential for contextualizing my thesis because my research scope is confined to the city limits of Lawrence, Kansas. Lawrence is a small city in northeastern Kansas with about 100,000 inhabitants nestled in surrounding farmlands of mainly soybeans and corn cultivation (United States Census Bureau 2019a). Situated about 40 miles west of the Kansas City Metropolitan area and about 25 miles east of Topeka, the area to the east of Lawrence has experienced rapid urbanization along the K-10 corridor as a consequence of Kansas City Metropolitan area's increasing urban sprawl. There are several urban wildlife species that have made their home in Lawrence such as raccoons, coyotes, rabbits, skunks, squirrels, opossums, mice, and rats. The presence of urban wildlife species is generally documented through local media (Burke 2012a; Burke 2012b) and focuses on human-animal conflicts due to health concerns, predation of kept animals, threats to gardens, and a general tendency to disturb the built human environment.

One urban wildlife species that is commonly associated with health risks for humans and pets alike are raccoons. Raccoons can carry diseases, with rabies and distemper being the most serious and common concerns. In 2012 the City of Lawrence saw enough raccoons with distemper to issue a warning to pet owners, as humans cannot contract distemper from animals, to prevent the disease from spreading to domesticated animals (Burke 2012a). Another threat to

pets from urban wildlife is predation. Coyotes are well known for preying on small, domesticated pets when they are readily available compared to other prey. Lawrence has seen an increase in the coyote population in the last decade that has meant an increase in conflict with humans over pet predation (Burke 2012b).

Another common source of conflict between humans and urban wildlife is the destruction of gardens. The manner of destruction depends on the species of urban wildlife and what that species is looking to find in a garden. Rabbits are known to significantly damage gardens for food (Oldridge 2007). Rabbits will eat the foliage of most common garden plants such as coneflowers, tulips, etc. as well as any tree bark they can reach (Oldridge 2007). This increased food availability from gardens coupled with the lack of predation in and around cities leads to population increases which exacerbate the problem (Oldridge 2007). A much less desirable and relatively common urban wildlife species, skunks, also damage gardens in search of food but using a different behavioral pattern. Skunks damage gardens by digging in search of insects hidden in the soil (Smith 2011). This behavior is a visual reminder of the human-animal conflict and negotiation of space that takes place within the urban landscape.

Finally, species that fall under the definition of urban wildlife tend to be controversial based on their location in urban spaces instead of any specific behavioral traits. Almost any animal that is considered urban wildlife could also be classified as a pest in a specific setting but those most commonly cited in the news sources in Lawrence are raccoons, skunks, squirrels, and opossums. Raccoons have been documented causing havoc rummaging through refuse, getting stuck in various places such as trash bins, and generally residing where they are unwanted (Fray 2009). Skunks will dig holes, live under human residences, and spray a lasting odor over humans and pets alike (Smith 2011). Squirrels and opossums also tend to chew through things and

usually end up in the trash, but they also continue to be major pests after death. One of the largest complaints that the City of Lawrence sees regarding urban wildlife is the remains of various species found on the roadways (Valverde 2017). This reinforces the fact that many urban wildlife species are seen as pests because of their occupation of places deemed to be human places by humans and unfit for the habitation of wild animals.

Mice and rats, common urban wildlife species, were studied within the City of Lawrence in the 1940s (King 1950). The home range of the norway rat and the house mouse were studied on a commercial city block of Lawrence in the 1940s. Both the norway rat and the house mouse are invasive species that are seen in virtually every urban setting in the United States. They appear to fit the same niche and behave similarly. The main finding from the study (King 1950) was that the home range and habitat of these rodents were determined by the presence of dense human population and specifically human garbage. The rodents cluster around these food sources and form colonies there. These mice and rats are not only adjusted to the urban setting but are actually reliant on dense human populations.

Feral cats are unique in that they have characteristics of urban wildlife while belonging to a domesticated species. They cohabitate with humans in urban areas, are sometimes seen as pests, and live outside direct human control. Feral cat-human relationships often resemble the urban wildlife relationships noted in this section but cannot be wholly categorized as urban wildlife because of their status as domesticated. However, they cannot be categorized as pets or working animals either due to their lack of ownership, place in the home, or services to humans. The symbiosis between humans and *Felis catus* makes it difficult to categorize as a species due to the varying nature of their relationship with humans.

The relationships between cats and humans are most often characterized as commensal or mutual. A commensal relationship is a biological relationship between organisms where one organism benefits and one organism sees no benefit or harm (Hulme-Beaman et al. 2016). A mutualistic relationship is a biological relationship between organisms where both organisms benefit (Boucher, James, and Keeler 1982). A fully socialized cat living in the home could be considered to be in a mutualistic relationship with their human owners because they provide companionship in exchange for food and shelter (Hu et al. 2014). A semi-socialized barn cat provides pest control in exchange for plentiful food in a mutualistic relationship that recalls the original circumstances of their domestication (Crowley, Cecchetti, and McDonald 2020). Feral cats living in colonies could be considered to be in a more commensal relationship with the humans around them than their owned counterparts. The colony cats are still benefitting from increased access to food, but the humans are not receiving the same companionship or pest control benefits (Hulme-Beaman et al. 2016). The category of a relationship between cats and humans is dependent on the context of that specific relationship between individuals or groups. How to navigate these relationships and negotiate shared space is a complex problem that communities around the world are considering. The presence of feral cat colonies in urban areas is an especially controversial issue with disagreement on management strategies. The management strategy discussed in this thesis is Trap, Neuter, Return (TNR) program, which has been increasing in popularity as a means to cohabit with feral cats while mitigating potential hazards to humans and cats involved.

Trap Neuter Return Programs

Topeka, Kansas

The “Topeka Community Cat Fix” is a TNR program that served as a model for the Lawrence Humane Society’s TNR program due to their years of experience and close proximity. Topeka, Kansas, the state’s capital, is a city of about 125,000 people in northeast Kansas with an area of approximately 63 square miles (U.S. Census Bureau 2020; U.S. Census Bureau 2019c). Topeka is located approximately 30 miles to the west of Lawrence, KS. Topeka Community Cat Fix, known as TCCF, is a non-profit organization that partners with Kansas State University’s College of Veterinary Science to provide TNR services, advocacy, and information to the city of Topeka and the surrounding community (Topeka Community Cat Fix 2021; Chilson 2016). TCCF finds cat colonies either by requests from caretakers or by targeting a certain zip code and canvassing for information on the local colonies. Canvassing is the term used in TNR for the process of going door to door to speak with residents and members of the community about the presence as well as ownership of outdoor cats. Once a colony is identified and the caretaker gives permission to neuter the colony, the volunteer trapping team goes out twice a month to trap cats.

The trapped cats are then neutered or spayed, vaccinated, treated for various medical conditions such as parasites, and finally have their ears tipped to identify them as sterile (TCCF 2021). The medical procedures are carried out by veterinary students from Kansas State University’s Shelter Medicine Program in their mobile surgery unit (Chilson 2016). This is mutually beneficial because the students get practice with neutering procedures while TCCF receives cost free veterinary services (Chilson 2016). The sterilized cats are then returned to their colony and caretakers. The whole process is completely free to the colony caretakers. TCCF takes a step further than other TNR programs by offering ongoing support to caretakers as

needed to ensure humane conditions. TCCF also actively advocates for feral cats and TNR programs (Topeka Community Cat Fix 2021). They have been instrumental in helping Lawrence Humane Society's TNR program establish itself as a local example, providing mentorship and collaboration.

Stillwater, Oklahoma

Operation Catnip Stillwater is a non-profit organization devoted to TNR based in Stillwater, Oklahoma. Stillwater is a small city in north-central Oklahoma with a population of about 50,000, has an area of approximately 47.5 square miles, and serves as the base for several colleges (U.S. Census Bureau 2019b; U.S. Census Bureau 2020). Oklahoma State University College of Veterinary Medicine runs the organization and provides neutering services to feral, stray, and community/free-roaming cats in the larger metropolitan area. The non-profit has been operating since being established in 2013 and currently alters hundreds of cats every year (O.S.U. College of Veterinary Medicine 2021).

Unowned cats are brought in one of two ways: individual citizens or by Operation Catnip's trapping team. Individual citizens can borrow traps available at the "trap depot," a shed adjacent to the main building, that is open on set times throughout the week. Trap rental is free for citizens of Stillwater, but a fifty-dollar refundable deposit is asked of those that live outside of the city limits. Alternatively, if individuals are not capable of trapping the cats themselves, they can submit a request form for Operation Catnip's volunteer trapping team to come out and perform the trapping (O.S.U. College of Veterinary Medicine 2021). The process of having members of the community submit the request for trapping is notably different than other TNR programs, such as the Lawrence Humane Society Program, which initiate contact with members of the community by going door to door at possible cat colony locations.

The trapped cats are brought to Operation Catnip Stillwater for one of their monthly TNR clinics during the academic school year. Once the cat is there it is sterilized, vaccinated, and marked as sterile with an ear tip (O.S.U. College of Veterinary Medicine 2021). The veterinarians will also assess and treat the cats for any basic conditions at this point. This work is performed by a combination of volunteers and veterinary students from Oklahoma State University (O.S.U. College of Veterinary Medicine 2021). The volunteers take care of the prep, clean-up, and other non-medical aspects while the veterinary students perform the operations and tend to other medical needs of the cat. This set up allows the veterinary students experience with sterilization surgery while providing a service to the community. Veterinary students are also provided with opportunities for research and several studies on communicable diseases in cats have been produced. Each clinic generally neuters anywhere from 100 to 200 cats (O.S.U. College of Veterinary Medicine 2021).

Gainesville, Florida

Operation Catnip Gainesville serves the city of Gainesville, Florida, and the surrounding community of Alachua County. Gainesville, Florida is a city of approximately 133,000 people with an area of about 63.75 square miles and is notable as the home to the University of Florida (City of Gainesville, Florida 2019). Operation Catnip Gainesville is an autonomous branch of the Operation Catnip organization founded at North Carolina State University in 1997. Operation Catnip Gainesville was founded in 1998 when Dr. Julie Levy of North Carolina State modeled the Gainesville program following the original program in North Carolina (Operation Catnip Gainesville 2020). Operation Catnip Gainesville is affiliated with the University of Florida and has its main clinic located within the university's College of Veterinary Medicine. Since its inception Operation Catnip Gainesville has sterilized approximately 65,000 cats in their

community by running spay and neuter clinics two days a week throughout the year (Operation Catnip Gainesville 2020).

Operation Catnip Gainesville operates using a similar system to Operation Catnip Stillwater and Topeka Community Cat Fix. They provide predominantly TNR services but set themselves apart by offering programs for kitten and facilitating cat placement with community residents. They accept unowned unsocialized adult cats from Alachua County for spay/neuter, vaccinations, and other basic medical care at the cost of 50 dollars each (Operation Catnip Gainesville 2020). The caretaker must fill out and sign a release form to ensure the cats are unowned and that the caretaker/owner is wanting them sterilized. Most cats are trapped and brought in by the community members that feed them and are generally responsible for them but there is a volunteer team dedicated to trapping and transport where it is needed. The cats are then spayed or neutered at one of the twice weekly clinics where they will then have their left ear tip cropped for indemnification as sterile. Each of the twice weekly clinics have the capacity to sterilize 250 cats for a total of 500 potential sterilizations every week. Each clinic offered can sterilize up to 250 cats. This is possible through a large team of volunteers including veterinarians and veterinarian students affiliated with the University of Florida (Operation Catnip Gainesville 2020).

Problem Statement

Feral cat colonies are often perceived, studied, and managed only through the lens of their species status as domesticated pets. While this may be an appropriate viewpoint for the study of socialized house cats, it is insufficient for feral cats. This is due to the fact that while cats are domesticated, they still retain their hunting abilities that allow them to survive

independently of humans. Thus, feral cats occupy a physical and cultural space between pets and wildlife and should not be researched from the perspective of pets alone. The research that has been done specifically on feral cats, as opposed to house cats, is often focused on human management programs such as TNR (Deak et al. 2019; Doherty et al. 2015; Gosling, Stavisky, and Dean 2013; Robertson 2008). This management focus leads to only a partial knowledge of the highly spatial factors at play in human-feral cat conflict. The way that both humans and feral cats interact in the urban landscape needs to be assessed to achieve a more holistic understanding of this complex dynamic.

My study assesses the interaction of feral cat colonies and humans in the urban landscape of Lawrence, Kansas. The overall question I am addressing is what variables, influenced by humans but chosen by cats, of the physical and cultural landscape inform where feral cats congregate in colonies? Additionally, how can these variables be evaluated while staying within the context of this master's thesis? My first objective is to assess the "place variables" of human population density, the sources of food utilized by the colony, the shelter available for colony habitation, and land use for their influences on the selection of the habitats for the location of the feral cat colonies. My second objective is to establish what the basic geography of feral cat colonies looked like in Lawrence during this study in 2019, providing a sort of baseline reference map for the community. Both of these objectives are meant to contribute to a more complete understanding of feral cat colonies in Lawrence. In order to achieve my objectives, I have mapped feral cat pickup locations in Lawrence with ArcGIS, explored possible significant place variables with Google Maps, created a cat density map for Lawrence, and performed an in-person investigation to evaluate place variables at ten different feral cat colony locations.

Study Area

My research occurs in the City of Lawrence, Kansas. Lawrence is a college town of about 100,000 inhabitants and home to the University of Kansas and Haskell Indian Nations University. The presence of the universities means that the population is significantly larger, as well as younger, during the fall and spring semesters. This population dynamic of migrating young people likely plays a significant role in the city's relationship with feral cats. The non-profit advocating for the TNR program in Lawrence, the Lawrence Humane Society, is another significant player, located at the far southeast corner of Lawrence. This is noteworthy because the majority of the feral cats reside in the eastern side of Lawrence.

Methodology

My methodology deployed a hybrid approach for researching feral cats in Lawrence, using participant observation, collaborative research, and GIS analysis. The first step I took was to join the new Trap Neuter Return program at Lawrence Humane Society (LHS) as a volunteer. This type of participant observation research allowed me to gain a hands-on knowledge of what cat colonies look like in Lawrence. I went out with other members of the volunteer TNR team on several occasions. My experiences including trapping cats for transport and alteration, observing colonies of over 100 feral cats *en situ* both before and after alteration, observing the preparation process for alteration, and canvassing neighborhoods to assess cat colony presence and community interest. After gaining contacts in LHS, I was able to obtain the feral cat pickup location data for 2019 that included over 700 entries, each of which records the location of where the cat was captured, the date, age, and other variables about each cat captured. The year 2019 was used instead of 2020 due to 2020 data being incomplete at the time I obtained it and it was also altered by the coronavirus outbreak. I narrowed down the various data in the entries to two

variables per cat: a) the location where the cat was picked up and b) the age of the cat at the time of pickup. The location where the cat was picked up is either recorded as an exact address or as the closest intersection to the collection point. I took a screenshot of a portion of the data in the excel spreadsheet illustrating the raw data of age and location that was inputted in ArcGIS (Table 1).

Table 1: Excel Spreadsheet showing age and pickup location of feral cats brought to LHS in 2019. Each row represents one cat. Each row (a single cat) was inputted into ArcGIS as a point at their respective pickup location.

	A	B	C
1	<u>Age (Months)</u>	<u>Location Found/Crossing</u>	
83	152.08	19TH ST. & KENTUCKY ST. LAWRENCE KS 66046	
84	15.21	19TH ST/HARPER ST LAWRENCE KS 66046	
85	60.88	19th Street/Harper Lawrence, KS 66046	
86	121.75	19TH STREET/HARPER LAWRENCE, KS 66046	
87	3.71	19TH STREET/HARPER ROAD LAWRENCE KANSAS 66046	
88	30.38	19TH STREET/HARPER STREET LAWRENCE KANSAS 66046	
89	2.46	19th street & massachussets street lawrence, ks 66046	
90	14.54	19th street& Stewert Lawrence, KS 66046	
91	1.17	19TH STREET & TENNESSEE STREET LAWRENCE KANSAS 66046	
92	1.17	19TH STREET & TENNESSEE STREET LAWRENCE KANSAS 66046	
93	22.38	19TH & BARKER ST LAWRENCE KS 66046	
94	30.42	19th & Massachusetts St. Lawrence, KS 66046	
95	30.42	1st Street & N Michigan Street, Lawrence, KS 66044	
96	15.21	2001 W 6th St. Apt. A-14 66044	
97	182.58	20TH & NEW HAMPSHIRE ST LAWRENCE KS 66046	
98	45.63	2100 W 27th Street, Lawrence, KS	
99	30.42	2127 Barker Ave, Lawrence, KS 66046	
100	28.33	21ST & HASKELL AVE,LAWRENCE,KS 66046	
101	45.38	21ST & LEARNARD AVE,LAWRENCE,KS 66046	
102	31.54	2200 Block of University Dr. Lawrence, KS 66049	
103	15.21	2200 Harper Lawrence KS	
104	30.42	2200 Harper St. Lawrence, KS 66046	
105	15.21	238 Michigan St. Lawrence KS 66044	

I constructed an ArcGIS database to analyze this dataset spatially. In order to set this data up against the background of Lawrence I imported three basemap shapefile feature class layers, 1) “Building Footprint”, 2) “Streets”, and 3) “City Limits”, from the Douglas County open-source GIS page and combined them into a single shapefile to create a basemap that visualized the Lawrence spatial data needed for my study (City of Lawrence, Kansas 2021). The three layers gave data on the addresses, roads, and buildings in Douglas County. After creating a basemap with these layers, I started the process of integrating the feral cat data into the basemap with ArcGIS. First, I created a new point-based shapefile in ArcMap to coincide with the pickup location for the feral cats. I converted the pickup location shapefile to the same coordinate system as the Douglas County basemap layers to ensure map accuracy. Next, working in ArcMap, I created two attribute table fields to record the age and pickup location variables. The ages are recorded as numeric float fields, fields that allow for a large range of possible numbers with decimals, and the addresses are recorded as text fields, fields that allow for alphanumeric symbols. Once my attribute table was set up, I manually inputted each data point and entered the cat’s age in the attribute table for that point. I located these points in ArcMap using the World Geocoding Service tool and verified the location using the attribute tables of the basemap layers as welling as utilizing *Google Maps*.

After inputting the cats’ locations and ages into ArcGIS, I selected 50 cat pickup locations to create a sample to analyze for reoccurring place characteristics to consider as variables in my study using *Google Map’s* “street view” function. The street view allowed me to observe and consider the numerous socio-environmental variables about the places the feral cats inhabit. The variables that I initially selected to explore for each feral cat pickup location included: property values, human density, presence/absence of refuse, type of residence (multi-

family or single family), land use, and upkeep of nearby buildings. I chose these initial variables based on my own field experience doing participant observation with the LHS TNR program and previous literature (Aguilar and Farnworth 2013; Aguilar et al. 2015; Hutchings 2003). Using Google Maps Street View to inspect the general vicinity, I determined if a variable was present and sorted that variable correctly. For example, if I noticed the pickup location was in a residential area, I then listed the type of housing present. I did this for each variable listed above for 50 cat pickup locations which allowed me to create an excel spreadsheet containing an exploratory sample that investigated the initial variables. The property value variable data was obtained it from the Douglas County, Kansas website's property viewer tool which provides property value data to the public (Douglas County Appraiser's Office 2021).

After analyzing the results of the exploratory sample, reflecting on my TNR experiences, and considering the existing literature, I decided that human population density, land use, sources of food, and available shelter would be the variables chosen for investigation. Human population density was chosen as a key variable because previous literature had shown a correlation between human population density and cat colony density (Aguilar and Farnworth 2013; Aguilar et al. 2015). Additionally, medium human population density was reoccurring in the exploratory sample, and I wanted to further explore this pattern. The feral cat density map also showed a possible human population density connection because of the clear clustering of the colonies in eastern Lawrence which has higher population density instead of western Lawrence which has lower population density. Land use was selected as a variable due to the results of the exploratory sample showing the majority of the pickup locations were in residential areas with single family homes. Land use was also a reoccurring theme in my experiences in TNR, as I had noted many sites I visited while volunteering were lower income residential areas and land use

has also been a variable used in other studies on feral cat colonies (Aguilar and Farnworth 2013; Aguilar et al. 2015; Van Patter and Hovorka 2018). A source of food is a vital habitat requirement for any animal and is often a key factor in the presence of feral cat colonies.

Experienced volunteers with the TNR program I participated in informed me that available food is a major draw for cat colonies and that the cats may move on to a different location if food is no longer available. Additionally, feral cat colonies are known to consume refuse as a main food source (Crawford, Calver, and Fleming 2020; Hutchings 2003; Fieseler 2021) so the presence of available trash or cat food is an important variable to sustain a colony as well as a critical piece of knowledge for colony management. Availability of shelter became a variable based on my experiences interacting with feral cats in the field. I observed that the cats rarely came out into open spaces and often rested in areas that provided some cover from the elements as well as privacy from humans such as underneath mobile homes, in sheds, in abandon buildings, and under cars. This observation has also been explored in prior literature (Normand, Urbanek, and Hicks 2021) and fit into the study well as a visible place characteristic.

In order to better visualize the cat pickup data and identify areas of high cat population density, I created a cat density map using the kernel density tool in ArcMap. After my raster had been created, I chose to classify the density data into ten different classes using the equal interval classification method with intervals of 13.62. Equal interval was chosen in order to convey the data in a readable way, allow for comparison to past or future studies, and to focus on areas of unusually high cat density without exaggerating the differences in density. I decided on ten classes to ensure the data visualization was detailed enough for large scale analysis but not so detailed as to manipulate the resulting nodes. The result was an isopleth map, a map that utilizes isolines to indicate areas of equal value. In the cat density map I created, the isolines are implied

through the use of a unique color for each area of equal value. I then overlaid the cat pickup location point shapefile layer and the City of Lawrence road line shapefile layer onto the kernel density layer to create a complete visualization of feral cat population density within Lawrence city limits in 2019 (Figure 3).

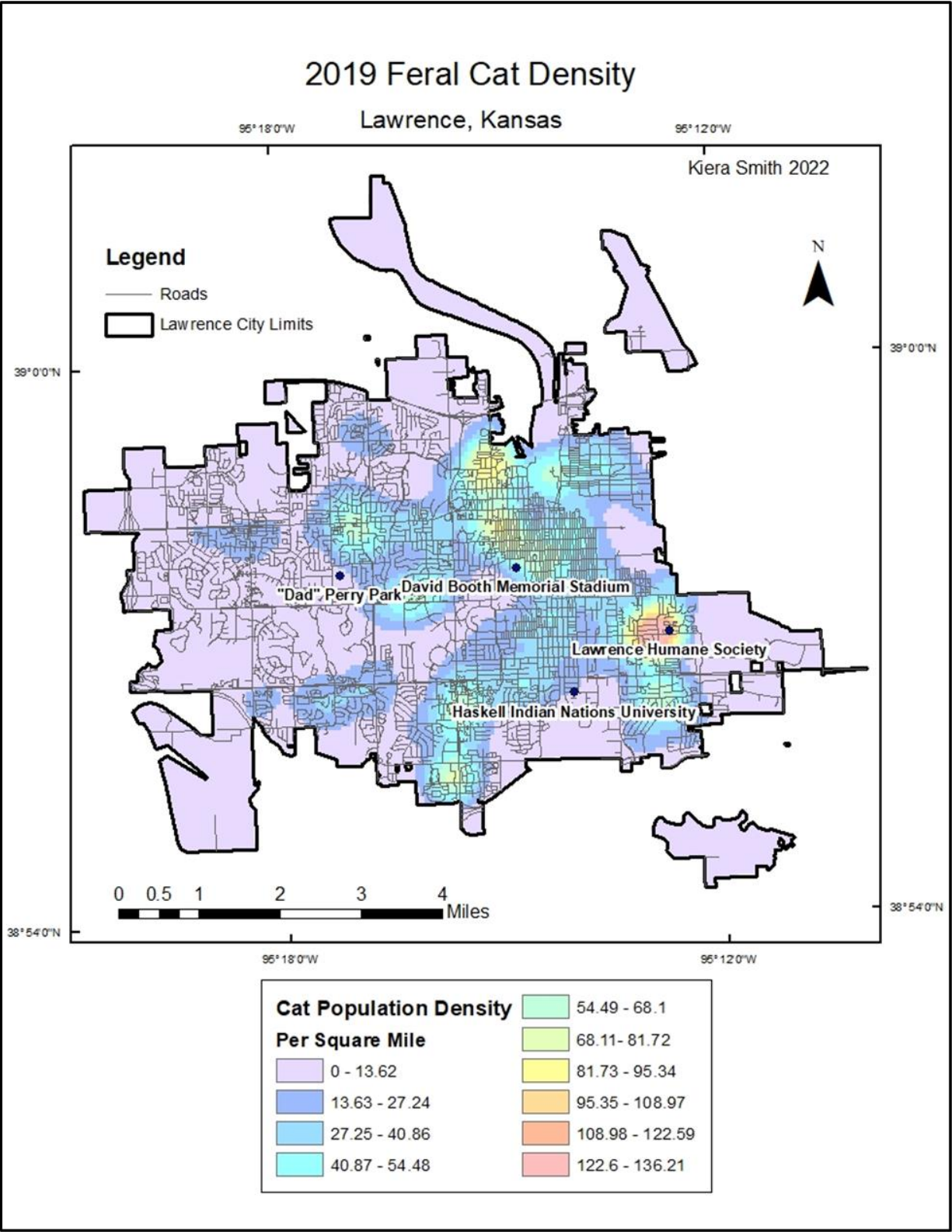


Figure 3: Map of the feral cat population density in Lawrence as of 2019. Locations are marked for reference.

The cat density map indicated different nodes of high cat density which I then narrowed down to the ten nodes with the highest cat density. In order to further investigate these findings, I designed a self-questionnaire to document my direct ground observations of the variables present in each node area. The self-questionnaire was a series of 16 questions I created to explore the environmental variables influencing cat colonies. I designed each question to be able to be answered with direct visual observation only and target one or more of my chosen variables. I then traveled to each location and answered the questions myself. Thus, the self-questionnaire was a method of recording my direct observations in a structured manner that allowed for comparison and analysis. An in-person investigation seemed to be the most appropriate based on the difficulty of continuing a remote GIS investigation compared to the relative ease and accuracy of gaining data through direct observation. Driving to each location took significantly less time and resources than trying to piece together a complete picture from remote data and thus was more appropriate for my research scope. An additional benefit was that all information gained in person was guaranteed to be up to date and likely more accurate than data found online. The self-questionnaire has 16 questions designed to gather information about the environmental variables present at each site as well as information about the human and cat populations present. These questions were meant to address the variables of human population density, land use, sources of food, and available shelter broadly as well as gain more specific site details for a broader picture of the habitat of these feral cat colonies. All questions were rooted in the existing literature, patterns in the exploratory sample, and my experiences with cat colonies as a part of the Lawrence Humane Society's TNR program.

Once I identified the nodes that indicated the highest density and designed my self-questionnaire, I narrowed my investigation area to one single intersection per node that was

chosen by overlaying the cat pickup location points shapefile on to the cat density map. I then selected the intersection with the highest recorded number of cats for investigation. The intersections chosen were Perry St. & N 1st St., W 2nd St. & Michigan St., W 8th St. & Michigan St., W. 11th St. & Indiana St., Kasold Dr. & W 10th St., Bob Billings Pkwy & Westbrooke St., E 19th St. & Harper St., Rawhide Ln. & Bonanza St., W 27th St. & Iowa (Frontage) St., and W 33rd St. & Fourwheel Dr. It should be noted that the node at E 19th St. & Harper St. has significantly higher cat density than the other nodes. There are feral cats in that area but there may be some human error exaggerating their presence. When employees at Lawrence Humane Society did not have a cat pickup location address to record in their records, they may have simply recorded the address of LHS which is in the same vicinity as E 19th St. & Harper St (see nodal concentration on map, Fig. 3).

Once these intersections had been identified I created a point shapefile layer to mark their locations along with a text attribute table field to record the crossroads. I created a map of Lawrence with the intersections labeled as a visual aid and reference (Figure 4). I determined that an approximately 100-foot radius would be an appropriate area around the center of the intersection to investigate with the questionnaire. A single intersection with a 100-foot radius was chosen because the area needed to be small enough to be investigated thoroughly by a single person but large enough to represent a significant portion of a feral cat's home range (Turner and Bateson 2014, 64). Investigating the node as a whole would have been too large an area to represent the home range of a feral cat in an urban area as well as too large to investigate myself using the self-questionnaire (Turner and Bateson 2014, 64).

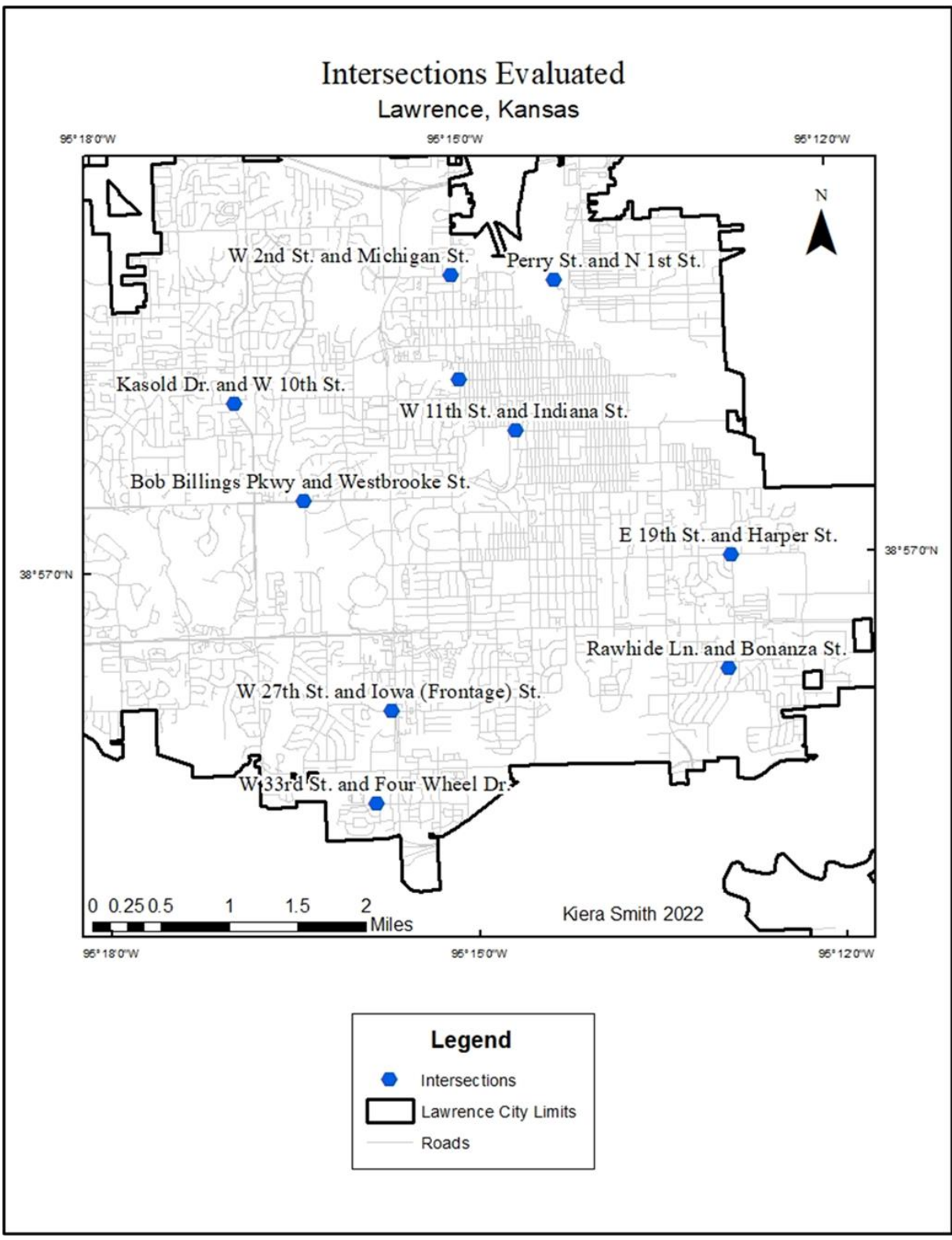


Figure 4: Map of intersections assessed in self-questionnaire.

I then traveled to each intersection selected and filled out the self-questionnaire based on my observations. This was done by traveling to each intersection by car, finding a parking place adjacent to the intersection, and making visual observations from the car or on foot. I was assisted in this process by fellow geographer Carolisa Watson who acted as a scribe, second observer, and resource for local Lawrence knowledge. This process was performed the same for all ten intersections within a single day in the mid to late afternoon. I then compared the questions across locations for basic statistics and insights into patterns. In order to organize the results in a visual way conducive to comparison, I created a table with one row for each question and response percentages (Table 2).

Table 2: Results of the self-questionnaire.

Question	Result
1. Commercial, residential, or mixed use?	Commercial= 20% Residential= 40% Mixed Use= 40%
2. If residential, single family, multifamily, or student housing buildings?	Single Family= 50% Multi-family= 10% Student Housing= 20% N/A (Commercial)= 20%
3. If commercial, what kind of business or industry is present?	Occurred once= Golf course, retail shops, hotel, fairgrounds Occurred multiple times= Restaurants (30% of intersections)
4. Public, Private, or mixed land ownership?	Public= 0% Private= 80% Mixed= 20%
5. Land a part of the KU campus?	Yes= 20% No= 80%
6. Special area nearby such as park, cemetery, church. Etc.?	Occurred once= Church, large park, Lawrence Humane Society, abandon building Occurred multiple times= Mobile home parks (20% of intersections)
7. Approximate parcel size (small, medium, large)?	Small= 50% Medium= 10% Large= 10% Mixed= 30%
8. Lots of open space and greenery or more compact buildings?	More Open= 40% More Compact= 30% Mixed= 30%
9. Daytime or nighttime populations?	Daytime= 30% Nighttime= 10% Both= 60%
10. Foot traffic level?	Low= 60% Medium= 30% High= 10%
11. Is this space popular with students, permanent residences, or both?	Students= 20% Permanent Residents= 60% Both= 20%
12. What does the general income level appear to be?	Lower= 10% Low-medium= 40% Medium= 30% High medium= 20% High=0%
13. Visibly placed cat food? Where?	Once at 1 st and Perry inside abandon building
14. Open/accessible refuse nearby? What and where?	Open dumpsters/scattered refuse= 60% No accessible trash= 40%
15. Shelter for cats available? What is it?	Structural shelter= 90% Brush only= 10% None= 0%
16. Any visible cats? How many?	<ul style="list-style-type: none"> One at 1st St. & Perry with signs of more hiding Multiple previously seen at 33rd St. & Four Wheel Dr.

Results

Human Population Density

The variable of human population density was addressed in questions 2, 8, 9, 10, and 11 in the self-questionnaire (see Table 2). Residential areas were common among the intersections with single family homes being more common than multi-family homes or student housing (see question 2). There was no discernable difference in preference for either open space or a denser urban landscape in question 8. Question 9 addressed the time an area would see the highest human population density. For example, a popular bar would see a higher population density at night while a church would see a higher population density during the day. The preference appeared to be a relatively even human population density throughout the day and night. Question 10 regarding human foot traffic showed that the majority of the intersections investigated had low to medium foot traffic. Low foot traffic would indicate only one or two people present at any given time while a popular student bus stop would be an example of high foot traffic. In question 11 the intersections were shown to be more frequently situated in areas that are commonly resided in by permanent residents as opposed to places the migratory student population reside in such as the University of Kansas dorms. The preference for residential areas with single family homes, medium density urban landscape, even human population density throughout the day, medium foot traffic, and permanent residents suggests that the cats are drawn to a mid-level human population density that provides the advantages of resources while minimizing direct human contact.

Land Use

Questions 1 through 8, and 12 all explored different aspects of land use as a variable. Question 1 recorded that residential and mixed areas were preferred over solely commercial

areas and single-family homes were the preference among the residential areas for question 2. In the less popular commercial or mixed areas of question 3 restaurants appear multiple times while golf courses, fairgrounds, retail businesses, and hotels all appeared once. The intersections also tended to be on privately owned land as recorded in question 4. The intersections that did include public property were partially on or near the University of Kansas campus land as seen in question 5. The special area section seen in question 6 is a catch-all category meant to encompass any particular aspect of the landscape that was noteworthy, unique, or relatively uncommon among Lawrence intersections. Generally speaking, this included any aspect of the landscape that contained something besides basic residences and businesses. The special areas noted in question 6 included a church, park, abandoned building and Lawrence Humane Society occurring once, with mobile home parks reoccurring more than once. The land parcel sizes tended to be smaller or mixed for question 7. The results for question 8 were fairly evenly mixed with no distinct preference for either open space or a denser urban landscape. For question 12 the general income level, based on what could be estimated visually, was mostly lower-middle to middle class. The land use results indicate a preference for private, residential, or mixed areas with smaller land parcel sizes and medium-density urban landscapes with some reoccurring areas being restaurants and mobile home parks.

Sources of Food

There are two sources of food commonly associated with feral cat colonies in urban environments: 1) humans directly feeding the colony by setting out food and 2) humans indirectly feeding the colony through accessible food scraps and trash. Feral cats also may hunt to supplement their diet (Fieseler 2021), but hunting is not evaluated here. The sources of food available to the colony was the focus of questions 13 and 14. The only visible cat food was

found in an abandoned structure at N 1st St. & Perry St. as seen in question 13. Question 14 addressed indirect feeding through accessible refuse. Any scattered trash or food scraps, open dumpsters, or other trash receptacles a cat could access were counted as a possible source of food. A little over half the intersection sites had some kind of accessible refuse. Most of the intersections did include accessible refuse as a food source, open dumpsters were a reoccurring element, but only one intersection had actual cat food laid out.

Available Shelter

Questions 6 and 15 concentrated on the shelter available for the colony to inhabit. The special areas noted in question 6 included a church, park, abandon building and Lawrence Humane Society occurring once with mobile homes reoccurring more than once. Question 6 is included in the available shelter variable section of the results as well as the land use section of the results because these special areas stood out compared to the more common residential and commercial land use types in Lawrence and can often provide shelter as well as being a notable type of land use. For example, mobile home parks are popular places for cats because of the crawl space underneath many mobile homes where the cats can seek shelter. Question 15 showed that shelter for the cats, beyond natural shelter such as brush, was present at 90% of the intersections. The kinds of shelter varied from abandoned buildings to openings under houses to carports or sheds. Almost anything that was openly accessible for a cat, large enough for a cat, and provided some protection from the elements, except for brush, was used as shelter. Overall, it appears that the cats do prefer human-made shelter that offers greater protection from the elements than natural cover provides. Feral cat colonies can be resourceful when it comes to shelter and often inhabit human-made spaces that are no longer occupied by humans or separate enough from direct cohabitation to allow the cats to avoid human contact.

Discussion

Human Population Density

Higher human population density has been linked to a more prominent feral cat colony presence in prior studies (Aguilar and Farnworth 2013; Aguilar et al. 2015) and Lawrence appears to have a similar pattern. The first indication of a correlation between human population density and feral cat density in Lawrence was the generally higher clustering of feral cat colonies in eastern Lawrence where housing is less spread out and the human population is denser than western Lawrence. Another variable that could be influencing the higher clustering of colonies in eastern Lawrence is available shelter because eastern Lawrence has significantly more outbuildings, sheds, breaks in the landscape such as fences, and older housing that could provide better shelter than the wide-open spaces of western Lawrence. Additionally, it should be noted that there are many socioeconomic factors, such as income level, that may influence the reporting of feral cats to animal control or the Lawrence Humane Society. However, I felt the rough human-cat population density correspondence seen on the cat density map still merited exploration, despite socioeconomic complexities, in the self-questionnaire. The results of the self-questionnaire support the prior findings but suggest the colonies may prefer areas of medium human population density over highly dense areas. I came to this conclusion because the results of questions 1, 2, 8, 9, 10, and 11 seem to indicate an overall need for enough space to avoid direct human contact as well as enough permanent residents to provide a food source beyond hunting. The preference for medium density areas supports the general characteristics of cat colonies. Colonies require a significant food source to support multiple cats and often prefer laid out cat food or accessible refuse, perhaps due to the reliability of anthropogenic food sources

throughout the year and the option to avoid expending energy hunting, which are produced by humans and more abundant in areas with larger human populations. However, the cats in feral cat colonies generally have little to no socialization toward humans and therefore avoid direct human contact as much as possible. Areas of medium human population density could offer the benefits of anthropogenic food sources while minimizing direct human contact. It is important to note that while the data shows a broad trend, it should not be taken as statistically significant. My speculation on the potential reasons for the trend is based on my experiences with feral cats and knowledge gained from prior literature but should not be considered definite.

Regardless of whether the cats of Lawrence prefer areas of medium human density or not, they still seem to show the same positive correlation between areas of higher human population density and higher prevalence of feral cats that is a reoccurring theme for feral cat colonies (Aguilar and Farnworth 2013; Aguilar et al. 2015). The feral cat colonies of Lawrence, as well as cat colonies in general, are choosing to cohabitate with humans of their own accord even when they are outside direct human control and could choose to avoid human populations in favor of more rural environments. This speaks to their agency as a species beyond the confines of the human home. They choose to create beastly places as pseudo-urban wildlife within the urban environment on their own terms despite being a domesticated species that also has a clear animal space as pets in the human home under direct human control. This adaptability is apparent in Lawrence where *Felis catus* occupies both animal spaces and beastly places.

The presence of feral cat colonies in human, urban environments bears a resemblance to the path that *Felis catus* took to domestication. Cats were domesticated in a gradual process as they were attracted to human settlements by rodent populations that accompanied large stocks of grain. The ancient cat-human relationship was mutualistic because the cats obtained easy access

to prey and the humans benefited from a lower rodent population. In the present situation feral cat colonies are attracted to areas of higher human population density for human produced food sources. The argument could be made that the modern relationship between feral cats and humans is closer to commensalism because the main party benefitting from the association is the feral cats while the humans are not seeing the same level of benefits. However, many caretakers feel they are gaining companionship out of their relationship with their colonies which would lean closer to mutualism. The status of *Felis catus* as a domesticated animal that lives in the human home as well as outside the home also adds nuance to the discussion of their place on the symbiotic spectrum. As I noted in the “Urban Wildlife in Lawrence, Kansas” section of this paper, their categorization is difficult and is probably dependent on the individual context. The relationship between feral cats and human population density is complex and would benefit from more detailed case studies beyond Lawrence and the research currently available.

Land Use

The questions surrounding land use produced several interesting results that I will explore in more detail here. Residential areas were popular with the cat colonies in Lawrence and single-family homes were the most prevalent type of residence. If residential land use is a preferred environmental characteristic of feral cat colonies in Lawrence, my sample size was not large enough to be considered statistically significant, there could be a number of factors influencing the preference and it may be connected to the human population density variable explored above. One reason could be the crepuscular nature of cats. Cats tend to hunt and eat around dawn and dusk which roughly corresponds to the times humans would be in their residences and potentially moving in and out of the home to travel for work. It would be logical that if the cats and humans are active at the same time contact would be increased and the likelihood that the humans may

feed the cats at the time increases as well. Another possibility is that the cats have stayed in the general area they were released in and produced offspring who have also stayed in that same home range. Cats are known to have some level of place attachment and generally prefer to stay in one general area, but the size of cats' home ranges can vary greatly if there are the resources to sustain them (Van Patter and Hovorka 2018). Therefore, it would not be surprising for a released cat that had previously lived in a home to stay or come back to the general vicinity of the home, probably the last place they were fed, and start a colony of unsocialized offspring. However, they would still most likely prefer to live off anthropogenic food and shelter. Single family homes may be more popular among the colonies because the homeowners may have more space for shelter and food with less interference from landlords and neighbors.

The possible preference for single family homes in residential areas could be linked to the feral cat's potential affinity for areas of medium human population density discussed previously. Residential areas with predominantly single-family homes on small or average size parcels of land have a less dense human population than multi-family residential areas or many commercial areas such as Massachusetts St. in downtown Lawrence but have a denser human population than the more rural areas outside of the city or the single-family homes with large size parcels of land in western Lawrence. Therefore, single-family homes in residential areas could be considered areas of relatively medium human population density. This line of reasoning is speculative but could be worth exploring in future studies. The feral cat colonies of Lawrence were also more likely to be found on privately-owned than publicly owned land. This may be due to residents feeling more comfortable feeding feral cats on land they own, avoiding conflict with the landowner or business found elsewhere. There would also be fewer obstacles to providing or building shelters to protect the colony from the elements. The reoccurring special areas, any area

that contained something besides basic residences and businesses, may also be connected to access to food and shelter. Restaurants were reoccurring among commercial areas the colonies resided in which, is likely due to accessible dumpsters consistently filled with food scraps. Mobile home parks were reoccurring among the residential areas which could be due to the availability of shelter under the mobile homes or less reporting of the cats to animal control.

Human alterations of the physical landscape of Lawrence due to culturally based boundary delineations such as zoning, different types of land use or urban planning may have impacts on feral cat colony location. The separation of residential areas would be largely arbitrary to feral cats without the visual physical differences and cultural differences that influence human behavior towards feral cats. Feral cats experience the landscape of Lawrence thorough the physical infrastructure they can observe, in this case rows of houses instead of large commercial buildings, but also through the way humans behave differently depending on their location. Cats are intelligent creatures, and it is possible that if they do prefer residential areas, it may be due to experiencing more positive, advantageous interactions with humans in residential areas than commercial areas. This is speculative but could be one of the ways the spatial nature of feral cat colonies has been influenced by the cultural landscape of Lawrence. If feral cat colonies are influenced by the type of human land use in their choice of habitat, then it would be another example of how feral cat colonies have been successful in creating beastly places while adjusting to human boundary delineation. In creating beastly places specifically in residential areas feral cats are still choosing to cohabitate with humans but in their own places and on their own terms. These unsocialized cats are still acknowledging and negotiating human boundaries but asserting their agency by avoiding direct human control. My investigation of the land use variable was meant to be exploratory and thus has a high level of speculation involved in its

discussion. A study of land use and feral cat colonies for a larger area or region, such as that of Kansas as a whole, may be able to better provide more reliable and statistically significant results.

Sources of Food

The three sources of food that feral cat colonies may take advantage of are humans directly feeding the colony by setting out food, humans indirectly feeding the colony through accessible food refuse, and hunting. The food sources present at the locations explored were mostly accessible refuse with one instance of visible cat food. This seems to indicate that human refuse is an important food source for the feral cat colonies of Lawrence but cannot be considered definitive. The exact diet of the feral cat population in Lawrence is outside of the scope of this study which instead focuses on how food sources influence feral cat habitat preferences. It is likely that there was more direct feeding of feral cats, through cat food or human food scraps, occurring at the sites investigated than I was able to observe directly. Food may have been placed out of sight or only laid out at night. Direct feeding of feral cats in Lawrence is controversial and many colony caretakers do not wish to be seen or identified as the caretaker by their neighbors or other members of the community. Many feral cat colonies in urban environments also supplement their main diet of refuse or cat food with hunting (Fieseler 2021) which cannot be evaluated visually. As opportunistic animals, feral cats in Lawrence could be taking advantage of all three sources.

Through possibly utilizing multiple anthropogenic sources of food, the feral colonies of Lawrence are taking advantage of, and in turn shaping, the cultural landscape of Lawrence. Humans have altered the landscape of Lawrence through developing the city and implementing a trash system that often results in edible scraps becoming available to the feral cat population in

open dumpsters, trash cans, on the ground etc. By taking advantage of the available food source of refuse, they are adjusting their behavior to the cultural landscape of Lawrence and thus altering it with their presence. The presence of feral cat colonies has both altered the physical landscape of Lawrence, digging in gardens, presence of urine and feces, scattering refuse etc., and the cultural landscape by creating controversy and discussion over their habitation outside the home. By feeding cat colonies directly and indirectly, through refuse, the humans of Lawrence are engaging in the creation of beastly places for feral cats. The feral cat colonies of Lawrence lay outside of the accepted animal spaces of the human home and othershelters and instead have created their own beastly places in the nooks and crannies of the city. Locations where humans have left refuse or laid our food often act as a node around which the colony makes their habitat and home range. Thus, the creation of these pockets of beastly places within the human domain of the city is a joint effort with feral cats exhibiting their agency by establishing habitats in formerly human places.

The main food source of a feral cat colony give us some insight into the cultural and physical place of feral cats that lies somewhere between pets and urban wildlife. The utilization of human food refuse as a major food source is a common trait of urban wildlife and synanthropes and constitutes indirect anthropogenic feeding for the cats. However, the direct method of laying out cat food was also seen, which feral cats have in common with their house pet counterparts though usually less frequently. The feral cats of Lawrence profit from both sources of food, as well as supplementing their diet with hunting, as seen in other feral cats (Crawford, Calver, and Fleming 2020; Hutchings 2003; Fieseler 2021). They are able to adopt the food sources of both the urban wildlife (hunting and refuse) and pets (cat food or food scraps being left out), while not quite fulfilling the requirements to be defined as either, enabling them

to successfully navigate the landscape of Lawrence. The food source of a feral cat colony is vital to the creation of the habitat and the aspects of the landscape that influence these food sources should be carefully considered for colony management.

Shelter

Shelter seems to be important to feral cat colonies based on my own observations and prior research (Normand, Urbanek, and Hicks 2021). 90% of the intersections investigated included structures that could be utilized by feral cats for shelter beyond what brush can offer in protection. This could indicate a possible preference among the feral cats of Lawrence for human-made structures to serve as shelter. It should be noted that only the availability of shelter was evaluated and there were no cats residing in the available shelter at the time of the data collection except for near Perry St. & N 1st St where an abandoned building was seen with cats inside. The absence of visible cats in the possible shelters at the time of the investigation could also be attributed to the shelters being on private property and therefore inaccessible for detailed investigation. Another possibility is that the cats were not active at the time of the data collection in the afternoon. Additionally, the intersection investigations occurred in 2021, two years after the data was collected, and the cat colonies could have moved on to a different location by that point. It should be mentioned that caretakers and non-profit organizations such as Lawrence Humane Society will make cat shelters from plastic tubs and other materials to place at known colony locations. This is not discussed in depth here because none were observable in the chosen intersections. As noted in the discussion on human population density, eastern Lawrence may be more attractive for colonies than western Lawrence due to the higher availability of shelter such as outbuildings, sheds, older homes, and greater cover in general than the more open landscape of western Lawrence. Prior research (Normand, Urbanek, and Hicks 2021) has established that a

form of shelter is an important aspect of feral cat survival and welfare, therefore it is reasonable to expect the colonies of Lawrence to seek out manmade structures, especially if dense, protective brush is not available.

By utilizing manmade structures, the feral cat colonies of Lawrence are engaging with the cultural landscape around them. The structures that become available shelters for the cats are a product of alterations made by humans to the physical landscape and the social factors that influence the use of those structures. Humans alter the landscape through building structures such as sheds, mobile homes, and commercial buildings specifically for human use as human spaces. These structures may slip from active human management, for example through a lack of maintenance, and opportunistic feral cats create a habitat for themselves. The presence of the feral cats may then help define the larger cultural landscape of the area. The presence of a feral cat colony can be perceived as a positive or a negative by members of the community and can influence their overall perception of the area. For example, if the patrons of the businesses near Perry St. & N 1st St decided they no longer wished to frequent those businesses because of the presence of the feral cat colony shelter nearby, that would impact the overall social and economic makeup of that area. Through using human-made structures as their homes, the feral cat colonies are continually negotiating their physical and cultural place and position in the cultural landscape of Lawrence.

Feral cat colonies are carving out beastly places from the spaces that were previously under human management. The creation of beastly places for themselves is a clear display of agency on the part of the feral cat. Although many synanthropes are proficient in shaping beastly places in the urban setting, cats are particularly adept at utilizing whatever shelter may be close to a food source. Cats make homes and beastly places in almost anything they can fit in. I have

seen feral cats carve out habitats for themselves in abandoned buildings, under porches, in the spaces underneath occupied mobile homes, sheds, and large pieces of trash such as discarded tubing, inactive machinery etc. This is not to say that humans are not important actors in the feral cats' adoption of these formerly human spaces. The members of the community are often directly responsible for, or have influence over, whether these spaces are returned to the human domain or the cat colonies are allowed to cohabitate with the human community. Individual neighborhoods in Lawrence need to evaluate if they can accept the beastly places of the feral cat colonies or if those cats need to be drawn away from that habitat and the space reclaimed for more active human management.

As mentioned previously, cats have a significant amount in common with urban wildlife and synanthropes despite being domesticated animals. The feral cat colonies of Lawrence are similar to much of the city's urban wildlife in their ability to take advantage of human infrastructure while avoiding being under direct human control and contact. However, their status as domesticated animals may give them an advantage over urban wildlife in creating habitats. At least some of the population of Lawrence sees feral cats as somewhere between pets and urban wildlife based on the passing of the ordinance that indirectly allowed for TNR as a management alternative to the extermination that urban wildlife are often subject to and exemption from the fines the owners of free roaming pets are subject to (City of Lawrence, 2019). Thus, feral cats in Lawrence may benefit from their position as domesticated animals when it comes to the use of urban infrastructure because of human perceptions of them as closer to pets than undomesticated urban wildlife. Shelter is a key visible environmental variable that could be explored further with multiple site visits to current, established colonies to determine that exact structures they inhabit.

Conclusion

In this thesis I have explored the environmental variables that influence feral cat colony location. My results show the two variables that seem most significant to feral cat colony location were 1) sources of food and 2) available shelter based on the results of this study, my experience working with feral cat colonies, and previous cat colony literature. Food is most likely the number one environmental draw for feral cats as the most basic necessity for life as well as a node for feral cats to cluster around. Anthropogenic sources of food, refuse, and direct feeding seem to be attractive draws as staple foods while hunting may be present to supplement their diet or provide recreation. In my opinion based on the results of this study, the availability of shelter is presumably the second most important variable after food. Protection from the elements can only increase the likelihood for a feral cat's survival, especially in a climate with cold winters like Lawrence. Almost all of the intersections investigated had various kinds of human-made shelter available and cats were found inside an abandoned building near one intersection. Cats' ability to successfully utilize many different combinations of food and shelter is a fairly unique attribute in a domesticated species and speaks to the ingenuity of feral cats in adjusting to life outside direct human control in an urban environment.

The human density and land use variables were meant to go beyond the food and shelter variables. These variables are clearly less significant than the food and shelter variables in determining the locations of feral cat colonies but may still hold a notable level of influence especially in specific locales. Cats as a species can exhibit high levels of agency and it would be unsurprising if their more secondary preferences, variables beyond the minimum requirements of survival, have an impact on colony location. The feral cats of Lawrence may prefer areas of medium human population density. This theory is speculative but based on the results of the self-

questionnaire and a basic visual analysis of the cat density map. If my assumption on feral cat preference for areas of medium human density is accurate, it is possible the colonies select areas that have a high enough human population to provide adequate resources yet have low enough human density to avoid direct human contact as much as possible. Areas with predominantly single-family homes in residential or mixed intersections were the most popular land use type for cat colonies in my study. In the commercial areas that were present in the study restaurants appeared to be reoccurring. I speculate on the reasons for these results in the discussion section but if there is a preference for these areas among feral cats it may be linked to where they have achieved the most success in finding resources and/or where they have previously had positive interactions with humans.

The “place” of feral cat colonies in Lawrence is an ongoing, controversial discussion for the city. A better understanding of the spatial variables involved in the creation of feral cat colony habitats is important to inform decisions and discussions in the community. My research offers greater insight into where feral cat colonies in Lawrence reside and why they reside there. I have placed cats as the central actors in their local environment and in this research and I have approached studying their habitats from an urban wildlife perspective in order to emphasize the significant agency of feral cats. This allows for my research to be meaningful for cats as well as humans when much of the literature surrounding feral cat colonies is focused on human centric management strategies. While humans certainly influence feral cat habitats, it is important to note that the cats are the actors responsible for creating their habitats and beastly places. In this vein I have attempted to explore feral cat habitat preferences as a vehicle to better feral cat-human relationships. By understanding what makes locations attractive to feral cat colonies, the humans of Lawrence can better identify areas that may be likely to become beastly places and if

possible, alter the human management of those locations to make them more or less attractive according to the wishes of the community. This research should also be considered valuable to members of the community in Lawrence because it offers a personalized, setting specific exploration of feral cat habitats in their community. While the results of the self-questionnaire should not be considered definitive, they provide general knowledge and potentially can serve as an avenue for further community discussion that acknowledges cat agency in the creation and location of feral cat colonies.

The cat density map created as a part of this research could also be a useful tool for the Lawrence Humane Society and the general populace of Lawrence because it is a visual of the distribution of feral cat colonies in Lawrence in 2019. The self-questionnaire confirmed at least one of these colonies is still active as of the time of collection in 2021 and it is likely that the other intersections investigated may have colonies missed in the self-questionnaire or are still attractive potential habitats to colonies. The visual of the map could also be used as educational material for the public by LHS to increase public awareness of the TNR program as a management strategy for feral cat colonies in Lawrence. Lastly, I have laid out my full methodology in this thesis which is open to the public so anyone with GIS skills could follow my steps, or improve upon them, to create up to date cat density maps of their own. The variables or methods used here could serve as a starting point for further research on feral cat habitats in Lawrence or elsewhere.

The variables in this study are general enough that they could be used in communities other than Lawrence, but it is important to note the results could vary depending on how feral cats interact with that particular landscape. Lawrence has its own unique physical and cultural landscape that the feral cat colonies navigate. The colony's requirements or preferences for a

potential habitat changes depending on that area's climate, terrain, flora, and fauna. For example, Lawrence has cold winters that can require some shelter to avoid hypothermia. Cat colonies in a more temperate climate may not show the same preference for manmade structures if the brush is sufficient protection from the elements. The amount of brush and types of plants may also vary. Seasons may also have an impact on feral cat colony location, for example if the colony moves to more protected habitat for the winter, then returns to the less protected habitat in the summer, and colony size. The influence of seasonality on feral cat colonies could be investigated in greater detail with a future study tracking a colony throughout the year. Cat colonies in other areas may have to contend with large predators that decrease the colony population on a regular basis or be free of predators and allowed to grow unchecked by predation. A study tagging and tracking the feral cats in a colony could assess the effects of other fauna on the colony.

The cultural landscape of a potential habitat could also alter the results despite using the same variables used in this research. Local attitudes on feral cats can have significant influence on where, if at all, colonies are allowed to reside. A community with a vulnerable ecosystem or species that are threatened by the presence of outdoor cats may move feral cats out of their beastly places and into their cultural landscape's animal spaces that may or may not be similar to the animal spaces of Lawrence. The socioeconomic status of a potential habitat could also mean more or less food and other resources are allocated to colonies by members of the community. Overall, the questions asked and variables assessed in other case studies may be comparable to this study, but the results will certainly vary by location.

The results of my study in Lawrence does inform feral cat research in similar settings. The process and methodology of this study show that spatial analysis of feral cat colonies is possible using basic animal control data despite some room for human error in data collection.

This margin of human error could also be greatly decreased by collaboration with those collecting the pickup data during the collection process. However, difficulty could still arise in replicating the study if the data is not easily accessible or the investigation of variables is hampered by the legal issues and controversy surrounding the feeding of feral cats. Locations similar to Lawrence could also specifically test the variables I found potentially significant, preferences for medium human population density, residential areas with single family homes, manmade structures, and refuse as a source of food, in more detail to assess the accuracy of my findings. The use of high-resolution imagery could provide more statistically significant datasets that better represent a given location than a single in-person visit can provide. I believe the self-questionnaire could still be used in conjunction with high-resolution imagery by allowing for greater detail in the questionnaire responses. Future studies could build and improve upon my questionnaire by tailoring the questions specifically to their location and circulating the questionnaire to both scholarly as well as local experts in order to increase the accuracy of their results. Regardless of location, I believe my findings, combined with basic feral cat knowledge, indicate that the major drivers of feral cat colony habitat location are most likely food and shelter and as such should be given priority in future studies.

The majority of research about feral cat colonies has been focused on management strategies. While management is an important and contentious issue, the focus on management can leave a gap in the literature regarding the complex network of interactions between cats, humans, and their physical as well as cultural environments. A greater understanding of how feral cat colonies navigate their landscape should inform and enable the management discussion. There are many facets of the feral cat colony habitats that could benefit from further research. The variables explored in my research could be examined on a more detailed scale with a greater

number of data points that would produce an even more substantial, statistically significant analysis. Additionally, a standardized procedure for feral cat habitat analysis could allow for comparison of multiple case studies. A case study comparison would be helpful in exploring if environmental variables are relatively stable for all colonies or vary significantly based on the physical and cultural context. Additionally, socioeconomic variables such as income level, race, and education level should be further explored for their influence on feral cat colony location to expand habitat analysis beyond the visible, physical landscape. I hope this thesis sheds some light on the complex web of spatial interactions that feral cat colonies navigate in Lawrence and elsewhere. There is still much to learn about the nature of these colonies, and I believe future research can only improve the often-contentious cohabitation of feral cats and humans.

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