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URBAN ANIMALS: GIS ANALYSIS OF STRAY CANINES AND FELINES IN ALBUQUERQUE, NEW MEXICO

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by

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ABSTRACT

While human influence and progress has shaped the cityscape of Albuquerque, New Mexico, many stray animals also consider this city to be their home. Albuquerque's Animal Welfare Department holds a human responsibility over these urban animals and their habitat displacement, requiring them to either be registered and owned or euthanized. Although animal rights are a topic continually in debate, the habitat choices made by stray animals are rarely questioned, due to anthropocentrism in the city's structure and laws.

Through observational field research with Albuquerque's Animal Welfare Officers, stray animal locations were collected throughout the city for one week in July 2017, and then analyzed using ESRI's ArcMap program. Comparing these stray animal locations with eleven human social variables provided insight into how the reported crime in Albuquerque has the most statistically significant relationship with the city's stray animals.

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Part I: Introduction

In February of 2018, Albuquerque Animal Welfare's Associate Director Deb Brinkley was placed on administrative leave after the city's Inspector General found that she was moving adoptable dogs from the city's shelters and transporting them to her privately-owned rescue in Aurora, Colorado. Because Brinkley did not obtain a permit for these animal's relocation and profited from their adoptions in another state, she was placed under investigation by the city of Albuquerque (French, 2018). While Brinkley claims that her movement of these animal was in their best interests, animal welfare laws are not nationally, regionally, or even state mandated. The politics of animal geographies can always raise issues because of local differences in what cities believe is correct for animal welfare.

One way that animal geographies can be identified and researched is by using Geographic Information Systems, or GIS. Although several animal welfare departments throughout the United States have successfully used GIS in their work, a GISystem has yet to be adopted by Albuquerque's Animal Welfare Department to assess the stray animal populations it works so hard to protect. My research set out to identify how GIS may bring light to social factors influencing stray animals in the city of Albuquerque. By using GISystems, stray animal geography of this city can be better understood and can perhaps even lead animal welfare systems to become better managed. GIS analysis can be used not only to identify stray animal habitats that affect the city's urban areas, but also to better understand how these animal's habitats may be influenced by human variables.

To conduct this research, I gathered plot points for stray animal locations throughout the entire city of Albuquerque for one full 40-hour work-week, July 3rd to 7th

2017. In addition to simply collecting the points, I was able to engage with Albuquerque's Animal Welfare Officers and get personal accounts of how the Animal Welfare department is managed. This analysis was focused on answering the research question: "How are human social variables statistically related to stray animal density in Albuquerque, New Mexico?"

Attempts to determine which social landscape variable was the most influential were hard because of the large spectrum of possible factors within the city of Albuquerque. However, during my time in the field with the Animal Welfare Officers, I found eleven factors that could be applied to every point collected and could be analyzed through ArcGIS analysis to find their levels of influence. This was done using several ArcMap tools which modeled spatial relationships and provided the insight needed to answer my research question.

Part II: Background

While homes in the United States may contain a wide variety of pets including fish (10%), reptiles (4%), horses (2%), and even small animals like hamsters (5%), dogs and cats have always outnumbered any other species. According to a 2017-2018 americanpetproducts.org study, 68% of all U.S. households do have a pet. In addition to the percentages listed above, 48 percent of U.S. homes contain dogs and 38 percent contain cats (americanpetproducts.org). Although animal welfare associations, like Albuquerque Animal Welfare, focus on all types of pets licensed and owned within their jurisdictions, these two species maintain a large margin over any other.

While human interaction throughout history is what has truly encouraged these two species to become commonplace (Price, 2002), the systems that we have formed to protect and regulate their rights as animals remain fractured. Although the United States Department of the Interior's Fish and Wildlife Service (FWS) has national programs, grants, and conservation efforts, these do not apply to the animals which are now labeled as domesticated.

Because we have identified many species, most notably cats and dogs, as domesticated, our federal and state laws regarding fish and wildlife do not apply. If these animals are not licensed and owned, they become labeled as strays and must find a home, shelter, or non-profit, or they may be euthanized. Different laws and strategies have been put in place to manage strays throughout the nation. This background focuses on these stray animal issues, both federally and in the state of New Mexico.

Animal Welfare in the United States

Although a substantial portion of homes in the United States have registered pets, the moral question of human dominion over another creature, morally and legally, isn't usually addressed within national politics. Blurred lines regarding the "legal welfarism" of animals can be species-biased, religion-based, or even legal stipulations forming a regulatory structure (Francione, 1995). While the "dog catcher" stereotype of the early 20th century may still be mistaken for today's animal welfare systems by many, the evolution of animal welfare systems, their employees, and their laws continue today.

As early as the 18th century, the United States began forming federal jobs regarding the collection of stray animals. While these jobs were centered on ensuring that the streets were not habitats for unlicensed animals in the country's cities, the term "animal welfare" was not used in publication until 1883 in the *Journal of Dairy Science* (Von Keyserlingk & Weary, 2017). Although the term had not yet been defined, as early as April 1886 the American Society for the Prevention of Cruelty to Animals, or ASPCA, was created by Henry Bergh (Beers, 2006). With the ASPCA being created, many animal advocacy groups seeking law and stipulations regarding animals began to form. Between 1886 and the 1983 publication, these groups formed throughout the nation, including: Pennsylvania Society for the Prevention of Cruelty to Animals (PSPCA) in 1867 which focused on horses and their protection while working, The American Humane Association of 1877 which broke ground on animal rescue and response organization, Friends of Animals (FoA) in 1970 which led animal-advocacy efforts in the United States, and People for the Ethical Treatment of Animals (PETA) in 1980 which remains a strong animal rights group today (Von Keyserlingk & Weary, 2017). Because of the effort put forward by these associations, by the late 20th century the American animal advocacy movement had begun and demanded government legislation towards animal protection and well-being.

In response to early ASPCA pressures, the US Federal Department of Agriculture (FDA) created the Animal Welfare Act in 1966 (Von Keyserlingk & Weary, 2017). These laws have been maintained and updated every decade to reflect updated federal regulations on animal ownership. In addition to the Animal Welfare Act, the USDA created the Animal and Plant Health Inspection Service (APHIS) in 1972. The APHIS, since creation, has been the government department managing all city shelters' licensing and registration for all animals owned as property in the United States. Although animal licenses are obtained through these local shelters, breeders, and rescue organizations, all of these departments are regulated and monitored by the APHIS and must abide by the Animal Welfare Act.

To ensure APHIS stipulations are maintained, small-scale animal welfare departments were put in place by local governments. The USDA publishes the Animal Care Policy Manuel, Animal Protection Guide, licensing guidelines, and compliance incentives each year for all animal holders. These national guidelines are general standards of practice in animal care and are required to be met throughout the entire nation. These stipulations include federal licensing laws for animals.

While the Animal Welfare Act's licensing laws are placed on institutions and not owners, the Animal Welfare departments throughout the country must adhere to "federal animal care standards cover humane handling, housing, space, feeding and watering, sanitation, ventilation, shelter from extremes of weather, adequate veterinary care, separation of incompatible animals, transportation, and handling in transit" (USDA, Licensing & Registration Laws, 2018) or they can lose all ability to license animals.

Because USDA licensing laws are now in place and animals without shelter are considered strays, humans have identified that animals living without government authority should still be placed in our care regardless of their intention (Munro, 2005). The social problem of animals living within urban environments is still being addressed and is seen by many as "speciesism", or an assumption of human superiority as a species, regulated by human law (Brill, 2005). While many animal welfare departments focus around collecting stray animals to rehabilitate and adopt to families, euthanasia of unlicensed animals still occurs every day throughout the country.

Animal Welfare in Albuquerque, New Mexico

While the concept of advocating for stray animals and their habitat issues may not be a top federal priority in the United States, local animal advocacy groups continue to grow in every state. Providing a voice for animals who cannot verbally represent themselves within our own cities is a focus of both the humanitarian agencies and the local government animal welfare departments (Beers, 2006). The city of Albuquerque has not only provided its Animal Welfare department with laws to guide its practice but has also made a conscious effort to involve community members in the city's process.

The Animal Welfare Department falls under the Humane and Ethical Animal Rules and Treatment (HEART) Ordinance, which is Albuquerque's rulebook on the topic of animal law. In this ordinance, the city has created guidelines that make the commercial purchase of an animal without an Intact Animal Permit or Companion Animal Litter

Permit illegal. This is citing Ordinance 9-2-4-4, which states "no person shall display, sell, give away, barter or auction or otherwise dispose of residential, commercial or public property without a litter permit" (cabq.gov). In addition to adoption ordinances, HEART also includes stipulations on grooming, boarding, caging, and many other requirements which breeders, shelters, and owners must meet to keep their licensed pet in the city.

In addition to the city shelters, Albuquerque has made an effort to make pet adoption easier through access to some animals in a commercial environment. Through the development of Lucky Paws, a pet adoption store in the Coronado Shopping Center, Albuquerque Animal Welfare encourages people within the city to make a conscious effort to take stray animals home. While this is still a shelter and not private pet sales, the pets brought to Lucky Paws by the AWD have been screened by behavioral teems and marked on their most adoptable traits.

The Albuquerque Animal Welfare department struggles to maintain staffing levels. There are currently only six animal welfare field officers working for the city, and they are all working overtime. In June 2018 a hiring event will be conducted by the AWD for new field officers, however because of high levels of training and long shifts these positions may remain unfilled.

Conclusion

Through public efforts to adopt better laws, provide resources and shelter, and maintain the health and welfare of animals in government possession, animal welfare continues to evolve. The Humane Society (humanesociety.org) continues to post all legislation, both pending and approved, for each state on their website. Non-profits, like the Humane Society and the countless others discussed above, continue volunteering their time and effort towards helping animals in need. While these private organizations provide effort towards making these social changes, local animal welfare offices throughout the nation are required to provide each city with just that – Animal welfare.

Part III: Literature Review

Introduction

While human-environmental relationships have long been studied in research fields like geography, biology, and ecology, more recently work has begun to focus on non-human ecologies as well as including the studies of feline and canine urban ecology. The literature review below focuses on research in four areas 1) research in animal cognition, 2) canine and feline understanding of landscape, 3) research in animal geography, and 4) animal GISystems in urban environments. These topics tend to sometimes have strong divides between qualitative and quantitative methods used to understand the information presented. However, the combinations of these four subjects may allow not only the geographical landscapes of animals to be understood and analyzed, but also account for which social factors have affected how these landscapes have formed.

Research in Animal Cognition

The topic of comparative animal cognition, which is the psychology of non-human intellectual understanding, is a relatively new field of animal geography. While the idea of thought and self were distinctly anthropocentric in the 17th century, scientists towards the end of the 20th century and beginning of the 21st century began to question whether humans were the only beings capable of possessing this conscious capability. With the computer science revolution of the last decade, the drive to study cognitive capacities beyond the human brain was instigated (Briscoe, 1997). Artificial intelligence gave weight to the proposal that the human mind may not be a divine intervention, but a series of modeled functions created because of our rapidly evolving neurological capabilities (Briscoe, 1997).

In the same way that the binomial code was created for these computer systems' intelligence schemas, the genetic code was also uncovered in the mid-19th century (Watson & Crick, 1953). With the assignment of four DNA nucleobases, everything biological soon became dissectible and comparisons were soon being drawn not only to computer manufacture, but also to the field of zoology. As early as the 1970s, biologists began to translate these gene expressions not only to physical features, but also to mating, dominance, foraging, and labor-assigning behaviors in species like the honey bee (Robinson & Ben-Shahar, 2002).

Following these findings, psychologists also began to research non-human animals in cognition, an area known as comparative psychology. Gathering data based on ethological observations, scientists found ways to identify communication interactions within many species and relate them to neurobiological gene associations (Hershberger, Plomin & Pedersen, 1991; Grandin & Dessing, 2013; Inoue-Murayama, Kawamura & Weiss, 2011) identified in the years before (Bekoff, Allen & Burghardt, 2002). Tests were soon developed to assess animals' understanding of environment and response (Ploger & Yasukawa, 2002; Crouzet, Joubert, Thorpe, & Fabre-Thorpe, 2012; Wellborn, 2000) and how it compared to human cognitive capacities for the same tasks (Andrews & Huss, 2013; Adkins-Regan, 2005). Causal reasoning, task associations, planning and even altruism began to drive studies of animal cognition in the beginning of the 21st century (Premack, 2007).

As the field of comparative psychology continued to grow throughout the last decade, many studies left the clinic floor and began to include ecological landscape within their research (Grandin & Dessing, 2013). Certain aspects of cognition, like tool use (Shumaker, Walkup & Beck, 2011), were being observed in captive research. Findings within this research indicated that the animals' capacities to expand upon cognitive aspects were much less limited when the animals were observed in their natural habitats (Flockhart, Norris & Coe 2016; Diaz et al., 2013; Byrne & Bates, 2011). The inclusion of ecology within psychological research allowed new research to be conducted regarding cognitive variables between species (Bekoff, Allen & Burghardt, 2002). Several topics, like seed dispersal within frugivore foraging animal communities (Soldati, 2015), allowed cognitive investigation to look beyond human associations and focus on associations relative to each species being studied.

Today, with so much information about animal cognition in local ecosystems, humans have better capabilities for problem-solving animal welfare and control issues. Research has helped to identify some of the cognitive capacities, including facial gesture recognition and human-implied perspective (Nogueira, 2017; MacDonald & Ritvo, 2016) of urban animals and provide methods of deterring these animals without euthanasia. With many cities in the United States dealing with growing numbers of stray and feral cats and dogs, this cognitive understanding of animals' intentions could allow humans to determine the motivations of these creatures to create their own urban landscapes.

Unfortunately, while research has been done on the cognitive capacities of both cats and dogs, the conclusions drawn have yet to instigate a comparative field study, regardless of the animal welfare societies funded throughout the United States. If observations of both canine and feline landscapes were to be performed in unison, and those landscapes were compared to the human social variables surrounding them, perhaps an idea of the human influence on these animals' cognition may be drawn and researched in the future. Animal welfare agencies, like Albuquerque's Animal Welfare, may truly benefit from allowing research to be collected because it regards the animals that they are protecting. If a statistical landscape of data is provided for support, stray dogs and cats may be better assisted by these community resources.

Canine & Feline Understanding of Landscape

Research has been conducted to determine whether animals are capable of cognitive capacities in the same way that humans are. Although the *Canis* (canine) and *Felis* (feline) genera are much less related to humans than other animals, like members of the primate family, these animals have succumbed to a strong reliance on humans for resources, shelter, and companionship (Olmstead, 2016). While some of these animals may still possess the ability to live outside of the human landscape, both canine and feline cognitions of landscape have been shaped around centuries of domestication and human evolution (Olmstead, 2016).

The Canidae family is composed of many species, but the species *Canis familiaris* is the one that is referred to in the United States as simply a "dog." While there are hundreds of breeds of dogs throughout the world, they are all the same species made up of the same genetic architecture. Although different breeds may have different behavioral adaptations to their environments, the cognitive networks established in their neurological evolution as a species do remain quite uniform (Wang et al., 2013). Because of the comparative psychological methods created in the last century, scientists are now able to better understand the canine psyche and research all the ways in which the species consciously communicates with not only other pack members, but also human beings (Macpherson & Roberts, 2013). Dogs have been used to sniff out bombs, guide disabled people through urban environments, and it has been suggested that they are even able to count and identify displayed patterns (Macpherson & Roberts, 2013). The brain area known as the hippocampus has been found to be associated with cognition, learning, and memory. Research regarding the canine hippocampus has recently become a focus in genomics and correlations have been seen within the DNA of humans and dogs that have been identified as representing specific cognitive differences (Head, Cotman & Milgram, 2000).

Canis familiaris is estimated to have evolved 12,000 to 15,000 years ago as a direct descendent of the gray wolf, Canis lupus with marked variations in muzzle and tooth size (Overall, 2011). Many scientists, both biological and psychological, believed that their evolution was forged through cooperation and domestication by forming a kinship with the human species (Overall, 2011). Unlike any other species, including chimpanzees, dogs have the highest capacity to communicate with humans because of their domestication and reliance on the human species (Wang et al., 2013). Because dogs and humans have adapted so greatly by forming a relationship with each other, the ecologies of both species always seem intertwined. It has been observed that unlike the rest of their Canidae family, today's urban dogs have shifted their focus from survival instincts to the social cues of the humans surrounding them (Reid, 2009).

Most dogs in the United States have now become domesticated and because of this, social learning has become a key factor in their ethology. It has been found in research studies that dogs exposed to human interaction are the most successful at their environmental tasks (Wobber & Hare, 2009). This research has identified that the formation of strong social bonds with humans allowed both species to blossom and thrive but may have hindered canine capacities to survive without human assistance because of a strong food dependence (Cooper et al., 2003).

The issue of stray dogs throughout the world has yet to be resolved because of this one-sided dependency of one species on another. The breeding of *Canis familiaris* throughout the last few millennia has always been targeted at the creation of a species to aid human social variables, agricultural development, and competition (Arnott et al., 2015). However, if the aid of dogs is no longer needed to support a family, these animals soon become a burden to some. Because of food dependency, stray dogs may have issues navigating urban landscapes on their own (Dias et al., 2013). Higher rates of rabies and health issues for canines are present in urban ecosystems with economic disparities because of the inabilities of impoverished people to provide their pets with veterinary medicine (Flores-Ibarra & Estrella-Valenzuela, 2004). Many animals are stray simply because they have been released from human care due to poverty (Flores-Ibarra & Estrella-Valenzuela, 2004). These animals' dependency on human interaction may be critical for their survival (Flores-Ibarra & Estrella-Valenzuela, 2004).

Feline cognition has also been studied, in many of the same ways. While canine domestication started approximately 12,000 to 15,000 years ago, research in evolutionary genomics has found that feline domestication started millennia later, approximately 9,500 years at the earliest in Cyprus (Driscoll, Macdonald & O'Brien, 2009). In this timeline, felines seem to have become domesticated into today's species, *Felis silvestris catus*, only after the human species reached the Neolithic Revolution within the Fertile Crescent (Manning, 1994). Research has pointed out that feline domestication, because of its timeline, seems to have resulted from cats *choosing* to become human pets (Manning, 1994). This may shed light on the ability of today's house cat to retain the capacity to be self-sustaining within an urban environment. The relationship between urbanization and domestication is so intertwined because of how much both humans and these animals developed alongside each other (Parr, 1966).

Although much less developed than canine research, studies have been done on feline cognition. While feline neurological evolution seems to have been centered around hunting and resource guarding, evidence shows that these animals have also developed the capacity to understand human cues and vocal gestures (Vitale Shreve & Udell, 2015). However, this may be dependent on whether the cat is brought up in a way to be a "family house cat" or a feral cat living within the urban landscape. Environmental scientists have monitored rates of bird, squirrel and rabbit survival and reproduction in habitats with and without feral cats. This research found that small vertebrates had much higher survival rates in habitats without feral cats and the domestication of these felines might have great benefits to the wildlife of the cities in which they live (Bonnington, Gaston, Evans & Whittingham, 2013; Bridges, Sanchez & Biteman, 2015).

Having a more defined understanding of the animal geographies of cats and dogs, including those in the city of Albuquerque, may help to foster the subject of animal cognition by providing statistics and detailed research into these animals' landscapes. Through my own research, I hope to provide a statistical analysis regarding the stray dog and cat communities in the city that can be used across fields of research to better understand these animals through the use of urban variables as factors in landscape selection.

Research in Animal Geography

The subject of geography is now a broad field, not only taking human landscape into account but also animal landscape and habitat. While the subject of zoology places a *physical* scientific method on animal research, animal geography, or the study of animal populations within their environmental and spatial distributions (Wolch & Emel, 1998), maintains its *social* science footing and studies the societal comparisons between species. While the field of animal geography had some footing as early as Herodotus' works in the 5th century, it was represented more as an aspect of historical geography than supported as an interdisciplinary field of science until the last few decades (Urbanik, 2012). Fields like Social Anthropology, Natural History and Archaeozoology looked to the past to try and reimagine animal-human relationships yet continued to maintain focus strictly around human societal evolution (Manning, 1994).

As many animals transitioned from rural areas into the cityscapes of the 19th century their place within human-developed culture began to pose authoritative issues (Wolch & Emel, 1998). The human assumption of morality over nature encouraged boundaries to be drawn indicating where animals were allowed to be placed, most often outside of city limits (Wolch & Emel, 1998). Much of the animal geography studied during this period remained focused around how animals should be placed by humans, not how they shape their own ecosystems. This, in turn, led to research of animals being conducted in zoos created to impose human boundaries on the animals being studied (Wolch & Emel, 1998). The construction of zoos in cities allowed animals to be studied yet removed any geographic attributes of this research because of the artificial habitats and strict confinements these animals were placed into.

It was not until the late 19th century that the field of zoogeography began to find footing as a branch of geography (Urbanik, 2012). This field was heavily influenced by the recent works of Charles Darwin (1859), Alfred Russel Wallace (1876), and Philip Sclater (1858), all identifying variation and development throughout the animal kingdom (Urbanik, 2012). Zoogeography researched not only animal species, but how these species were connected to and influenced by their ecosystems, including the ecosystems created for them in confinement (Wolch & Emel, 1998).

This field of animal geography was reinforced by Marion Newbigin's 1913 book, *Animal geography; the faunas of the natural regions of the globe*. This book challenged geography's main focus on plants and reinforced the idea that animals had just as much agency in this field of study (Newbigin, 1913). While this book spoke of animal landscapes and their variation based on ecological differences, it was not until Richard Hesse and W.C. Allee's 1937 book, *Ecological Animal Geography*, human influence was added to this field of research in a chapter titled: "The effect of man on the distribution of animals" (Hesse & Allee, 1937).

In the early 1950s, University of California Berkley's Carl Sauer continued to challenge the anthropocentrism of geography and identified the human transition of "natural landscapes" into "cultural landscapes" (Wolch & Emel, 1998; Urbanik, 2012). Sauer brought into light that animal geography could no longer be researched as a disconnected field because of human influence on every animal's habitat throughout the world. His works included economics, religion, and even feelings of kinship in how animal geography is shaped (Wolch & Emel, 1998; Urbanik, 2012). Sauer brought attention to the idea that while animal geography cannot be disconnected from human geography, it should not be centered around it (Wolch & Emel).

Animal Geography researchers in the 1960s, including Charles F. Bennett, Ted Ellis, Percy Edwards, and Ludwig Koch, introduced questions concerning not only animal lineage and genealogy, but how these animals represent their own place and space in human culture (Philo & Wilbert, 2000). Because animals are imagined so differently throughout global societies, including cultural and religious variations concerning 'animal agency', geography has become crucial to understanding animal packs living within cities, even if these packs are socially isolated (Philo & Wilbert, 2000). The study of animal geography brings both animal and environmental ethics into question, because of spatial bias in animal typology (Buller, 2016; Philo & Wilbert, 2000). Farms, zoos, laboratories, and even households throughout different global cultures have different ethical stipulations for animals primarily due to human culture, not the animal's natural habitats (Philo & Wilbert, 2000).

Understanding animal ethics is now important to those in the field of animal geography because of the human responsibility for constantly changing landscapes (Buller, 2016). The Institute for Critical Animal Studies (ICAS), originally founded in 2001 under the name "Center on Animal Liberation Affairs (CALA)", continues conducting research in the field of animal geography but does so in order to initiate chaos with the intention of inciting animal liberation (www.criticalanimalstudies.org/about). While this may seem extreme to many in the field of animal geography, the ICAS believes that any animal research must take animal ethics into account (Buller, 2016). As research in animal geography continues to develop, the flaws in prior research regarding anthropocentrism become more apparent and constantly create new questions regarding the morality of animal research.

Research in this field continues to change our own understanding of animal landscape – including the animals that we have formed strong societal bonds around. If we can maintain an understanding that these animals have their own agency and cognitive thought processes, human geography can be introduced as a variable factor in assessing their environment. Although animal landscapes may have been shaped by human authority in the past, the research conducted throughout the last few centuries discussed above challenged our assumptions of superiority in the animal kingdom (Wolch & Emel, 1998; Buller, 2016). Through strictly observational research, including human interaction, animal societies may finally be understood from their own social context, not simply by how it applies to humans.

Animal GISystems in Urban Environments

While our human understandings of animal landscape and habitat may have been hindered because of our own species' "hands-on" involvement in observational research, GPS location tools and GIS data mapping tools now provide animal landscape imagery and field data through a digitized and "hands-off" method. Research has evolved through the addition of GIScience, now measuring and analyzing animal distancing techniques (O'Kane, Page & Macdonald, 2014), migratory movement patterns (Sarkar, Chapman, Griffin & Sengupta, 2015), and even species evolution and extinction trends (Erp, Hensel, Ceolin, & Meij, 2015) through the use of the digital topography (Horvath, Marcou, Varnek & Baskin 2017), timeline patterning (Jordaan, Hall & Frisk, 2011), and statistical software formulations (Wong & Lee, 2005) these GISystems provide.

Tools within Geographic Information Science (GIS) are now used extensively in ecological research. Translocation experiments are one way to assess data and form statistical conclusions within animal field research (Shepack, Freidenburg & Skelly, 2016). GIS allows geographers, psychologists, biologists, and zoologists to model animal landscapes and project how they compare with human-landscape interactions. For example, the "digital ecologies" (Peck, 2014) created through GISystems allow agricultural workers to understand the issues their livestock may be facing within the environment. Maps have recently been created to define predictive landscape models, and studies have shown that these digital data-layers can provide insight into issues faced with raising livestock, like identifying pest networks (Feldmann & Ready, 2014).

GIScience is a tool that can be used to understand the human-landscape relationship with animal ecosystems by overlapping them in GISystems software applications, like ESRI's ArcMap. For example, some datasets have recorded the location and number of stray dogs living within a city. Maricopa County Arizona has set up a network processing center allowing community members to geolocate stray animals that they have found (https://gis.maricopa.gov/ACC/Stray/index.html). This system is managed by the county's Animal Care and Control center, which also includes its own GPS points of stray animals brought into its own shelters. GISystems like these provide communities with the ability to not only search for their own missing animals, but also to be included in rescuing animals that they have found through the use of a user-friendly mapping system.

Possessing feature datasets with stray animal listings can be beneficial in a broad number of geographical topics. Maintaining GIS records, for example, recording the location and numbers of food sale points in each area as it relates to stray dog populations (Dias et al., 2013), can allow researchers to see environmental correlations that are statistically relevant. Dias' study of the stray canine population on the University of São Paulo campus in São Paulo, Brazil provided density maps of the canine communities. This study identified why these dogs were in specific areas on campus. It was found through kernel density mapping that the highest density of these stray dogs was related to the restaurants on the university because they provided the preferred source of leftover food. While this study did not propose solutions to community members on how to correct the issue that they were facing, it provided data to which a solution may be reached in the future.

Another study described the environmental physical landscape features created by human land use and development and explained how this is a factor in determining where stray cats were likely to colonize (Flockhart, Norris & Coe 2016). Flockhart's study used not only GIS for mapping these cat landscapes but was also able to assess the points collected using statistical analysis. This study was also able to assess factors such as household income, urban development, and building density and their impact on feline landscapes. The findings presented a spatially explicit prediction of cats throughout the city, showing high numbers in residential areas and low numbers in commercial areas. Similarly, these overlapping human and animal datasets may provide answers to how urban animals' ecosystems are influenced by human urban landscapes. For example, monitoring feline landscapes within high-density residential areas of Tompkins County, New York between 2009 and 2011 provided some insight. These kitten cluster areas have been identified and spay/neutering training program have been targeted to address these areas that have unusually high breeding grounds (Reading, Scarlett & Berliner, 2014).

Because of the topographical issues facing stray pet collection in various cityscapes, GIS has recently been introduced into public animal welfare systems across the country. Currently, the ASPCA is coordinating efforts with some of the United States' largest cities to establish GIS platforms for reporting stray animals (https://www.aspcapro.org/gis-research). However, very few public animal welfare agencies maintain records within GIS platforms open to the public. In Albuquerque, New Mexico, the city's Animal Welfare Department is partnered with the ASPCA, but no GISystem has yet been brought to aid the local community. Hopefully, soon the entire country, including the city of Albuquerque, will follow suit and animal welfare issues can be aided by one of the many GISystems' mapping and problem-solving capabilities.

Conclusion

The combination of social information and plotted research points makes the field of animal geography have both qualitative and quantitative methods that can support each other within a single research project. Although the literatures reviewed in this proposal concerned the broad field of animal geography, none of them include field experience with animal welfare officers and statistical analysis using ArcGIS software within the project. My research will not only shed light on how Albuquerque's stray dog and cat populations are comprised throughout the human landscape, but also how human variables correlate to these populations. Using GISystems and observational research of these two species and their environmental survival tactics, both qualitative and quantitative comparisons can be made to help understand these animal's landscape choices.

Part IV: Research Methods

Research Question: How are human social variables statistically related to stray animal density in Albuquerque, New Mexico?

Hypothesis: The spatial variance of stray animals within the city of Albuquerque is distributionally influenced by the city's human population and its social variables (population density, ethnicity, age, family composition, and crime locations).

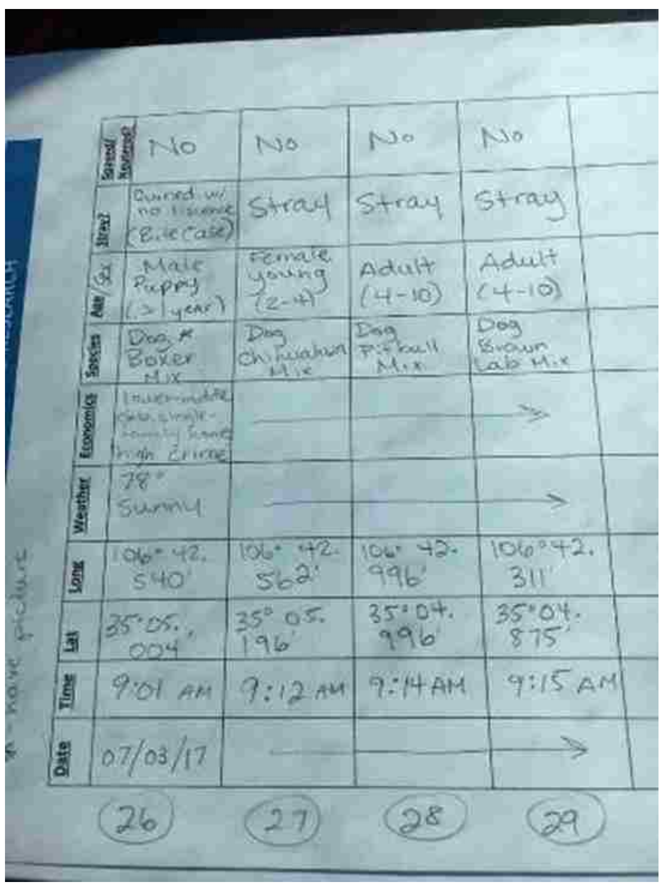
Research Site: The New Mexico Museum of Natural History & Science describes the state as having an extremely high animal and plant diversity, ranking second in the country for the number of native animals (151). The museum identifies that the state is comprised of five ecosystems: Alpine-conifer, desert and basin, juniper-scrub, plains-mesa, and riparian habitats. However, the city of Albuquerque, including the area researched, only fall into two of these categories: Desert and riparian.

According to City-Data.com, Albuquerque is New Mexico's largest city with a population of 559,270 as of the 2016 census. The city has both large Hispanic (47.6%) and Caucasian (40.5%) populations with smaller Native American (4.2%), African American (2.8%) and Asian (2.8%) populations. The 2016 median household income was $50,522 and the median home value was $191,600.

Data: The data collected in this research began with field collection of GPS points and several recorded variables (listed below) of stray animals throughout the city. The UNM Geography and Environmental Studies Department provided me with a Garmin eTrex 20 handheld GPS device for point collection. In addition to the GPS, I created a field research spreadsheet (Fig. 1) to record field comments. These variables identified not only where the animals were recorded, but other social factors experienced during the field research in the city of Albuquerque.

Most of the animal points were collected during a 5 day 40-hour work-week (July 3rd - 7th, 2017). Each day of the week I was assigned to an Animal Welfare Officer and rode alongside them in their own Animal Welfare vehicle for 8 hours. After being assigned to an officer and a vehicle, I spent each day in the passenger seat with my GPS device, a paper notepad, my cell phone, and my field research data form.

Figure 1. Field Research Data Form



Date	07/03/17	→		→
Time	9:01 AM	9:12 AM	9:14 AM	9:15 AM
Lat	35°05.004'	35° 05.196'	35°04.996'	35°04.875'
Long	106°42.540'	106°42.562'	106°42.996'	106°42.311'
Weather	78° Sunny	→		→
Economics	lower-middle class, single-family home, high crime	→		→
Species	Dog Boxer Mix	Dog Chihuahua Mix	Dog Pitbull Mix	Dog Brown Lab Mix
Age/Sex	Male Puppy (<1 year)	Female young (2-4)	Adult (4-10)	Adult (4-10)
Stray?	Owned w/ no license (Bite case)	Stray	Stray	Stray
Spayed/Neutered?	No	No	No	No
	26	27	28	29

In the field, the officers were directed to locations by computer screens in their vehicles. These computers listed stray animal reports called in to 311 by people within the city, Albuquerque Police Department officers, and other Animal Welfare Employees that had received information from citizens visiting the animal adoption offices. Although stray animal sighting was the main objective of my research, many of the calls that the officers received involved other animal issues. These issues included bite cases, expired licenses, abandoned animals, and many other issues involving animals considered to be owned or previously owned. This research examines only those interactions/locations that involved stray animals.

A total of 65 animal GPS points, each with field research data, was collected in 40 hours of research. At every location the GPS point, as well as observable neighborhood characteristics of each area, were recorded. While the neighborhood characteristics were not used in my final analysis, they provided me with a general idea that I should include measurements of these social variables in my research. My cell phone was used to record the time, weather, and all pictures taken during my research. When given permission from the animal welfare officers, I observed the animal to record its species, age, and sex. The officers then scanned the animal with a registration device, checked it for medical issues, and informed me if the animal was registered with the city as well as if the animal was spayed or neutered. Finally, my notepad was used to collect details about how each day progressed and included side-notes on many of the animals collected.

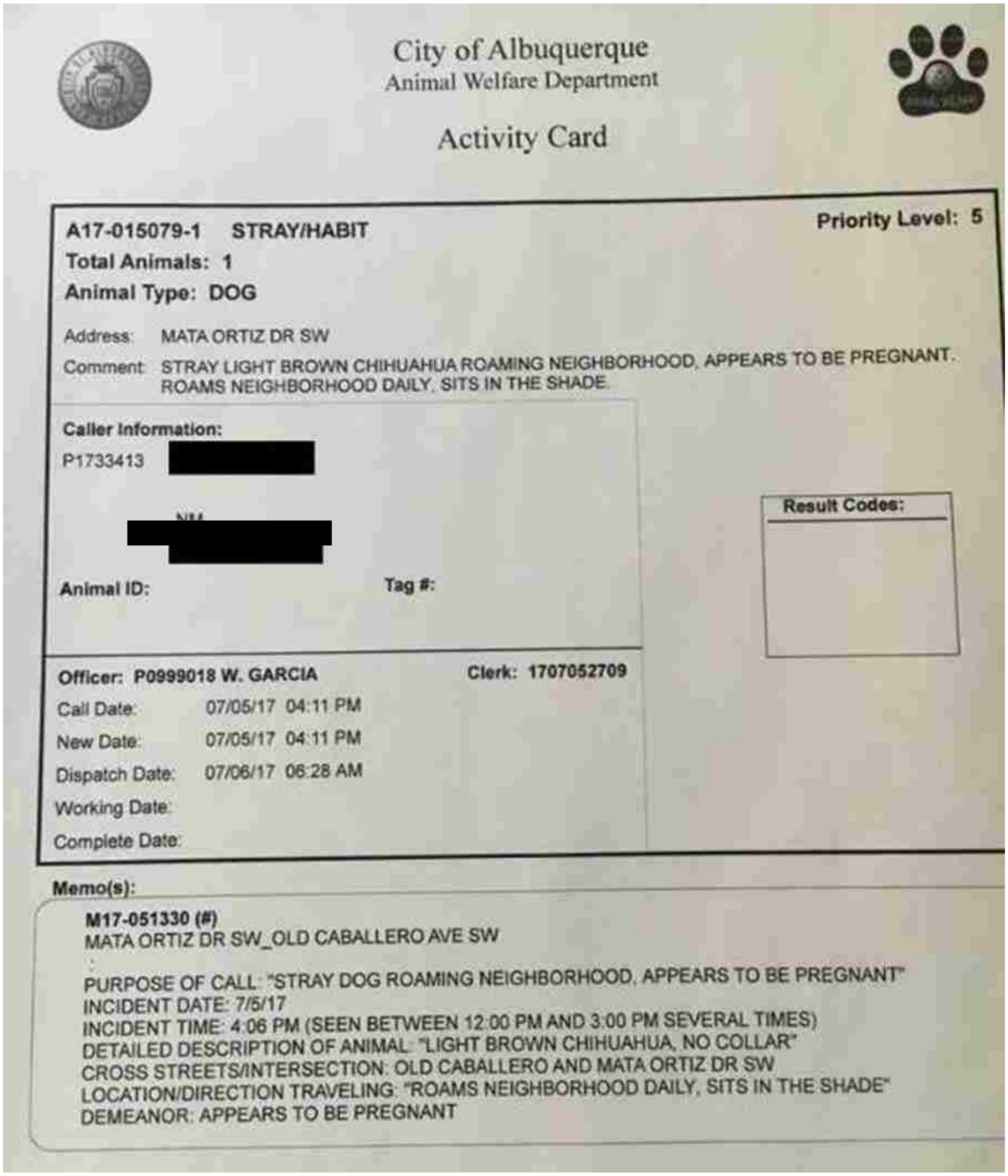
In addition to these points, one of the animal welfare officers was able to provide me with 13 "Activity Cards" from Animal Welfare's computer system, each containing information on calls placed and reported. These activity cards not only provided information on the type of report, animal species, and location of call, but also were ranked according to "Priority Level" assigned by the person receiving the call. All 13 of these activity cards were from reports placed on July 5^{th} and 6^{th}, during the time of my research, but dispatched to other officers than the one that I was riding with on both days. While these points did not include many of the variables on my field research data sheet, they did provide me with the date, time, species, and address of each point (some including additional information). Officer Hevey ensured me that all 13 of these points applied to my research and were all instances of strays throughout the city. An example of one of the activity cards provided to me is below (Fig. 2). The name and phone number of the person who placed the call has been edited out for privacy reasons.

After my field research was complete the data were combined into a single spreadsheet identifying all 78 animal points.

Analysis: Once collected, the data points were extracted from the GPS and their latitude and longitude were uploaded into a Microsoft Excel spreadsheet. Once the spreadsheet was created, the additional information collected at each point was added to later become features once in ArcMap. After all the available data was within the excel spreadsheet, the excel file was saved as a Comma-Delineated File or (*.csv) and imported into the ArcMap software through the Add XY Data tool. This tool identified that the latitude and longitude of each point was collected using the WGS 1984 coordinate system and located each point along the base map of Albuquerque. Because the basemap of Albuquerque did have a different coordinate system (WGS 1984 Web Mercator Auxiliary Sphere

Projection), I changed the coordinate system of the points collected during research to the points of the basemap used (Fig. 3).

Figure 2. Activity Card provided to me by Officer Hevey



City of Albuquerque
Animal Welfare Department

Activity Card

A17-015079-1 STRAY/HABIT **Priority Level: 5**
Total Animals: 1
Animal Type: DOG

Address: MATA ORTIZ DR SW
Comment: STRAY LIGHT BROWN CHIHUAHUA ROAMING NEIGHBORHOOD, APPEARS TO BE PREGNANT. ROAMS NEIGHBORHOOD DAILY, SITS IN THE SHADE.

Caller Information:
P1733413 [redacted]

[redacted]

Result Codes:

Animal ID: **Tag #:**

Officer: P0999018 W. GARCIA **Clerk: 1707052709**
Call Date: 07/05/17 04:11 PM
New Date: 07/05/17 04:11 PM
Dispatch Date: 07/06/17 06:28 AM
Working Date:
Complete Date:

Memo(s):
M17-051330 (#)
MATA ORTIZ DR SW_OLD CABALLERO AVE SW

PURPOSE OF CALL: "STRAY DOG ROAMING NEIGHBORHOOD, APPEARS TO BE PREGNANT"
INCIDENT DATE: 7/5/17
INCIDENT TIME: 4:06 PM (SEEN BETWEEN 12:00 PM AND 3:00 PM SEVERAL TIMES)
DETAILED DESCRIPTION OF ANIMAL: "LIGHT BROWN CHIHUAHUA, NO COLLAR"
CROSS STREETS/INTERSECTION: OLD CABALLERO AND MATA ORTIZ DR SW
LOCATION/DIRECTION TRAVELING: "ROAMS NEIGHBORHOOD DAILY, SITS IN THE SHADE"
DEMEANOR: APPEARS TO BE PREGNANT

In addition to the animal points collected, each of the city's 157 census tracts were added to ArcMap as polygons. The census tract data was downloaded from the US Census Bureau's website, www.census.gov, along with population data used in analysis. The Spatial Join tool within ArcMap's Analysis Tools toolbox was then used to join all the animal points to the census tract polygons, having each polygon contain a field with the count of animal points within it.

Once this join was created I was able to adjust the symbology of the layer properties by graduated color, generating a new layer displaying animal count. The maps below display both the animal points collected during research (Fig. 3) as well as each of the city's census tracts and the density of animals were found within each one of them during the data collection period (Fig. 4).

Figure 3. Stray animal locations throughout the city

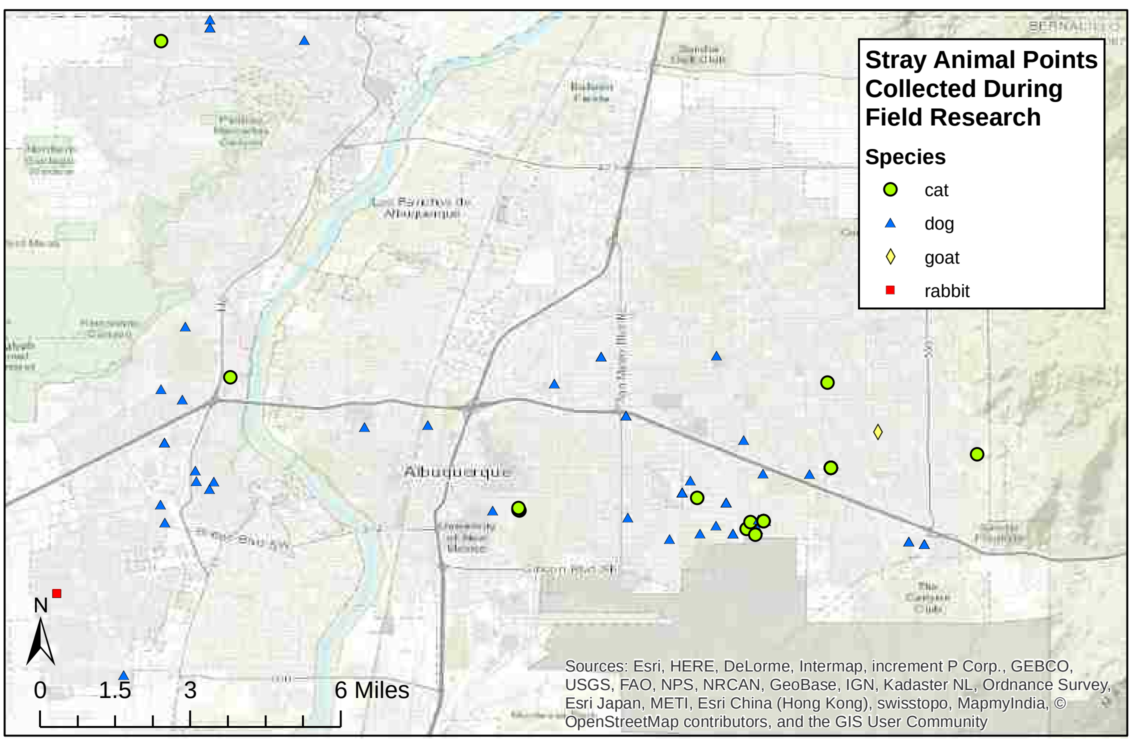
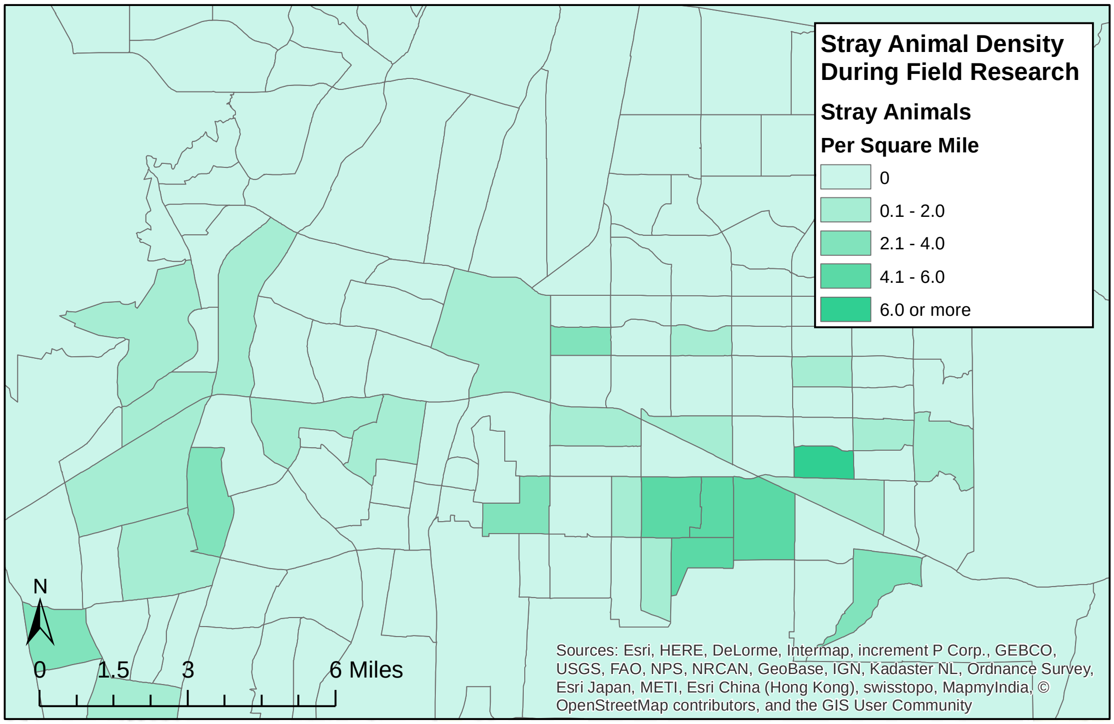


Figure 4. Stray animal density within each census tract during field research



After all of the animal points had been converted to density within census tracts, ten statistical factors from the US Census Bureau were identified as potential factors to be used in statistical analysis. These factors were chosen for their hypothesized potential to influence the variation in stray animal locations. These variables were:

1. Percentage of Hispanics living within each census tract
2. Percentage of Caucasians living within each census tract
3. Percentage of African Americans living within each census tract
4. Percentage of homes with children under 18 in each census tract
5. Percentage of homes with seniors over 65 in each census tract

6. Average family size in each census tract
7. Percentage of single-family homes in each census tract
8. Percentage of vacant homes in each census tract
9. Percentage of rented homes in each census tract
10. Population density of each census tract

In addition to these factors, 429 recorded crime instances for July 3rd to 7th, 2017 were collected from www.CrimeMapping.com and added as a feature class. These statistics included 17 different types of crime, the highest percentages being auto theft (41.26%), vandalism (13.52%), and larceny (13.29%). These crime points were added and then analyzed to show frequency within each census tract. Once crime frequency was calculated per census tract, crime density was added as a final factor for data analysis:

11. Crime density of each census tract during field research

All 11 variables are shown in the maps below in graduated color symbology (Fig. 5 to 15). These images show which variables have similar distributions throughout the city and which variables are very dissimilar.

Figure 5. Hispanic population percentages in each census tract

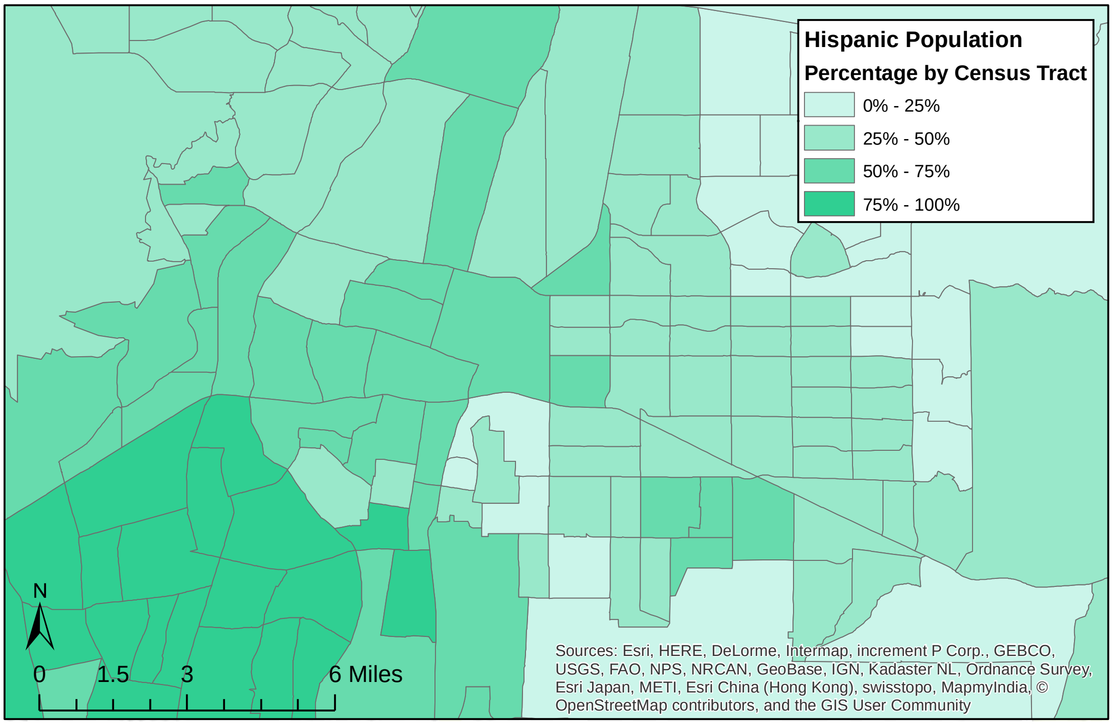


Figure 6. Caucasian population percentages in each census tract

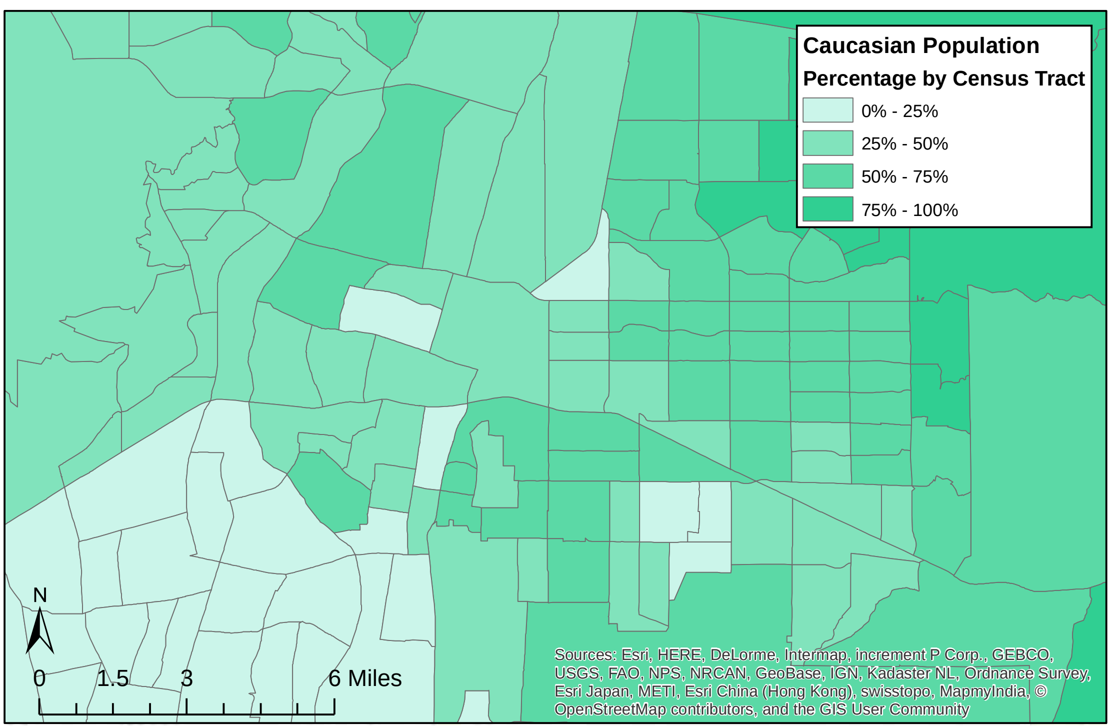


Figure 7. African American population percentages in each census tract

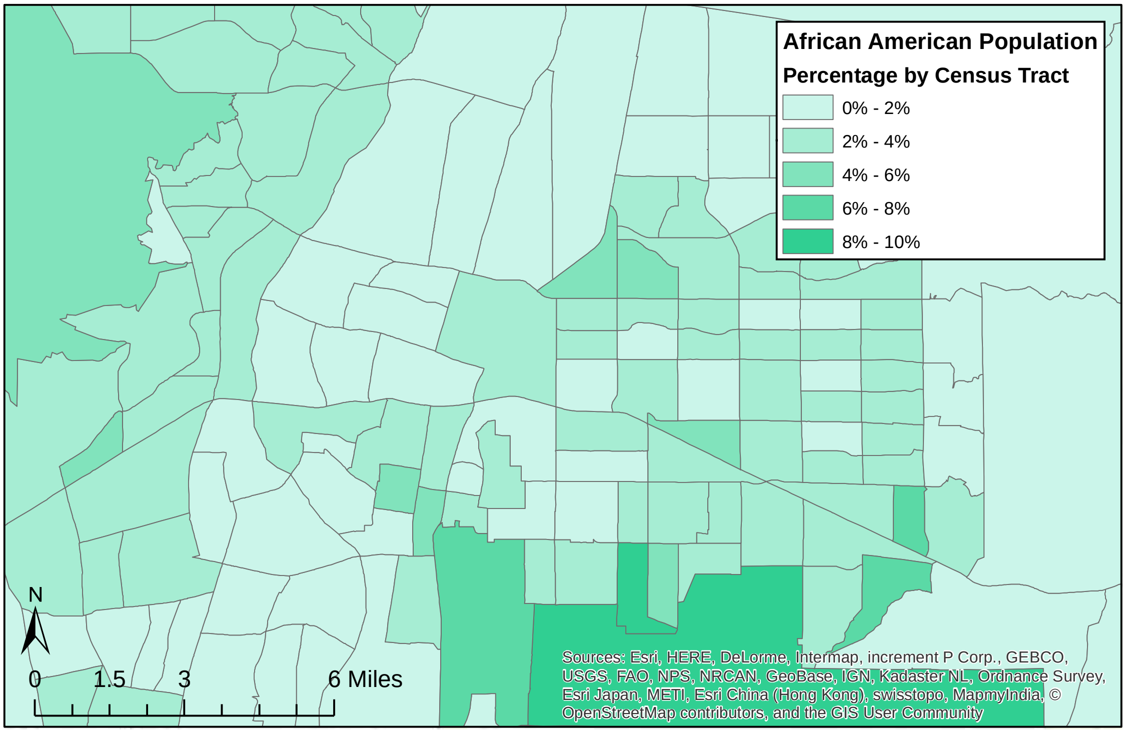


Figure 8. Percentage of homes with children under 18 in each census tract

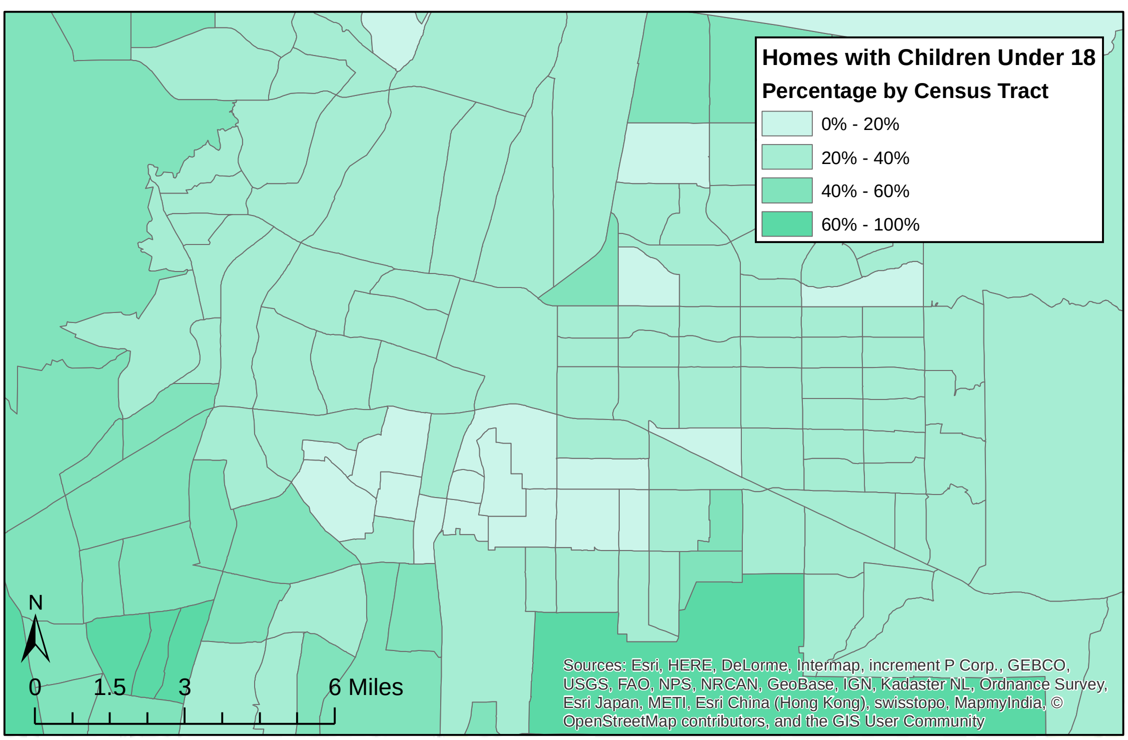


Figure 9. Percentage of homes with adults over 65 in each census tract

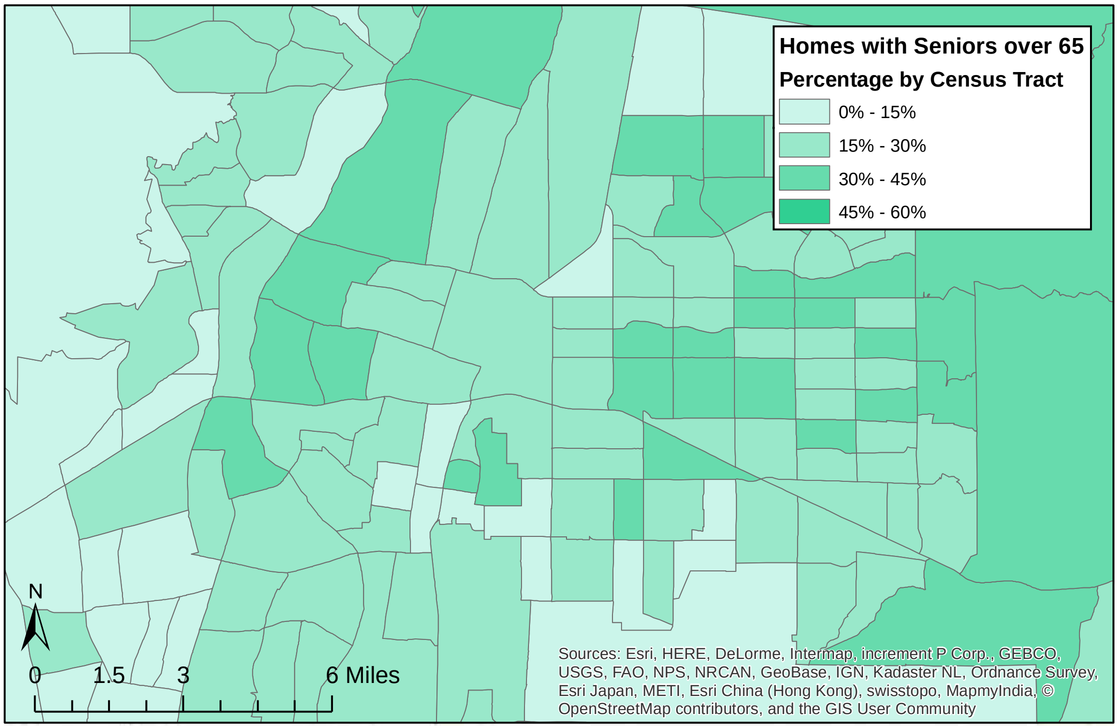


Figure 10. Average family size within each census tract

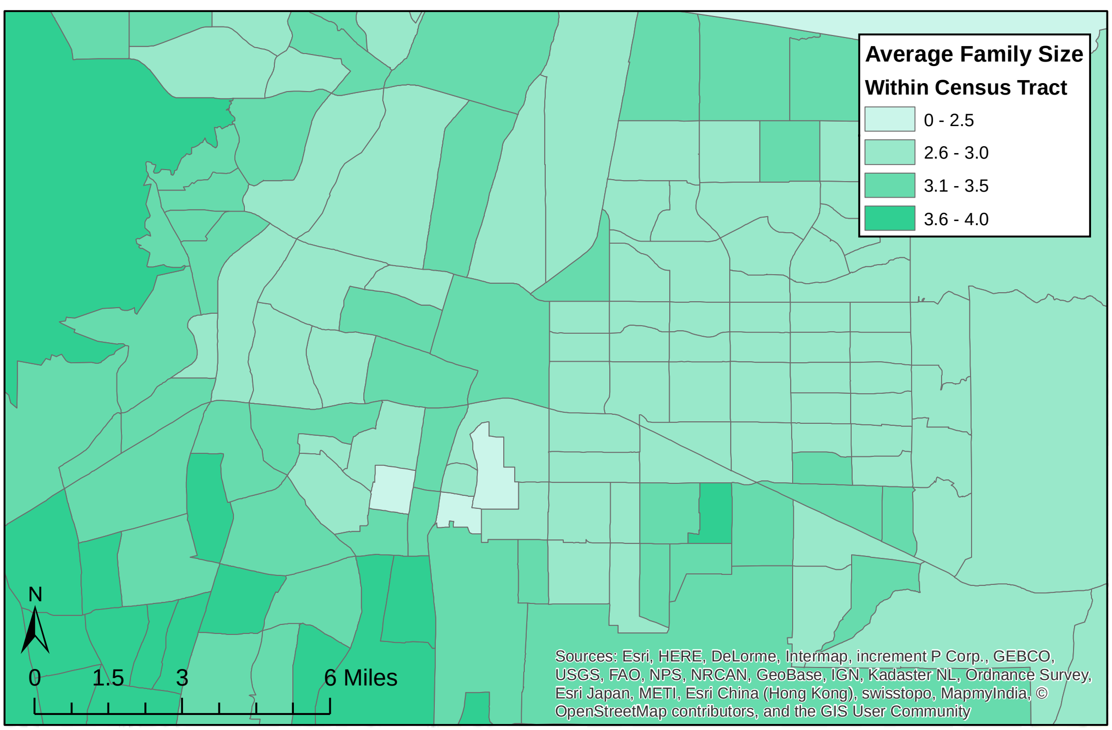


Figure 11. Percentage of single family homes within each census tract

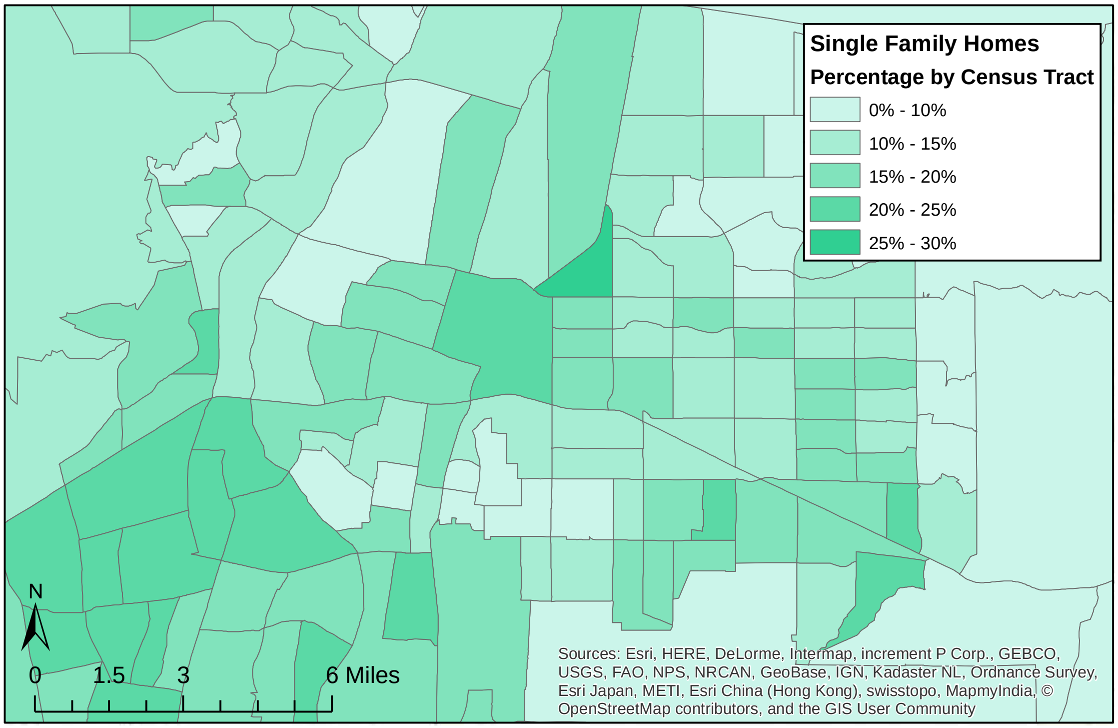


Figure 12. Percentage of rented homes in each census tract

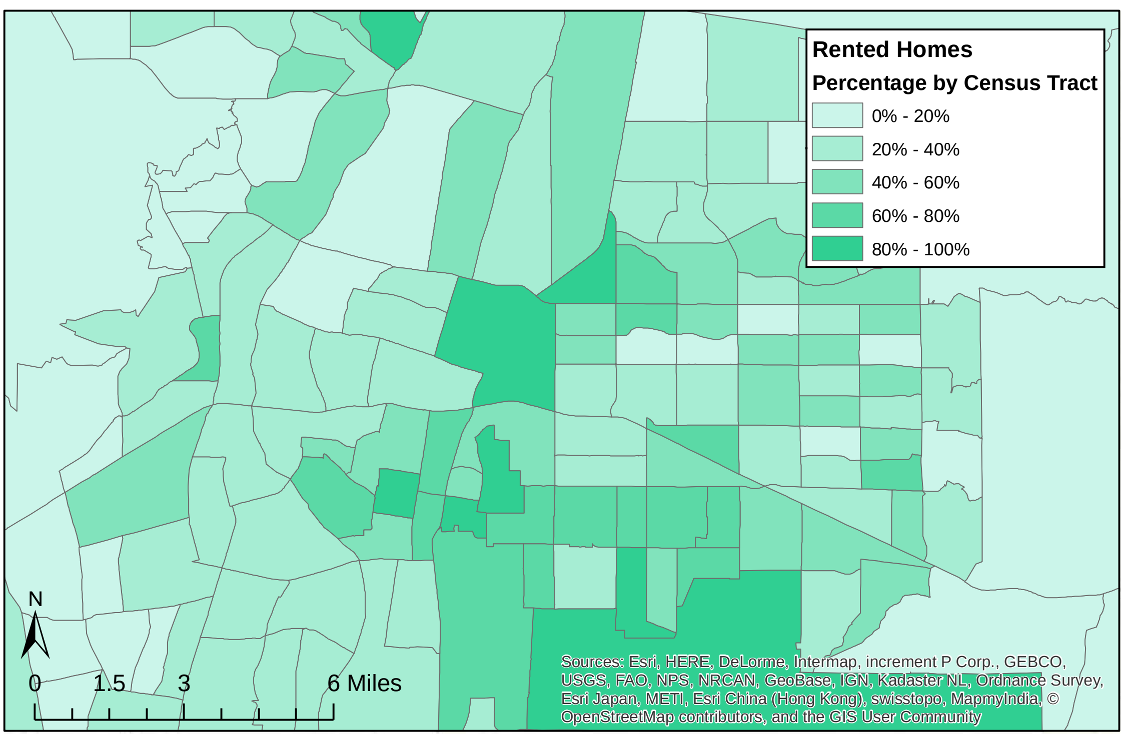


Figure 13. Percentage of vacant homes in each census tract

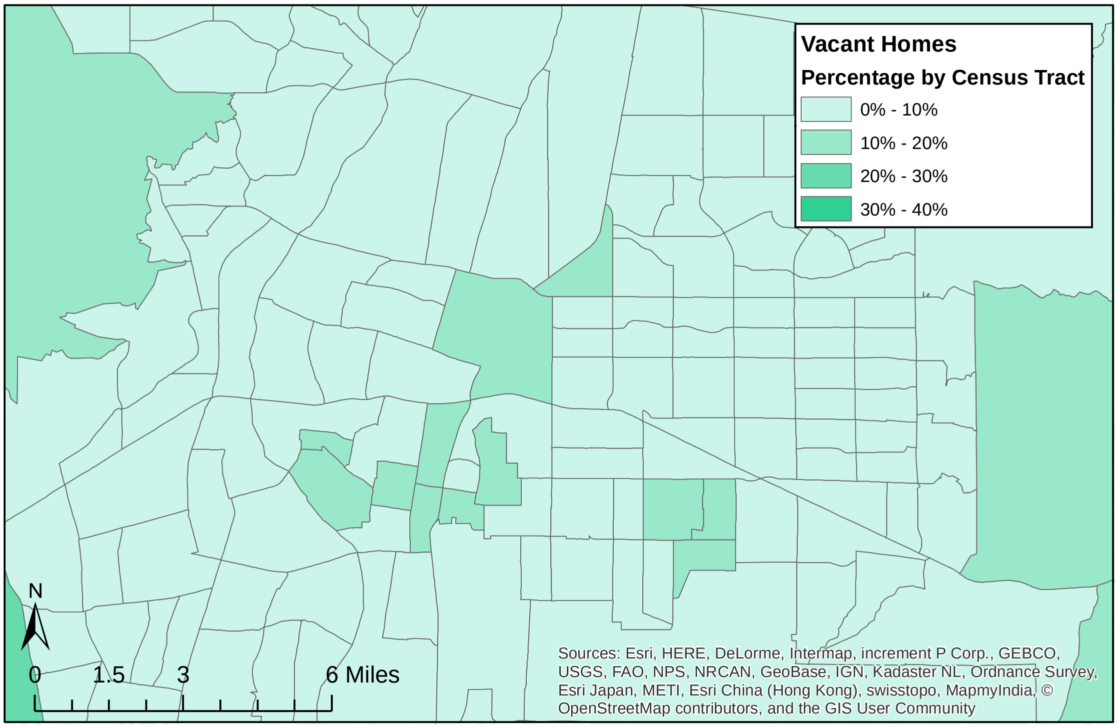


Figure 14. Population density of each census tract

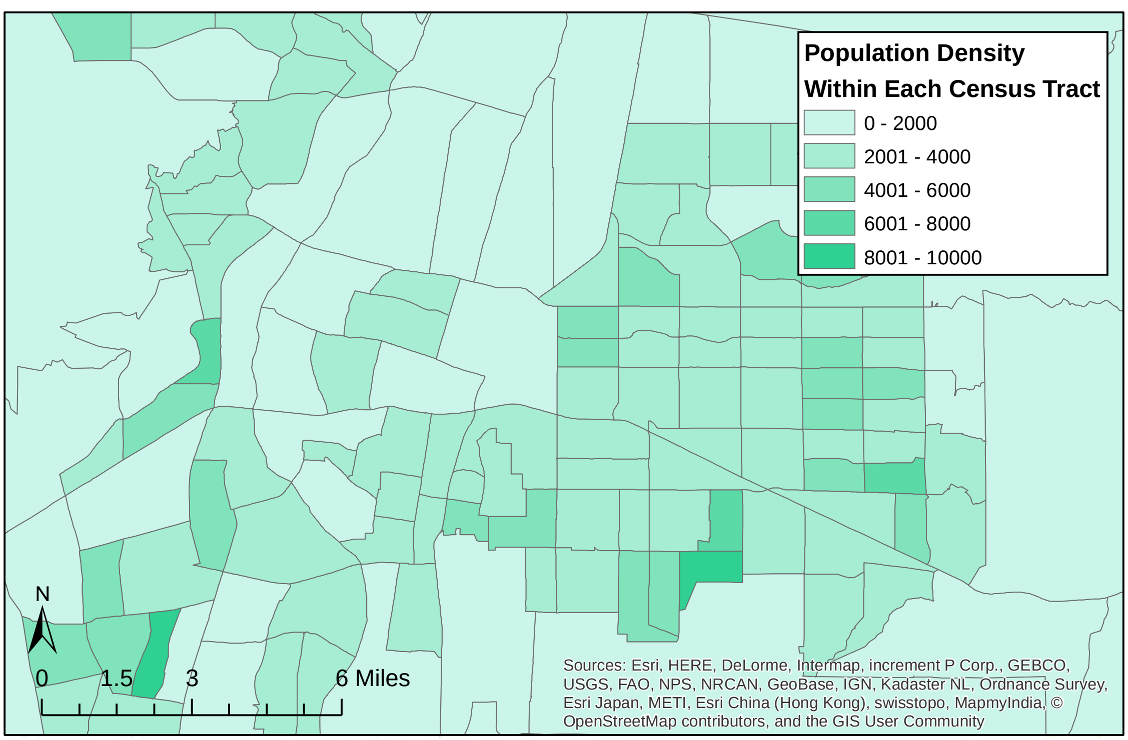
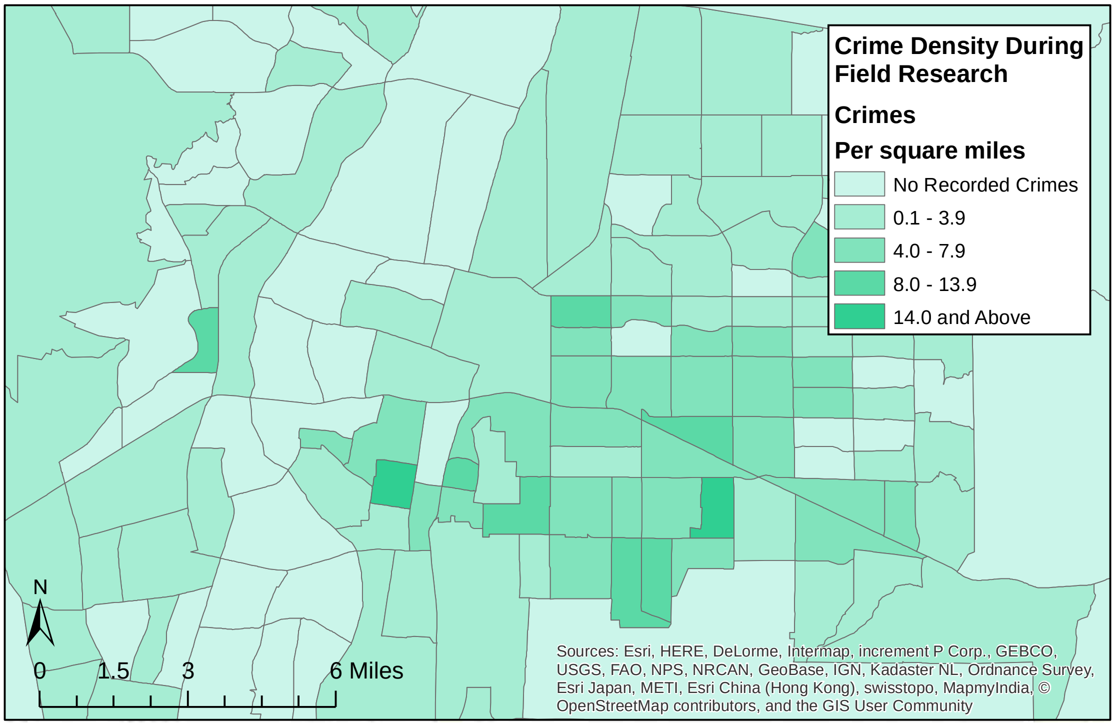


Figure 15. Crime density of each census tract during field research



To compare the impact of these variables, two tools were used in ArcMap: Optimized Hot Spot Analysis (OHSA) and Ordinary Least Squares (OLS). Although these tools were used to analyze the same data, they provided two different analyses and interpretations.

The OHSA tool provides a visual representation of clusters of variables and where the table's "hot spots" are. These hot spots (and low cold spots) use the Getis-Ord GI statistic to show statistically significant spatial clusters of each variable among all census tract polygons. This tool analyzes spatial dependence of the input features and produces a map showing where both groupings and scarcities of each feature are located. The Gi_Bin, or confidence level, identifies the hot spots as census tracts which have significant spatial clusters of high values and the cold spots as census tracts which have significant spatial clusters of low values. The bin number produced in the OHSA analysis (0 - 3) indicates how statistically significant each census tract is at a certain confidence level. Hot spots with a 99% confidence level are census tracts in the +3 bin; hot spots with a 95% confidence intervals are census tracts within the +2 bin; hot spots with a 90% confidence intervals are census tracts within the +1 bin; and a clustering of features with a 0 bin is not stasitically signifcant enough to be corolated. In the same way Cold spots with a 99% confidence level are census tracts in the -3 bin; hot spots with a 95% confidence intervals are census tracts within the -2 bin; hot spots with a 90% confidence intervals are census tracts within the -1 bin.

The other ArcMap tool used in analysis was the Ordinary Least Squares (OLS) tool. The OLS tool uses linear regression equation to predict a variable's values. When analyzing observed values, this tool shows how much each value deviates from its linear prediction in standard deviations. This tool generates both an ArcMap visual output of all the census tracts' standard deviations from the mean and a summary report (see next section) which identifies certain variable's probability of relationship with the "input" variable.

Methodology: These twelve OHSA and the OLS test (all eleven variables and stray animal points collected) were analyzed to determine which variables are most impactful to stray animal locations throughout the city. The results of these tests and their figures can be found in the next section.

Part V: Results

Both tests did provide visual maps of the variables being analyzed (Fig. 16 – 28), but Hot spot analysis provided no statistics for relationship between variables. While the OHSA (Fig. 16 – 27) clearly depicted which areas in the city are hot spots for each variable separately, the OLS provided a map for all variables' relationship to one another (Fig. 28) as well as a statistical report of these variables in relation to one another.

Figure 16. OHSA for stray animal density in each census tract

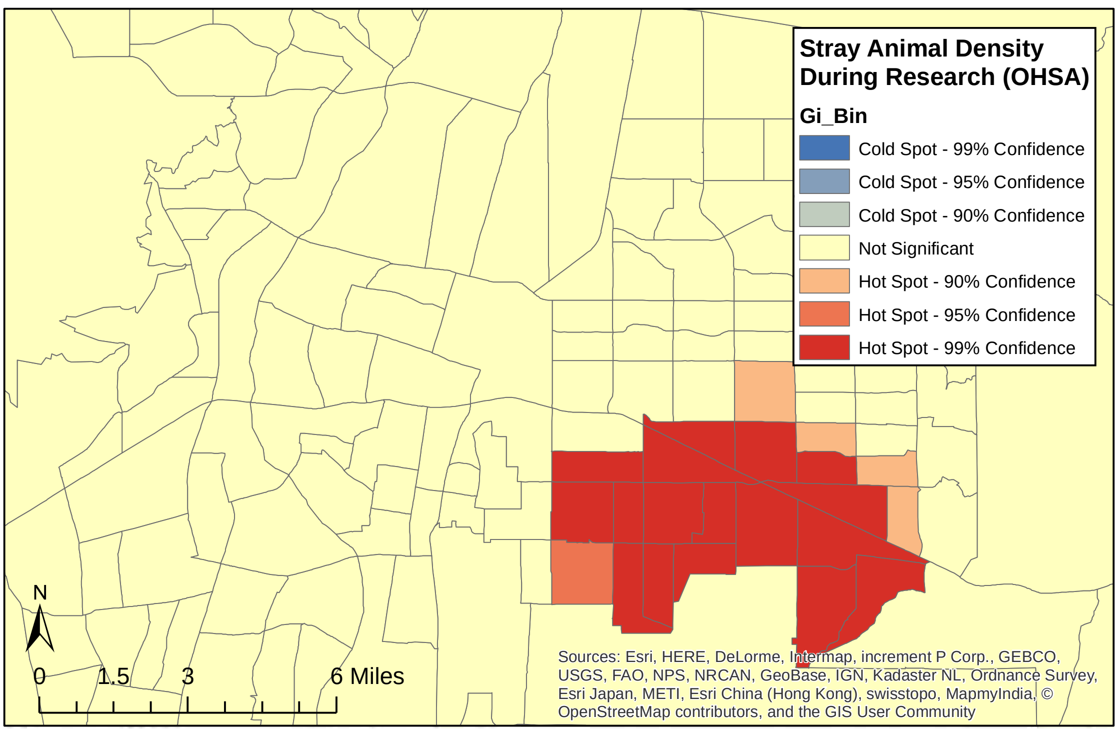


Figure 17. OHSA for the Hispanic population percentages in each census tract

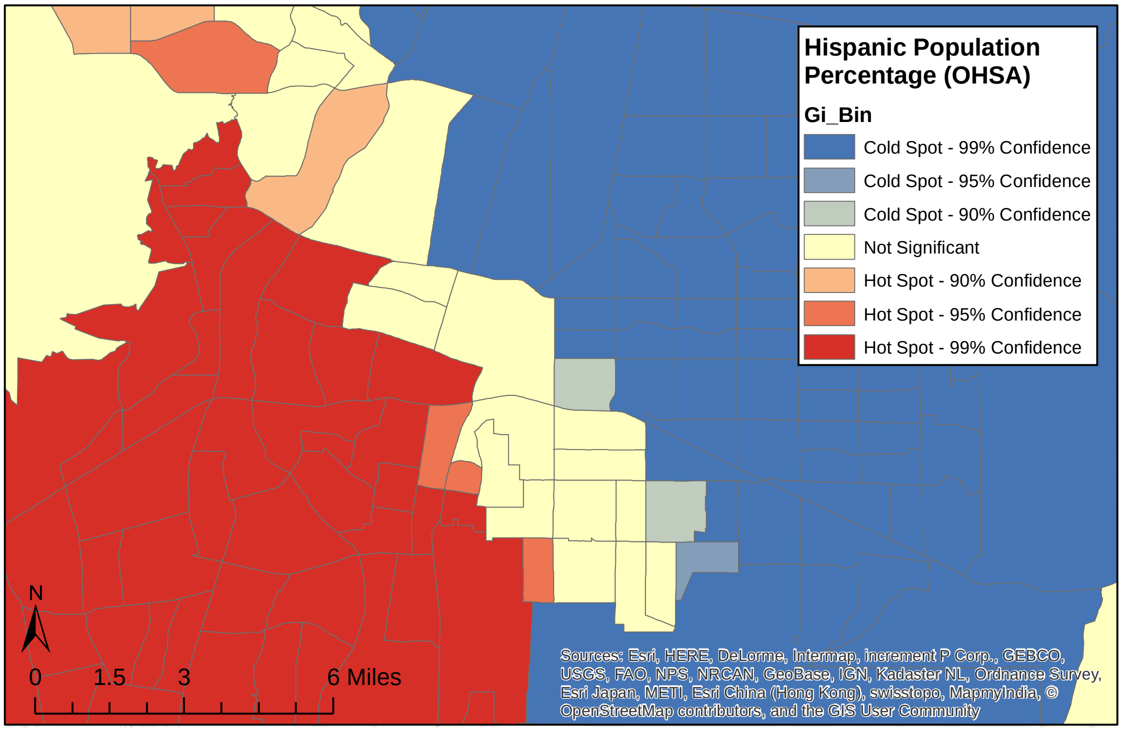


Figure 18. OHSA for the Caucasian population percentages in each census tract

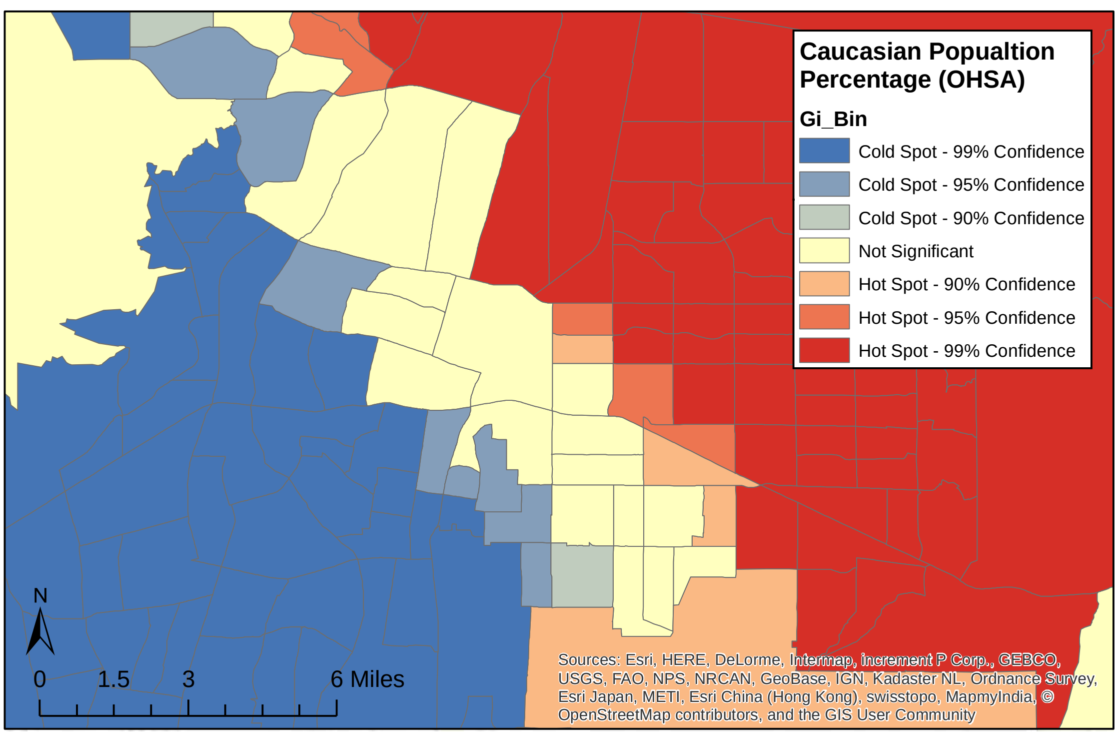


Figure 19. OHSA for African American population percentages in each census tract

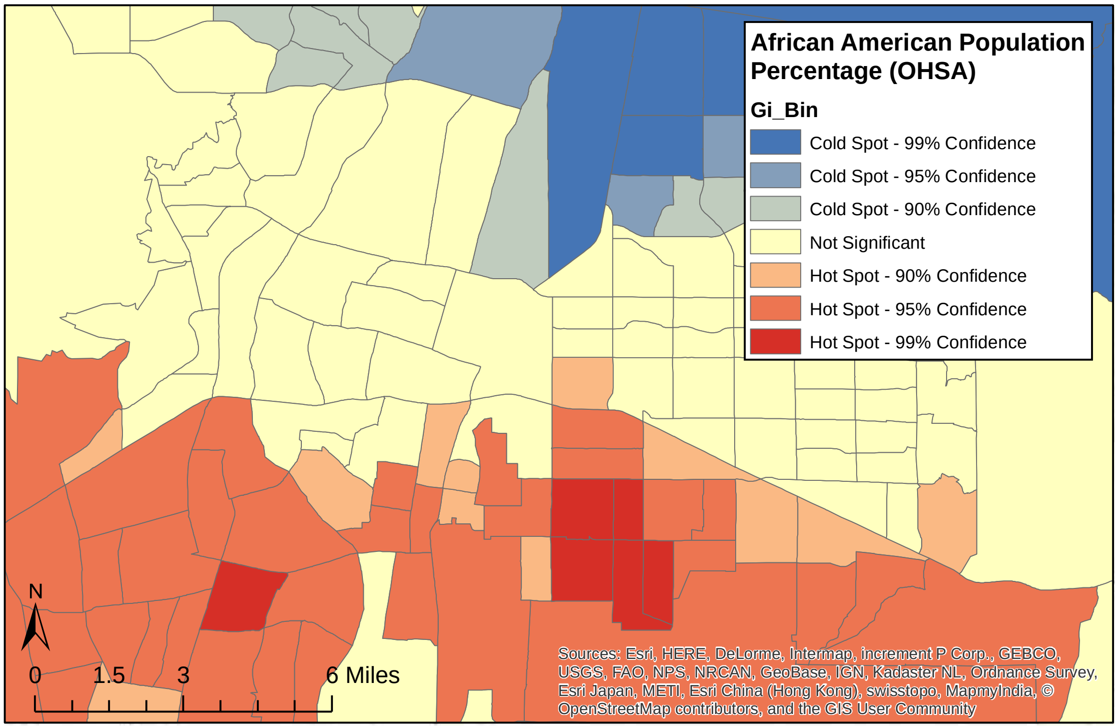


Figure 20. OHSA for percentages of homes with children under 18 in each census tract

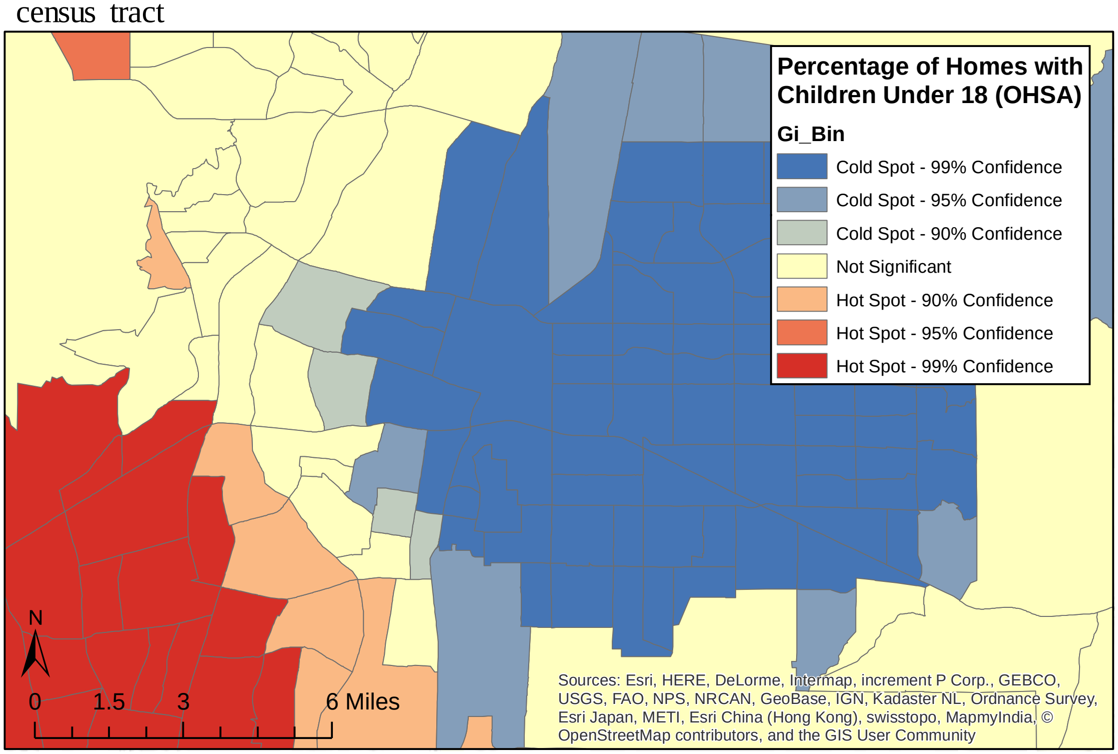


Figure 21. OHSA for percentages of homes with seniors over 65 in each census tract

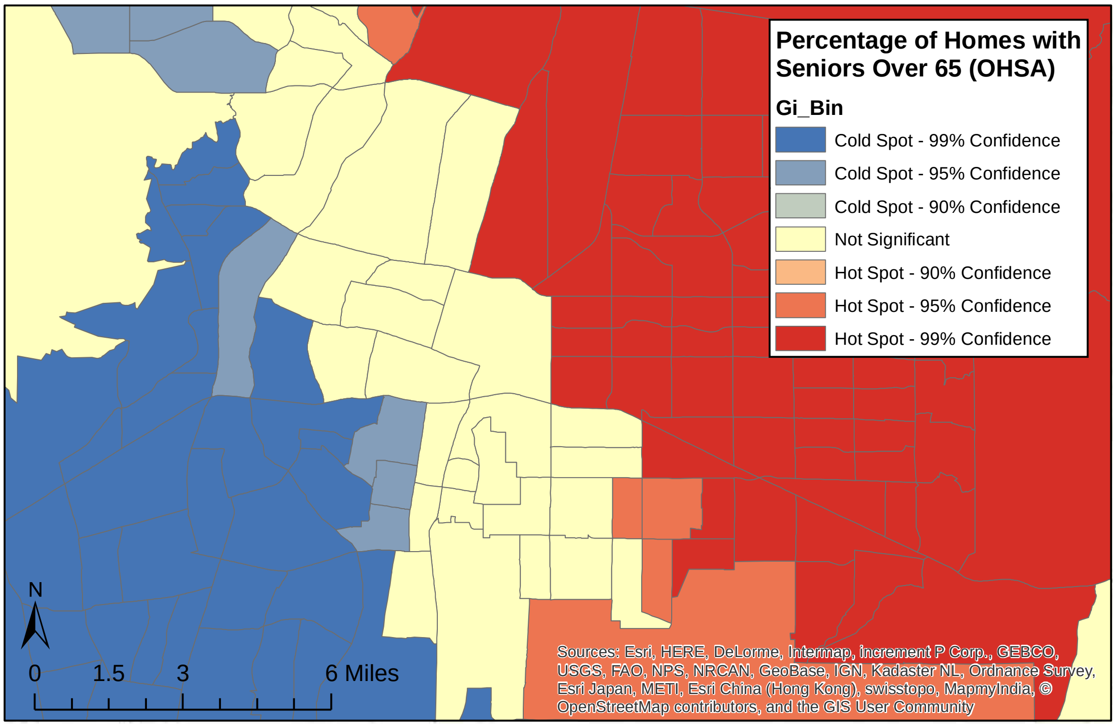


Figure 22. OHSA for average household size in each census tract

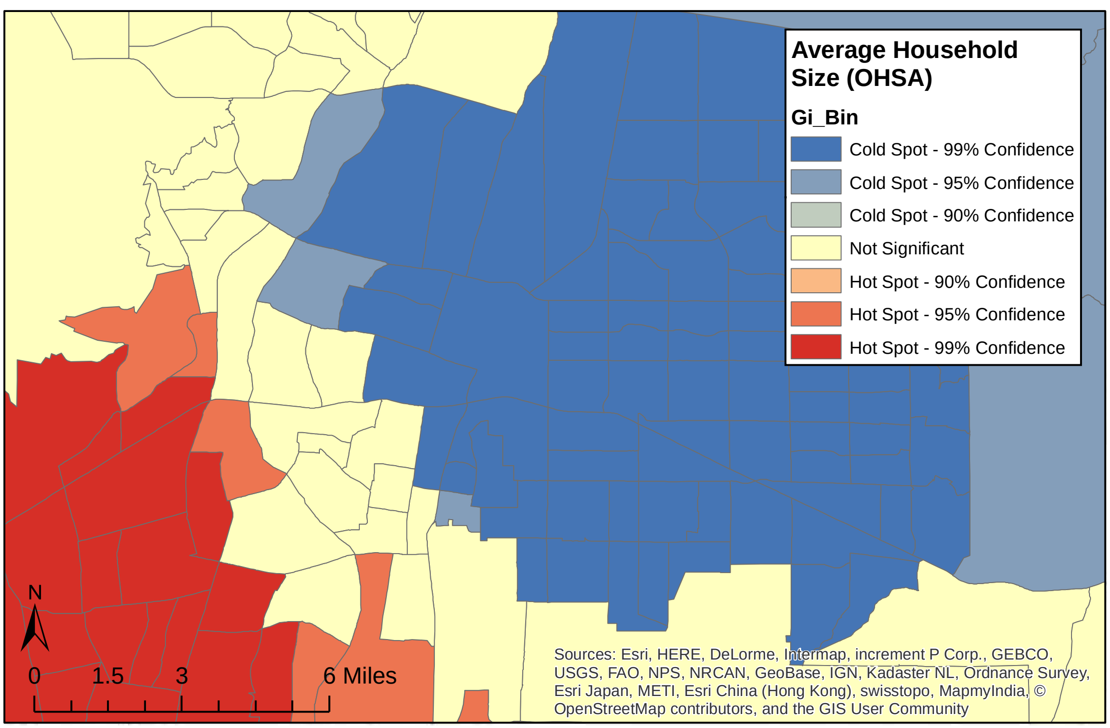


Figure 23. OHSA for percentages of single-family homes in each census tract

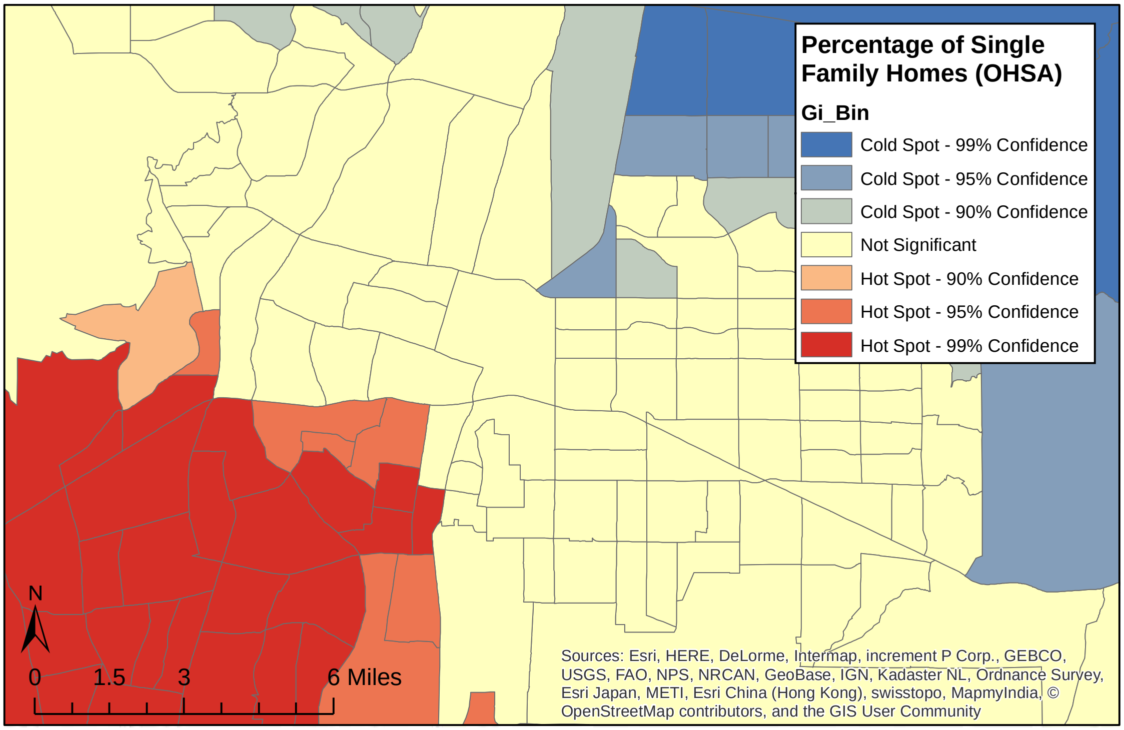


Figure 24. OHSA for percentages of vacant homes in each census tract

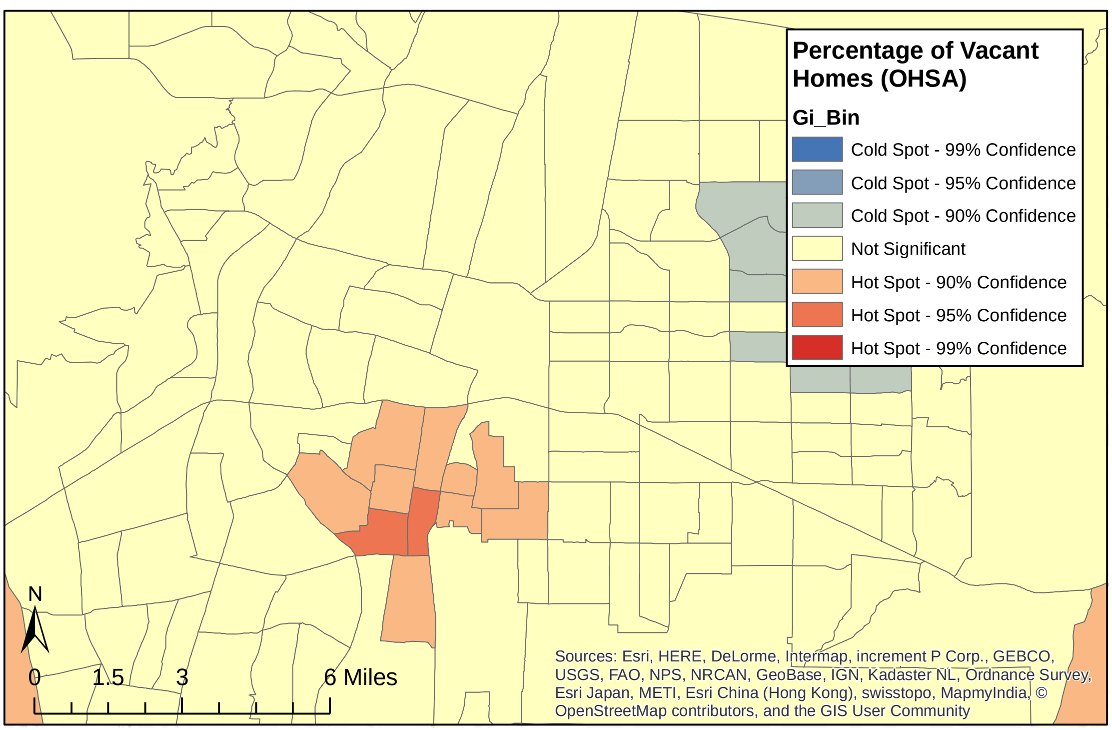


Figure 25. OHSA for percentages of rented homes in each census tract

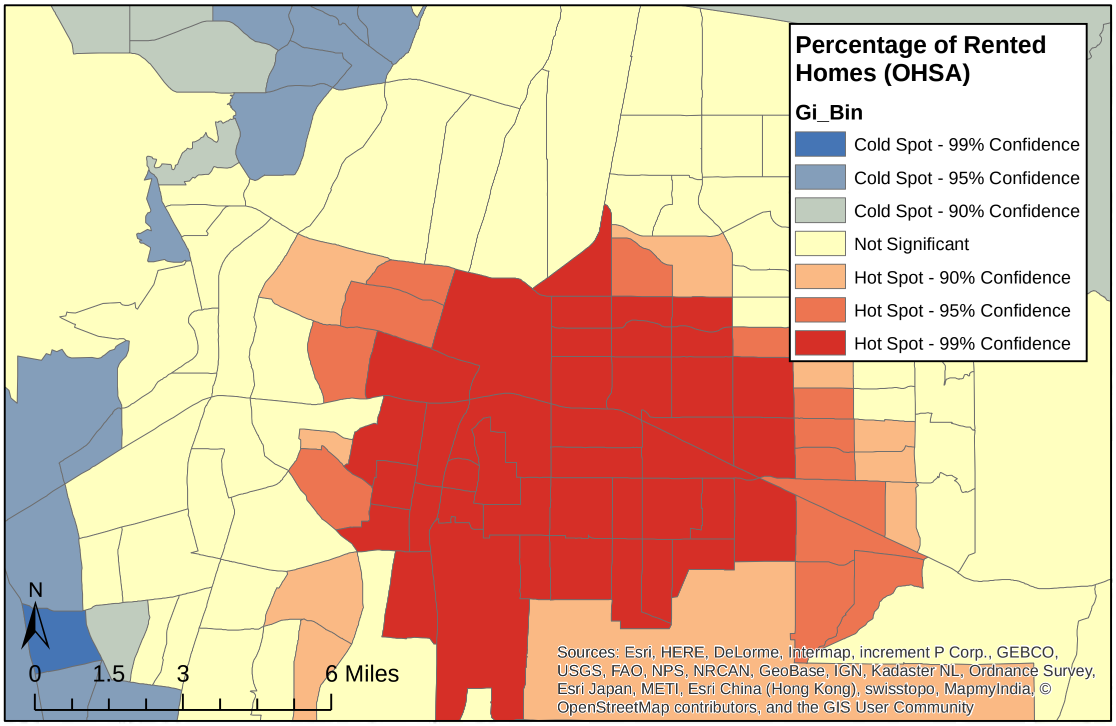


Figure 26. OHSA for population density within each census tract

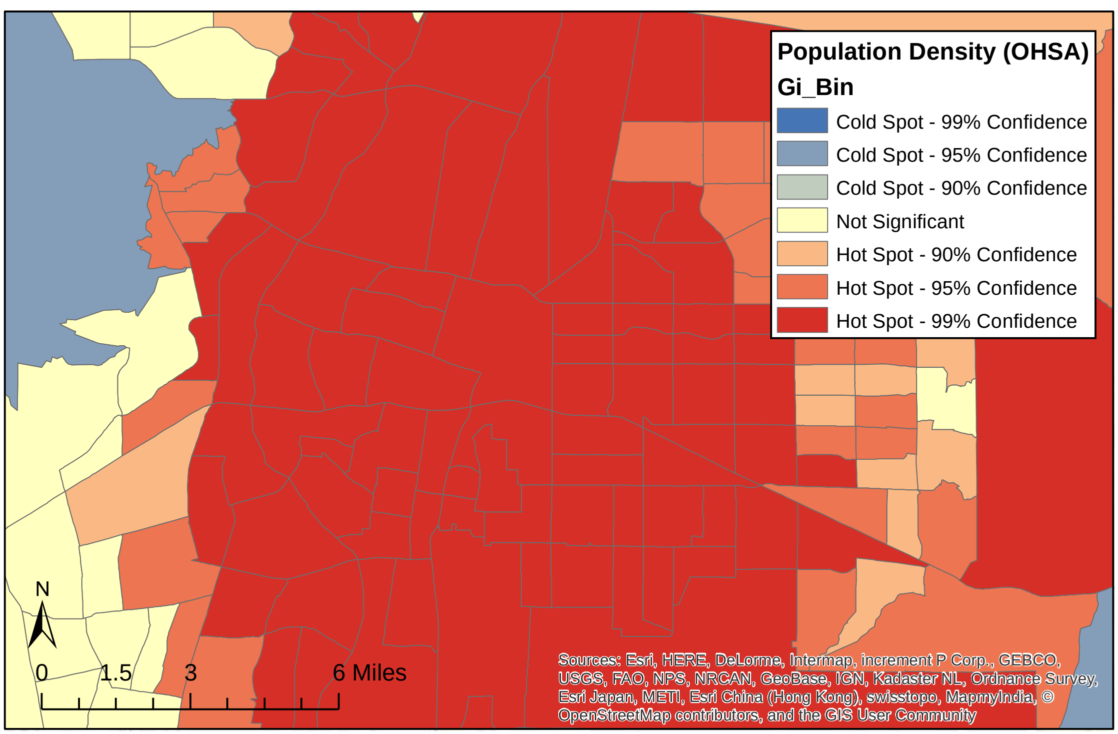


Figure 27. OHSA for crime density within each census tract during field research

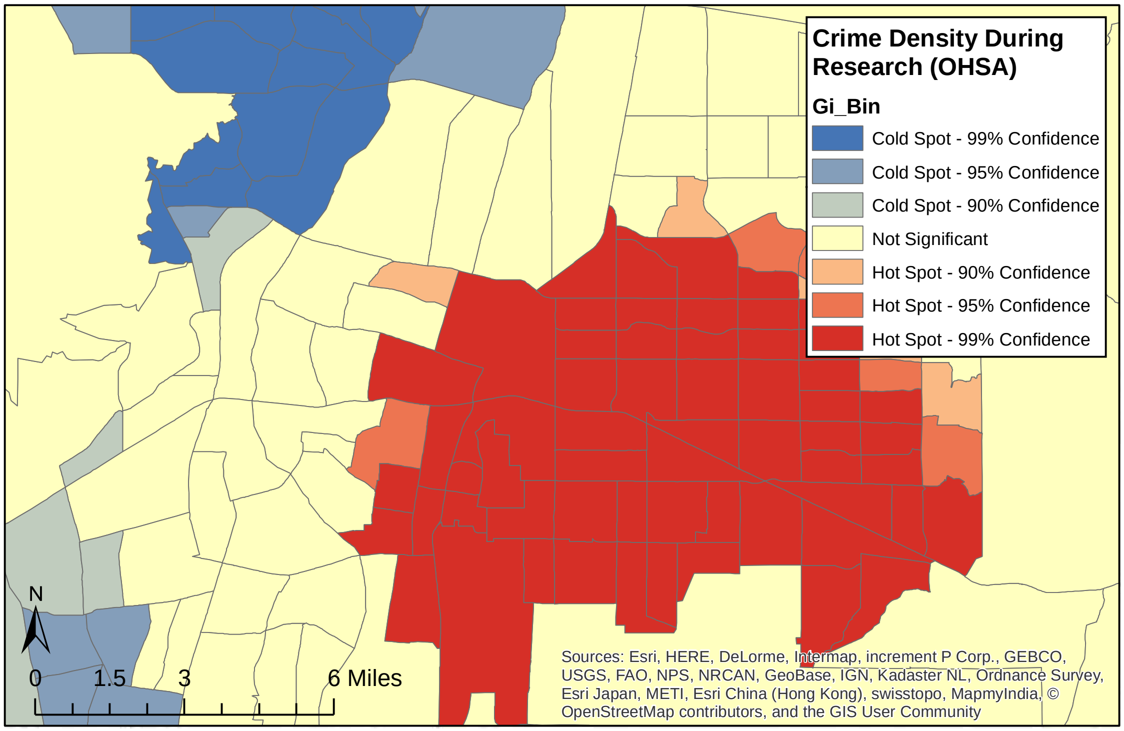
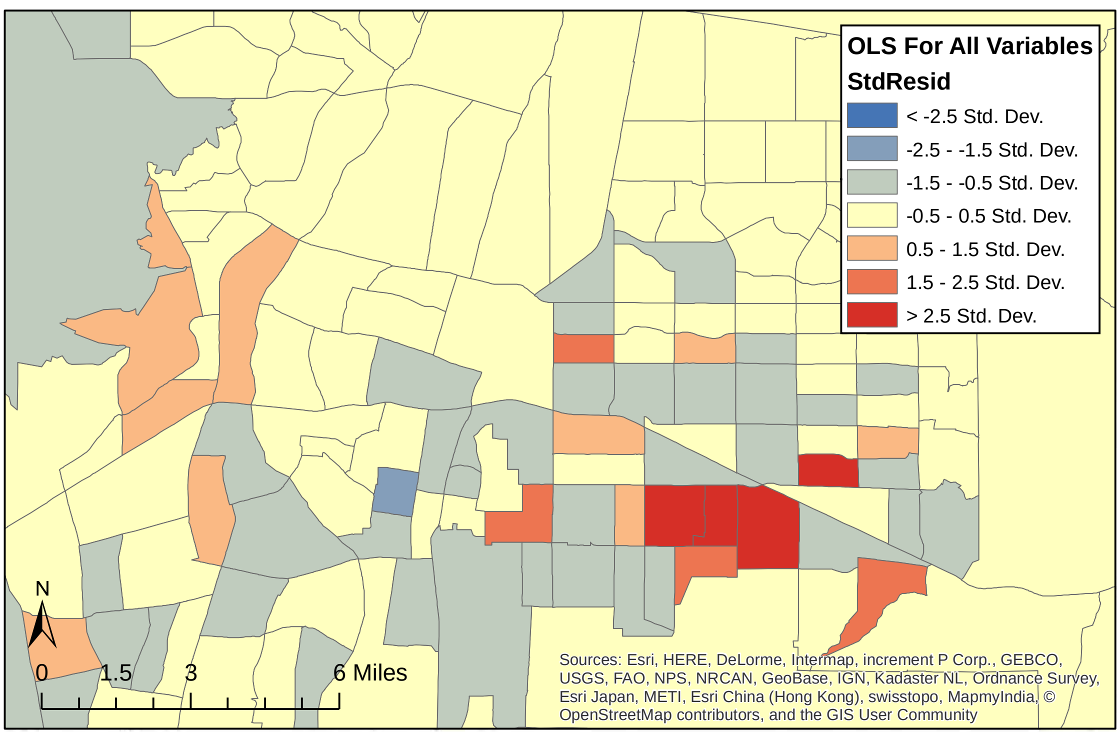


Figure 28. OLS for eleven human social variables tested



The OLS report clearly indicates which variable has a statistically significant association with the dependent variable by having an asterisk (*) by its "Probability [b]" or p value. This variable, crime density, is highlighted in Table 1 below.

Table 1: Results from OLS Report of All Variables

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust-t	Robust_Pr [b]	VIF [c]
Intercept	-5.860266	1.712405	-3.422242	0.000817*	1.985123	-2.95209	0.003686*	
Hispanic Population	-4.342788	1.945547	-2.232168	0.057128	2.344556	-1.85229	0.06602	26.00632
Caucasian Population	5.694887	3.012717	1.890283	0.060716	3.696098	1.540784	0.125559	16.02468
African American Population	0.959267	0.375192	2.556739	0.061587	0.530271	1.809014	0.072524	2.012415
Homes with Children Under 18	-7.550324	3.701498	-2.039802	0.053181	3.500939	-2.15666	0.062673	32.62567
Homes with Seniors Over 65	0.70341	2.483663	0.283215	0.777422	2.403505	0.29266	0.770207	3.446674
Average Family Size	2.725022	1.05724	2.577488	0.070943	1.016995	2.679485	0.068223	35.53188
Single-Parent Home	4.548876	3.479471	1.307347	0.193169	3.931478	1.15704	0.249157	4.666068
Vacant Homes	3.178564	2.390909	1.329437	0.185798	1.789919	1.775814	0.077866	1.399688
Rented Homes	1.152426	0.736698	1.564312	0.119934	0.661491	1.74163	0.083606	3.891904
Crime Density	0.108372	0.033931	3.19386	0.001730*	0.048989	2.21215	0.028512*	1.61393
Total Population	0.000082	0.000052	1.58784	0.11451	0.000044	1.846288	0.066892	1.269571

Because the highlighted variable, crime density, does have a p value < 0.05, this OLS identifies that it has a high likelihood of being associated with the animal density within each census tract. This variable shows a strong statistical relationship with the animal points collected and can support the theory that at least one of these variables share a relationship with the input variable. Below are several tables from the OLS report showing the relationships of the variables from the linear regression.

Table 2: OLS Diagnostics of all Variables

Input Features: Animal Point Percentages & 10 Variables	**Dependent Variable: All Animal Point Percentages**
Number of Observations: 157	Akaike's Information Criterion (AICc) [d]: 460.703964
Multiple R-Squared [d]: 0.253564	Adjusted R-Squared [d]: 0.196938
Joint F-Statistic [e]: 4.477857	Prob(>F), (10,146) degrees of freedom: 0.000008*
Joint Wald Statistic [e]: 23.770858	Prob(>chi-squared), (10) degrees of freedom: 0.013735*
Koenker (BP) Statistic [f]: 18.362484	Prob(>chi-squared), (10) degrees of freedom: 0.073542
Jarque-Bera Statistic [g]: 1321.006392	Prob(>chi-squared), (2) degrees of freedom: 0.000000*

The OLS Diagnostics table above (Table 2) shows the statistical analyses produced throught the Ordinary Least Squares ArcMap tool. These ten statistic formulas provide measures of fit for all variables through the use of different formulas. These ten variables are described (Table 3) on the next page.

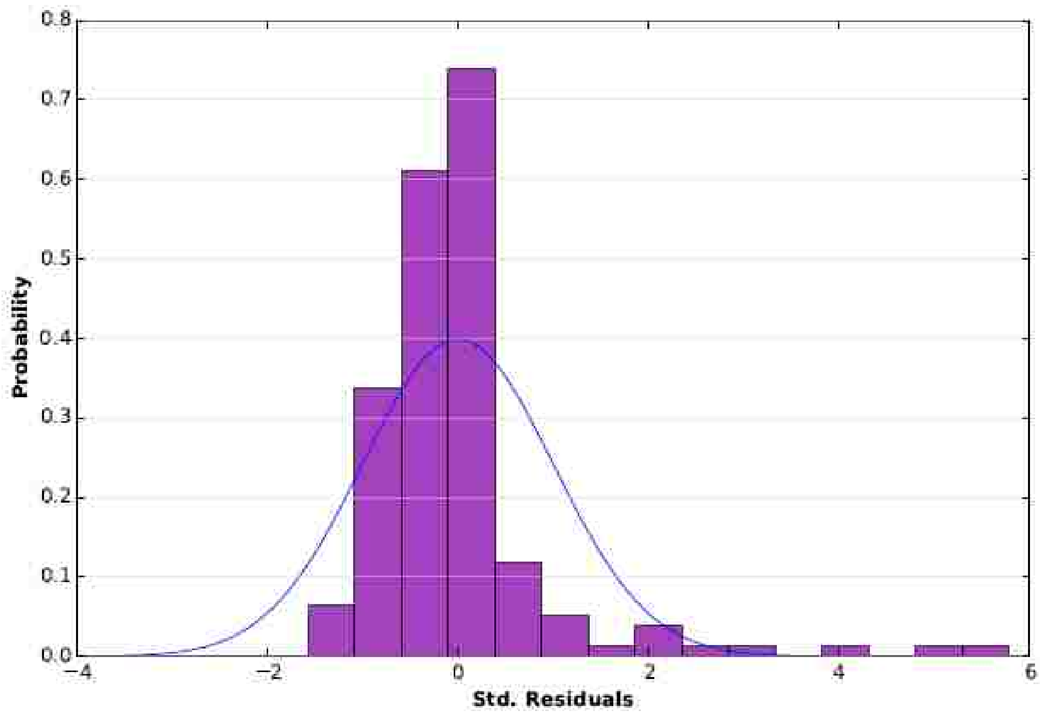
Table 3: Descriptions of Variables for OLS Analysis

Variable	Description
Multiple R-Squared & Adjusted R-Squared	These variables asses model performance with values ranging from 0.0 to 1.0. This value indicates the approximate variation in the dependant variables. For example, a value of 0.5 indicates the model explains 50% of the variation.
Joint F-Statistic & Joint Wald Statistic	These statistics measure overall model significance. If these tests show a 95 percent confidence level, or a p-value smaller than 0.05, they can be seen as statistically significant.
Koenker (BP) Statistic	This statistic assess stationarity, or wheter or not the explanitory varibales have a consistant spatial relationship with each other. A p-value of 0.05 or less indicates heteroscedasticity.
Jarque-Bera Statistic	This statistic assess model bias, or wether or not the observed variable's values are normally distributed. A p-value of 0.05 or less indicates a statistically significant spatial autocorrelation.

When refering to Table 2, the Multiple R-Squared (25.3564) and the Adjusted R-Squared (19.6938) values show that this model and its independent variables explain approximaetly 20 – 25 percent of the variation in the dependent variable. Because these values are both low, only a small percentage of the relationship between the animal locations and the variables assessd can be explained by the OLS model. The Joint F-Statistic and Joint Wald Statistic both indicate model significance because both have a p value of less than 0.01. These values indicated that this model is statistically significant. Because the Koenker (BP) Statistic is used to identify consistancy and stationarity and the result of this analysis was greater than 0.01, the model did not show consistancy and a 95% confidence interval cannot be assumed. Finally, the Jarque-Bera Statistic displayed a value of 0.00000. Because this result was $p < 0.01$, a bias is predicted in this model because the residuals, the observed variables minus their prediction, are not normally distributed (Table 4).

The histogram on the next page (Table 4) shows both a normal curve of probability over standard residuals (blue line) and the actual distribution of the points (purple bars). Because the deviation from normal distribution is significant, as seen in the Jarque-Bera test, this distribution does have statistical significance.

Table 4: Histogram of Standardized Residuals of the OLS Analysis



All the tests run during the OLS do indicate that the density of crimes committed during field research time is the variable with the largest statistical significance to be associated with the density of animals in Albuquerque, New Mexico. The analysis showed this because it has both p values below 0.05 and a robust probability below 0.05. The p value shows a clear relationship, a statistically significant association between the density of crimes and the density of animals found within each census tract.

These results point to a statistically significant association between only one of the variables tested within the total set of eleven. Although the other ten variables do not show a statistically significant association in this research, other tests with different dates, animal collection reports, or simply more census data may provide different results in future analysis.

Limitations of Study: While this study did provide insight into how one of the variables showed a relationship with the animal points collected, all the other variables assessed showed no correlation. Many different factors may have played a role in how these variables compared.

One of the factors that may have influenced the results of this analysis was the specific dates of the field research. These animal collections and crime recordings were specific to the same week in July. While they did relate to one another in terms of timeline, they both may have offered completely different results when collected on another day, month, or year. Crimes and stray animals cannot be predicted by having data from only five days of field research. A longer and more evenly distributed study could provide results which draw very different conclusions.

Another factor that may have influenced the results was the dramatic difference in timeline lengths. The five-day results (crime and animals) and the year-long data on the other ten variables were assessed using the same analysis. Perhaps crime did show the strongest relationship with the animal points collected because they were both data from the same days, while the other variables had a more averaged dataset from 365 days. Understanding how crime and stray animals throughout the city are averaged during an entire year may provide completely different statistics and correlations. If this research were to be conducted again, it should be a year-long field observation for better continuity.

Part VI: Discussion

While the formation of zoos within cities used to be a method of having authority over animals centuries ago (Wolch & Emel), the animal welfare systems today have a very different method of maintaining order. It is no longer simply a matter of controlling animals for human rights alone, they must also adopt the ethical standards for animal rights put into place by centuries of advocacy groups, including the ASPCA. The city of Albuquerque's animal welfare department has not only the authority to provide shelter for these stray animals, but also the responsibility to ensure that these animals are spoken for (Beers, 2006).

Past research has shown that animal geography is impacted by humans (Hesse & Allee, 1951) and this research has attempted to identify how human variables clearly demonstrate that relationship in Albuquerque. In a similar method to the stray dog recordings in Brazil (Dias et al., 2013), the use of GIS in this analysis provided a strictly observational method of recording animal geographies. The findings of this research and the inferences drawn from it provide insight into human-animal geographical relationships in this New Mexico city.

The data collected in this study showed that spatial variance of stray animals within the city of Albuquerque is correlated with the city's human population and at least one of its social variables. While many of the variables were not supported in the Ordinary Least Squares analysis, the social factor of crime density did show a statistically significant relationship with the animal density in each census tract. The crimes included in this analysis were: Assault, auto theft, burglary, commercial theft, counterfeiting, public disturbances, drug arrests, DUI, fraud, larceny, murder, possession of drug paraphernalia, robbery, shooting, shoplifting, building theft, and vandalism.

Unlike the other variables analyzed, the crime report analyzed data based on addresses not simply summarized by census tract. While both crime and animal datasets were broken down into census tracts to make all variables be compared, they may have had the strongest correlation because they were collected in the same five-day window. Because these observations took place during a holiday, which involved fireworks and gunshots, both animals becoming stray and crime rates may have spiked during the research, but this would not be reflected in the other variables because they are averaged.

Another reason why crime may have showed the most statistical significance is because of the local government's role in both Animal Welfare and Police systems. Both the Albuquerque Police Department and the Animal Welfare Department are part of the city government and in many ways the officers are connected through referrals.

During my field research a substantial portion of the calls were impacted by police involvement, both city and state officers. While the city of Albuquerque has created the ABQ311 service for residents to call in issues like stray and endangered animals, many of the calls received by Animal Welfare officers are redirected from calls to 911. Not only were 47 of the 78 total Animal Welfare calls initially placed by 911 calls during my field research, seven even included city and state police officers responding to the calls and filing police reports (Fig. 29).

Figure 29. Animal locked in car in front of Walmart store

In addition to animal welfare calls being misdirected to police officers, several calls during my field research were calls from state and city police needing assistance from animal welfare officers on crime scenes (Fig. 30). While many of these calls were not directly related to stray animals within the city, the relationship between law enforcement officers and animal welfare officers was apparent. Crime may have been the most statistically significant variable of the eleven studied because of the government relationship that these two offices share with one another. All three of the officers that I was able to ride along with remarked on the large amount of calls they usually receive being redirected from the Albuquerque Police Department, all remarking that its usually makes up most of their day. Although Albuquerque has city call centers to handle animal control issues, these centers are not always able to provide assistance.

Figure 30. Welfare officers called to assist in arrest with State Police

While 311 is the number that citizens should dial to contact animal welfare, it has many issues that prevent response. Unlike 911, 311 has scheduled hours (Monday through Saturday – 6 a.m. to 9 p.m., Sundays – 9 a.m. to 6 p.m.). If anyone were to call 311 to report a stray animal after these times, they would be redirected and told to call 911 and report the issue. While the animal welfare officers are in fact working 24 hours a day, they can only receive reports each night from 911 dispatchers. While I did not have the opportunity to ride along with any officers during their night shifts, I would recommend including this in any further research to determine how often calls are redirected from 911 because of scheduling issues.

Distinct areas of poverty in Albuquerque may be influential to a correlation between crime and stray animals as well. According to the U.S. Census Bureau, the same source used in my research, Albuquerque's poverty rate in 2016 was 18.9%, much higher than the national poverty rate for the same year at 12.7% (www.census.gov). Throughout my time in the field, the officers not only were forced to respond to impoverished areas for police assistance, but also chose to do so to show me that these were the distinct areas where they knew stray animals could be found. The variable of income or federal assistance in further research may show a similar correlation to stray animals because income and crime are so ubiquitous.

While I could not find prior research, which studied correlations between crime and stray animals in my research, I found one department which has created a new bureau due to very similar research. On January 1st, 2016 the FBI created the National Incident-Based Reporting System (NIBRS), a dataset focusing on animal abuse and neglect, to use as a method of criminal prediction (FBI, 2016). The bureau believes that the individual relationship between animal cruelty and criminal acts has such a strong correlation that the first may be a predictor of the second and has based an entire system around it. While there is a difference between animal cruelty and stray animal occurrences, perhaps the same predictions can be drawn but generalized to small city areas instead of individuals. While no other research has yet been conducted to validate the relationship that I have studied, I believe that the efforts made by the FBI may instigate research into these correlations.

Although the other variables studied did not show a statistical correlation to the animal points collected, having such a strong correlation with crime may simply shed insight into other variables which were overlooked in this study. These seventeen crime variables were all combined to see crime occurrence as one aspect of research, however, after doing the analysis it can now be seen that this test could be run again with each crime as a variable of its own.

Although crime data collected in this study did show that spatial variance of stray animals within the city of Albuquerque may be related to only one of the measured variables, the research and crime data used was only collected in the 40 hours that I spent in the field. This short time-span and data provided by only one officer's patrol each day may have affected the layout of animal points in my research. With additional time in the field and more access to officer reports, a larger number of both animal and crime points may show a different statistical relationship. An animal collection report from individual field observation may also provide different results due to impartiality. If this field research was repeated, I would suggest an unbiased individual method of research not involving the animal welfare department or not including research variables, like crime, which can be biased due to shared relationships.

Several other variables may have proved to be statistically significant if this research had been extended and lengthened. While the other nine variables did not show a strong relationship with the animal densities in each census tract, this may have only been representative of the 78 animal points used in analysis. Conducting the same research using both the census tract data and a wider scope of animal observations may provide different results and draw different conclusions on variable significance.

According to the statistical significance indicated by the Ordinary Least Squares test, spatial variance of stray animals within the city of Albuquerque is correlated to the city's human population and its social variables. While my results showed relationship between one social variable and stray animals further research should be conducted to continue analysis.

The findings within this field research show that animal geographies are impacted by human geography and its implications, even if these impacts are subtle. While these stray animals were not currently owned by human beings in Albuquerque, the canines recorded in this research will have to be owned or they will be euthanized because city laws insist that they are incapable of surviving without human assistance.

While research in animal cognition and geography initially compared animals directly to humans without taking landscape into account (Andrews & Huss, 2013; Adkins-Regan, 2005), the inclusion of landscape-related variables (Flockhart, Norris & Coe 2016; Diaz et al., 2013; Byrne & Bates, 2011; Bekoff, Allen & Burghardt, 2002) looked at how animals were impacted by humans development. This research has shown that while these stray animals may not be directly impacting the human landscape, human variables are impacting the stray canine and feline landscape in Albuquerque, New Mexico.

Part VI: References

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