SOCIOPOLITICAL, ECOLOGICAL AND BEHAVIORAL ASPECTS OF FREE-ROAMING CATS

by

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(Under the Direction of Sonia M. Hernandez)

ABSTRACT

There are an estimated 50-60 million owned, free-roaming cats in the United States today. The behavior of domestic cats (*Felis catus*) in the outdoors is a controversial subject requiring further research to address cat predation on wildlife, as well as threats to cat welfare while they are roaming. We used point-of-view video cameras (KittyCams) to investigate the activities of roaming pet cats in Athens-Clarke County, Georgia during 2010-2011. Project results suggest that approximately 44% of roaming cats hunt wildlife, and that reptiles, small mammals and invertebrates are common prey in suburban areas. Eighty-five percent of wildlife was captured during warmer weather (March-November). KittyCams video revealed that cats consumed or abandoned the majority of captured prey rather than depositing prey at their residence. Eighty-five percent of project cats were witnessed exhibiting at least one risk behavior during one week of roaming. The most common risk factors experienced by suburban free-roaming cats included: crossing roads, encountering strange cats, eating and drinking substances away from home, exploring storm drain systems and entering crawlspaces. Male cats were more likely to engage in

risk behavior than female cats and older cats engaged in fewer risk behaviors than younger individuals.

INDEX WORDS: Domestic cat, *Felis catus*, free-roaming owned cats, indoor-outdoor house cats, cat predation, suburban cats, suburban wildlife, cat and wildlife interactions, risk factors, perceptions of domestic cats, stray cat management

KITTYCAMS: A WINDOW INTO THE WORLD OF FREE-ROAMING CATS

by

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2012

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August 2012

DEDICATION

To my daughter, Jessee Genevieve, who entered my life during my time in graduate school. May she grow to be a steward of the natural world and to love and respect animals as much as I do.

ACKNOWLEDGEMENTS

Thank you to our KittyCams funding sources:

National Geographic

Morris Animal Foundation

Kenneth A. Scott Charitable Trust

Pender Pet Caring Foundation

Oconee Rivers Audubon Society

Thank you to my dear advisor, Sonia Hernandez, who believed in me and gave me the opportunity to work on this innovative research. My success in this endeavor would not have been possible without her guidance on every aspect of academia. Thank you to my graduate committee, Bob Warren, Norm Thomson and especially, John Carroll, who has supported me through several project ideas, always providing valuable insight to research methods and analysis. Craig Miller taught me the basics of Human Dimensions of Wildlife research and to him I am grateful for advice and assistance with my human dimensions efforts. Thank you to Kyler Abernathy and Barrett Foster of National Geographic Remote Imaging for their frequent technical assistance with the KittyCams. Our cats were very hard on their equipment yet they always managed to bring the cameras back to life and immediately ship them back to Georgia so we could continue data collection.

Thank you to the Warnell School of Forestry and Natural Resources for supporting me financially as I worked towards my new career. Warnell offered terrific training in Wildlife Ecology, I was provided with opportunities to gain relevant teaching experience and to apply for

significant awards. The Warnell program, faculty and staff fully prepared me to serve as a professional in the field of wildlife conservation. I'd like to particularly thank Warnell staff that helped me apply for grants (Eileen Carroll and Tina Jones), take care of graduate student paperwork (Rosemary Wood), assist with the KittyCams website (Morgan Nolan) and help me with everything from shipping to babysitting (Joyce Black). The following Warnell, Ecology and Veterinary students served as volunteers for our cat health screenings: Shaun Boone, DVM, Albert Mercurio, Kristy Segal, Maren Mason. Their veterinary/cat handling experience was invaluable.

I acknowledge my parents for their emotional support though my 5-year journey to switch careers. Also, someday very soon, I will no longer need that check in my holiday cards. Thank you to my sister for serving as an editor for PowerPoint files, manuscripts and more. Thank you to my friends, many of you which I met in graduate school are now treasured, lifelong friends. Thank you for keeping me sane by balancing school with fun and parenting advice. Lastly, thank you to my husband, Justin, for the patience you have exhibited as I have worked on this degree. Thank you for keeping our family afloat with a minimum amount of chastising about my departure from a job with a decent salary. Thank you for supporting my travel bug, listening to my rants, spending countless hours hiking and exploring with me, and supplying me with wine. I could not have accomplished this without you.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW OF FREE-ROAMING DOMESTIC CATS

Domestic cats (*Felis catus*) are a common sight in urban and suburban neighborhoods throughout the world and the number of cats is continuously growing (American Pet Products Association 2012). Domestic cats may be feral (stray, unfriendly, often untamed and unsocialized), stray but somewhat or completely tame, or pets (outdoor "barn cats" and more commonly, indoor-outdoor house cats). Stray cats and a proportion of owned domestic cats roam free without supervision. Free-roaming cats are *not* confined to a house or yard for some portion of each day (Levy and Crawford 2004). Free-roaming cats are the subject of impassioned debates over issues of both wildlife conservation and cat welfare (Longcore et al. 2009). Cats are instinctive and opportunistic predators (Davis 1957, Adamec 1976). Future wildlife management in urban and suburban areas must be cognizant of all components of our current food webs and their resulting influences on native species. Because natural areas are in decline throughout the world, wildlife increasingly depend upon suburban fragments to fulfill habitat requirements (Angold et al. 2006). In addition to other anthropogenic threats present in urban and suburban habitats (roads, windows, pollution, pesticides), the hunting habits of domestic cats may negatively impact populations of native wildlife species (Baker et al. 2008, van Heezik et al. 2010). Domestic cats are America's favorite pet (American Veterinary Medical Center 2007), yet millions roam the streets of suburban areas, subjected to vehicle accidents (Rochlitz 2003) and exposure to injury or disease (Nutter 2005). It is expected that a minority of cat-owners in the

U.S. confine their pets to an indoor lifestyle (American Bird Conservancy 1997, Loyd and Hernandez 2012). Additionally, many Americans support and/or maintain neighborhood colonies of stray cats (Levy and Crawford 2004).

Domestic cats as pets

Cats are believed to have been domesticated from the wildcat (*Felis silvestris*) in the Near East approximately 10,000 years ago (Wade 2007). They were originally valued as predators of pest rodents around grain and crop stores. Domestic cats were brought to America with European settlers and were widely introduced to help control increasing rodent populations associated with the spread of agriculture (American Bird Conservancy 1997). Today cats are cherished as companion animals and are welcomed into our homes.

Annual surveys by the American Pet Products Association continue to report that domestic cats are the most popular pet in the United States. In fact, cats have surpassed dogs as the most popular companion animal in most of North America and Europe (Serpell 2000). The American Bird Conservancy (1997) estimates that a majority of cats spend some time outside every day. Crooks and Soulé (1999) found that 77% of surveyed southern Californians allow their pets to roam. A recent survey of Athens-Clarke County, Georgia residents revealed that 45% of cat owners here permit their pets to roam free outdoors (Loyd and Hernandez 2012). In contrast to feral cats that have large home ranges (up to 8 km^2) (Fitzgerald and Karl 1986, Guttilla and Stapp 2010), pet cats often have small home ranges (Horn et al. 2011) and spend a majority of outdoor time in their own yards (Barratt 1997, Kays and DeWan 2004).

Human perceptions of cats

The issue of domestic cats in the environment has become increasingly controversial over the last decade as researchers continue to compile evidence of negative impacts of free-roaming

cats on native wildlife (Calver et al. 2011). This debate extends beyond responsible pet management to feral cat management. The number of roaming feral domestic cats in the USA is unclear but is thought to be in the tens of millions (Levy et al. 2003, Jessup 2004, Mott 2004). Such high population estimates have implications for both wildlife and public health (Barrows 2004, Longcore et al. 2009) and there is broad interest from community groups, non-profits and management agencies in reducing cat populations. Biologically effective, yet socially acceptable management for feral cats is a matter of contention in the United States and in many developed countries abroad (Robertson 2008). Historically, management involved capturing and euthanizing unwanted feral cats at local shelters. A second strategy, growing in popularity throughout the developed world, involves trapping cats, sterilizing them and releasing the cats back to the site of capture (Trap-Neuter-Release, TNR) (Levy and Crawford 2004). This control method is considered more humane than euthanasia and is promoted by organizations such as: Alley Cat Allies, The Best Friends Animal Society, The American Society for the Prevention of Cruelty to Animals (ASPCA), and The Humane Society of the United States (HSUS). Theoretically, cat colonies should decline over time as neutered members are not reproducing. Recently, cities (ex: Baltimore, MD; Athens, GA; Jacksonville, FL) and states (Illinois) have adopted TNR as their sanctioned method of cat control though the process remains highly controversial (Longcore et al. 2009).

While biologists may harbor concerns about impacts of domestic predators on wildlife and the natural environment, there is also a large group of stakeholders concerned with the welfare of abandoned and feral cats. A few studies report higher disease prevalence among cats living in feral colonies than in owned cats (Nutter et al. 2004a, Norris et al. 2007). Feral cats are subject to environmental extremes, vehicle trauma and predation, all of which contribute to high

mortality rates (Nassar and Mosier 1982, Warner 1985, Andersen et al. 2004, Nutter et al. 2004b) and relatively short life spans (Warner 1985). Such incidences have led one animal rights groups to agree that euthanasia is the most humane management option (People for the Ethical Treatment of Animals 2009); however, others favor the maintenance of feral cat colonies over management actions that include lethal control (Alley Cat Allies 2009).

Whereas advocacy groups pressure policy makers to create cat management legislation relevant to their missions, agencies have little information on which management option the general public prefers or about underlying beliefs, knowledge and experiences that might be related to preferences. A few studies (Ash and Adams 2003; Lord 2008; Loyd and Miller 2010) previously investigated the human dimensions behind the issue of feral cat management, but the extent of the research is geographically limited and general public perceptions of cats and knowledge about cats has not been examined. The controversy over management of feral cats seems to stem from positions of two polarizing groups, the pro-cat advocates (which argue for non-lethal solutions to feral cat overpopulation) and pro-wildlife advocates (which argue for cat removal from the environment as cats are an invasive species detrimental to wildlife) (Williams 2009). Similar disagreements occur regarding responsible pet ownership. Many communities debate the common practice of allowing cats to roam free outdoors (Angier 2009), yet it is important to note that the general public may or may not be as divided as representative wildlife and cat advocacy organizations.

Prior human dimensions research has focused on public preference for TNR management. For example, Texas A & M University faculty and staff preferences for cat removal and TNR were almost equally split; respondents were most likely to support feral cat population control in areas where cats were near people, suggesting their primary concerns

involved impacts on people (Ash and Adams 2003). Ohio residents who owned cats were more likely (than non-cat owners) to support using tax dollars to fund TNR programs as a method of feral cat control (Lord 2008). Lord (2008) also reported significant differences in beliefs about free-roaming cats according to respondent's type of residential community. A majority of residents for each residential group agreed that TNR would be a good management tool for feral cats (urban 79%, suburban 71%, rural 71%), however, specific preferences for other management strategies (i.e. removal, capture and euthanize) were not investigated (Lord 2008). Loyd and Miller (2010) recently examined predictors of preference for TNR management and found age, gender and support for wildlife rights to significantly influence public preference for this management option among Illinois homeowners. Lauber et al. (2007) found ethical judgments of those supporting fertility control (TNR) for cats to include concern over killing animals to satisfy human interests and protection of the individual cats. In contrast, lethal control is often advocated by people who believe fertility control (TNR) works too slowly (Lauber et al. 2007) or not at all.

Because there is limited information on public attitudes (and specific group attitudes) towards cats and their management, I aimed to investigate this issue in my dissertation study area (Athens-Clarke County, Georgia) where the controversy over cat management has been the subject of ongoing debate for several years. In April of 2010, after months of public hearings, the Athens-Clarke County Council approved TNR legislation exempting TNR groups from provisions of county animal law (that previously stated that anyone who feeds stray cats are the animals' owners and responsible parties), allowing registration of cat colonies with the county, and providing $10,000 in vouchers for cat sterilizations. Additional information on public

perceptions may help policy makers understand the controversy, the possible influences on public opinion, and more generally, where public opinion falls.

Risks experienced by free-roaming cats

There are an estimated 50-60 million owned, free-roaming cats in the USA today (American Veterinary Medical Association 2007). According to the HSUS, free-roaming pet cats have an average lifespan of only 3-5 years, while indoor cats live 12-18 years. Factors contributing to the reduced longevity of roaming cats include: vehicular accidents, aggression from other cats, exposure to poison, infectious disease, parasites, domestic dogs, and wild predators (Nutter 2005, HSUS 2009).

Exposure to infectious disease may be one of the most underestimated risks that free-roaming cats encounter. Outdoor cats have been found to have a higher rate of Feline Immunodeficiency Virus (FIV), *Dirofilaria immitis* (heartworm), as well *Bartonella henselae* infection (the causative agent of Cat Scratch Disease) when compared to indoor cats (Maruyama et al. 2003). Access to the outdoor environment is also an important predisposing factor to risk of *Toxoplasma* infection (Lucas et al. 1999, Dubey et al. 2002) and haemobartonellosis (*Mycoplama haemofelis)* (Grindem et al. 1990). *Mycoplasma haemofelis* can cause anemia, conjunctivitis, respiratory disease, and death (particularly in stressed or immunosuppressed cats). Outdoor cats are also exposed to infectious disease carried by ectoparasites such as ticks and fleas. Cat fleas can serve as a vector for Haemobartonellosis, *Bartonella henselae, Coxiella burnetti*, *Rickettsia felis* (and other flea-born rickettsioses) and *Yersinia pestis* (the bacteria that causes potentially fatal plague) (Comer et al. 2004, Case et al. 2006). Ticks serve as a vector for C*ytauxzoon felis,* an emerging protozoan parasite that is nearly always fatal for domestic cats (Birkenheuer et al. 2006).

Owned, free-roaming cats may contract infectious diseases and parasites via encounters with other owned or unowned feral cats. The prevalence of parasites and infectious disease among feral cats has been well documented and may pose a risk to pet cats (Yamaguchi et al. 1996). A high percentage of feral cats in the UK had antibodies to FIV (53%) and Feline parvo virus (84%); 62% of feral cats had been infected with *Toxoplasma gondii* and the feces of greater than 80% of these cats contained eggs of the parasite genus *Toxocara* (roundworms) (Yamaguchi et al. 1996). Ninety-one percent of cats in one colony studied by MacDonald et al. (2000) were infected with *Toxocara cati* (the feline roundworm). Moreover, a recent study reported 96% of feral cats tested in Egypt had antibodies to *T. gondii*, while 60% had antibodies to *Bartonella* (Al-Kappany et al. 2011). Similarly, proportions of feral cats that were seropositive for antibodies against *B. henselae* and *T. gondii* were significantly higher (93% and 63%, respectively) than those found in pet cats (75% and 34%) in North Carolina (Nutter et al. 2004a). Seroprevalence of FIV and Feline Leukemia (FeLV) in unowned cats brought to a Colorado shelter were significantly greater than sampled owned pet cats, and these strays also hosted greater numbers of zoonotic parasites (Hill et al. 2000). Akucewich et al. (2002) documented a high prevalence of ectoparasites such as fleas (93%) among feral cats in Florida while Anderson et al. (2003) recorded 75% of sampled feral cats to host hookworms. The potential health threats posed by interactions of owned, free-roaming cats with other, (possibly) stray cats should not be underestimated. My study site, Athens-Clarke County, Georgia, hosts a large population of feral cats (estimated population ~20,000).

Owned, free-roaming cats have been documented to prey on diverse wildlife (Konecny 1987, Mitchell and Beck 1992, Woods et al. 2003, van Heezik et al. 2010), and predation may also increase exposure to infectious disease and parasites. For example, small mammals and

birds serve as intermediate hosts for *T. gondii* infection (Yamaguchi et al. 1996, Afonso et al. 2007). While *Toxoplasma* does not generally cause clinical disease in cats, it can result in illness and behavior changes in people (Webster 2001, Dabritz and Conrad 2009), putting cat owners at risk. Small rodents are a common prey item of free-ranging cats (Kays and DeWan 2004, Meckstroth et al. 2007), and rodents are an intermediate host for numerous other parasites. Free-roaming cats may contract *Salmonella* from reptiles and birds and may be poisoned by the toxins excreted by common *Bufo* toads (i.e., American toad, Fowler's toad). Pet cats may also experience other negative interactions with wildlife. Cats can come into contact with medium-sized predators, including gray foxes (*Urocyon cinereoargenteus*) and opossums (*Didelphis virginiana*) and attacks could inflict serious injury to cats (Mitchell and Beck 1992). Finally, several studies have documented evidence that coyotes (*Canis latrans*) prey on domestic cats (Crooks and Soulé 1999, Grubbs and Krausman 2009).

Many of the above-mentioned health risks to free-roaming cats also have implications for public health. Numerous infectious diseases caused by bacteria and parasites can be transferred from owned, free-roaming cats to their owners (Dabritz and Conrad 2010, McElroy et al. 2010). These include: *B. henselae*, *Salmonella spp.*, *T. gondii, T. cati,* tapeworms, hookworms, *Sarcoptes scabei*, and ringworm.

Other common risks free-roaming cats encounter include car collisions or becoming lost. Rochlitz (2003) estimated that between 14 and 36% of pet cats were once stray (before adoption), suggesting a large number of owned cats become lost. Road accidents constitute a common cause of injury for domestic cats. In fact, Rochlitz (2003) estimates vehicle accidents to be the fourth most common cause of cat death in Great Britain. The Santa Clara County California Humane Society reported that 57% of all animals found dead on county roads were

cats (Gray 1997), and Baltimore, Maryland annually removes more than 500 owned cats found dead on city roads (Childs and Ross 1986). While cats are usually wary of their surroundings, they often stand little chance against fast-moving vehicles. Lastly, HSUS also provides warnings about the threat of free-roaming cat exposure to common poisons, such as anti-freeze (ethylene glycol) and rat poison (HSUS 2009).

Domestic cat predation

Domestic cats have been identified as "one of the world's worst invasive species" (Lowe et al. 2000), at a time when non-native, invasive species are widely considered to be a leading cause of species endangerment in the United States (Wilcove et al. 1998, Czech et al. 2000, Clavero and Garcia-Berthou 2005). Predatory exotic mammals have contributed to the extinction and decline of a range of vertebrate species worldwide (Nogales et al. 2004). Domestic cats are generalist predators that may exploit a wide range of prey, and cats are able to readily switch prey (Fitzgerald and Turner 2000). While feral domestic cats are deemed responsible for much of the stated decline in some wildlife populations, the contribution of *owned* domestic cat predation is underestimated and needs further attention. The number of owned cats in the United States has tripled during the last 40 years (Lepczyk et al. 2010), possibly amplifying effects to natural North American systems.

Domestic cats are thought to pose a significant threat to the birds, herpetofauna, and small mammals that they prey upon (Crooks and Soulé 1999, Kays and DeWan 2004, Lepczyk et al. 2004, Nogales et al. 2004, Dauphiné and Cooper 2009). Cats hunt instinctively and have been documented killing a prey item even while eating their favorite food (Adamec 1976). Previous research has shown that feeding cats does not curb their natural inclination to hunt wildlife prey. Barratt (1998) reported the number of prey that cats captured was not influenced by the number

of meals provided. Davis (1957) observed that domestic cats continued to hunt rats and pigeons during periods of supplemental feeding and that feeding did not decrease hunting. Cats have been implicated in a number of species extinctions on islands, but have also been found to have negative impacts on songbirds in non-insular environments (Crooks and Soulé 1999, Baker et al. 2008).

Free-roaming cats are especially abundant in urban and suburban environments. These ecosystems serve as habitat to diverse mammals, reptiles and amphibians as well as resident and migratory songbirds (Crooks and Soulé 1999). Such suburban environments contain fragmented islands of natural habitats, surrounded by roads and development which act as barriers to wildlife movement and exert other anthropogenic influences on the health of natural systems (pollution, sediment run-off, loss of plant food sources, bird collisions with windows, etc). Due to the decline of natural areas and the rapid expansion of developed areas (Grimm et al 2008), urban and suburban habitats are critical to the future protection of biodiversity. Furthermore, some suburban fragments prove very valuable to species richness where peaks in richness have been observed at intermediate levels of urbanization on the rural-urban gradient (Faeth et al. 2011). Domestic cat densities in urban/suburban areas generally exceed those of like-sized predators by a factor of 10-100 (Liberg et al. 2000b), thus predation pressure can be extreme. Suburban backyard habitats may provide valuable resources to native wildlife, but they may also become ecological traps if they harbor non-native predators.

The fact that cats prey on native songbirds and wildlife is undisputed. However, the rate of wildlife consumption has been a point of contention in public debates (see the blog www.voxfelina.com for criticisms of science to date), specifically with regards to responsible cat ownership (Angier 2009). Predation on wildlife by feral domestic cats has previously been

investigated in a variety of international locations, most commonly on islands systems (Hawaii, US; Natividad Is., Mexico; Canary Islands; Australia; New Zealand; Galapagos). These studies relied on stomach content or scat analysis to document feral cat prey choice (Fitzgerald and Karl 1979, Liberg 1984, Konecny 1987, Dickman 1996, Nogales and Medina 1996, Molsher et al. 1999, Keitt et al. 2002). Additional studies (Churcher and Lawton 1987, Barratt 1997, Crooks and Soulé 1999, Woods et al. 2003, Lepczyk et al. 2004, Baker et al. 2005, van Heezik et al. 2010) collected information from homeowners on type and frequency of prey deposited by owned cats at residences (Table 1.1). The methodology used in these studies underestimates predation as cats do not bring all kills home to their residence; some are likely eaten or abandoned on site. Kays and DeWan's (2004) observations of 11 roaming cats suggest actual predation rates may be more than three times higher than rates measured by prey returns to owner residences. Additionally, previous cat capture data are likely subject to sources of error including: misidentifying prey, under-reporting predation and lack of willingness by participants to report predation on native species (Baker et al. 2008, van Heezik et al. 2010). Given its significance to wildlife conservation and the current problematic evidence, domestic cat predation necessitates research using improved methodology to reduce error and accurately represent the average impact of a free-roaming, hunting cat. Baker et al. (2008) stressed the need to validate current estimates of predation by prey returns through new methods in future investigations.

Prior studies found mammals to be, on average, the most common prey item captured by owned domestic cats, followed by birds and reptiles (Figure 1). A cat's hunting approach is extremely slow, including lengthy sit-and-wait periods, thus birds may be less frequent victims because they fly away before the pounce (Fitzgerald and Turner, 2000). Some prey items are also

more palatable than others. For example, Cricetid rodents (native mice) and lagomorphs are commonly consumed by cats whereas Murid rodents (non-native mice and rats) and insectivores (shrews) are caught, but often left uneaten (see review in Fitzgerald and Turner, 2000).

Seasonal variation in prey catch has been reported overseas (Liberg 1984, Churcher and Lawton 1987, Barratt, 1997, Paltridge et al. 1997) and peaks in avian prey take that occur during spring and summer in New Zealand are hypothesized to reflect seasonal availability of nestlings and fledglings (van Heezik et al. 2010). Nogales and Medina (1996) and Gillies and Clout (2003) reported prey take to vary by habitat type, and cat prey choice in suburban North American environments is likely to differ in comparison to frequently studied locations (such as Europe, Australia, New Zealand and small islands). The impact of cats on native wildlife in urban and suburban American systems is understudied. While Lepczyk et al. (2003) identified several suburban bird species of conservation concern that were depredated by cats (including Ruby-throated Hummingbirds and American Bluebirds), predation events likely affect numerous other backyard wildlife species. Recent research in suburban Washington DC reported domestic cats to be responsible for nearly half of all documented predation events on nestling and juvenile Gray Catbirds (Balogh et al. 2011). Domestic cats were also found to be a dominant nest predator of urban Mockingbirds in Florida (Stracey 2011).

Depredation of songbirds by domestic cats has received some attention in the literature and media (see review in Dauphiné and Cooper 2009), but information about cat predation on other taxonomic groups remains deficient. Lizards have been found to form a significant part of the feral cat diet on some islands (e.g., Canary Islands, Nogales and Medina 1996; Galapagos, Konecny 1987). A stomach content analysis study in Australia revealed that some cat stomachs contained 10 or more lizards of several species (Paltridge et al. 1997). Lizards, frogs and toads

may constitute frequent prey items of North American cats during spring and summer. Cats are opportunistic predators and prey selection is correlated with prey availability (Liberg 1984, Molsher et al. 1999). Carolina anoles, fence lizards and American toads are widely available (seasonally) in suburban southeastern habitats, yet herpetofauna represent taxonomic groups least likely to be recognized by the public as susceptible to cat predation because they are easily consumed and because they quickly decompose, leaving no obvious evidence of cat predation as the ultimate cause of death.

Certain prey species may be disproportionately represented in cat prey take, though the lack of background information inhibits predictions of specific species. Life history characteristics may make some groups more susceptible to cat predation (for example ground-foraging strategies) and studying predation events by taxonomic groups may identify patterns amongst prey with important management implications. Groups may be further analyzed by native/non-native status. One study in California examined correlations between native rodent abundance in sites with cats and those where cats were excluded, finding more non-native pests (such as *Mus musculus*) in areas with cats while diverse native species were present in the absence of cats (Hawkins et al. 2004). The usefulness of cats for pest rodent control may be a misconception.

Although some advocacy groups (e.g., Alley Cat Allies) claim domestic cat predation is natural and compensatory (whereby predation substitutes for death that would occur naturally), depredation of local wildlife may be a valid conservation threat to biodiversity in suburban habitats. Recent research on the impact of cat predation in the UK (Baker et al. 2008) and New Zealand (van Heezik et al. 2010) suggest predation represents additive mortality for songbird species already subject to existing urban/suburban threats, including habitat loss and window

collisions. The addition of another major source of mortality may drive some songbird species to threatened status. Baker et al. (2008) measured predation rates on several species of urban songbirds and concluded that cat predation constitutes a significant mortality factor for some local populations in the UK. Lastly, Erickson et al. (2005) ranked cat predation as third behind buildings and power lines as a cause of anthropogenic bird mortality in the United States.

North American wildlife evolved alongside native predators thus additional predation pressure exerted by high densities of introduced predators may result in local extinctions of some continental species. Baker et al. (2008) recorded cat densities of 229-523 cats/km ^{2} in an urban area of the UK, far higher than native mesopredator densities (averaging 37 animals/km ^{2} for red foxes). Liberg et al. (2000) summarized observations of cat densities and listed over 2,000 cats/km^2 in sites in urban Rome, Italy, Jerusalem, Israel and Ainoshima, Japan. Such high densities of generalist predators can be assumed to exert greater negative influence over prey populations than native predators.

Cats can also have considerable impact on the broader health of ecosystems by outcompeting native predators (George 1974) and by changing the composition of natural communities (Crooks and Soulé 1999). Domestic cats have been labeled "keystone modifiers", causing substantial long-term changes in the structure of the biota of the environment in which they occur (Hawkins et al. 2004). Introduced predators can also influence plant communities through reduction of vertebrates that play an important role in seed dispersal, pollination or soil disturbance (Darwin 1859), resulting in cascading trophic impacts on entire ecosystems.

Influences on cat behavior

Cats are extremely variable in behavior and habits; therefore it is difficult to generalize behavior by studying just a few individuals (Bateson 2000). Some cats hunt frequently whereas

others are content to sit in one location all day. Predatory behavior, specialization, and prey preferences differ by individual (Bateson, 2000); however, age, gender and health characteristics may be predictors of cats' risky behavior in the outdoors. Hill et al. (2000) and Yamaguchi et al. (1996) documented higher rates of disease in male cats. MacDonald et al. (2000) found 81% of female domestic cats in a studied colony to be clinically normal, while only 47% of males were free of infectious disease. The authors found no effect of age on infectious disease status in the colony. Barratt (1998) discussed a negative relationship between the age of pet cats and predation behavior in Australia. Younger pet cats were also reported to capture a significantly greater number of prey than older cats in New Zealand (van Heezik et al. 2010) and the UK (Woods et al. 2003). A survey conducted by Rochlitz (2003) in Great Britain revealed that cats exposed to vehicular accidents differed by age and sex; the odds of being in a road accident decreased with age and males were more likely to be hit by a car than female cats. Childs and Ross (1986) documented that males constituted 63% of road accident victims in Baltimore.

Cat hunting behavior may differ by time of day and season. George (1974) analyzed the behavior of three cats and found 50% of prey captures to occur during the day with just 30% at night. Barratt (1997) found almost all prey captures returned to residences at his Australian study site occurred during the day. In temperate climates, cats may be more active during spring and fall months than during periods of extreme cold or mid-day summer heat. George (1974) found cats to be more active during crepuscular summer hours while Churcher and Lawton (1987) found that cats in England brought home more prey during calm, dry weather. The amount of time spent hunting varies widely by individual and it is well known that some cats are more active or successful hunters than others. The influence of docility (feral vs. owned) and reproductive status on hunting behavior has been studied previously, documenting that feral

males are more efficient hunters than owned females and that female mothers capture more prey than non-mothers [see summary in Fitzgerald and Turner (2000)].

PROBLEM STATEMENT

There is an urgent need for additional scientific information on the activities of roaming cats, to inform conservation management, policy and concerned pet owners. Woods et al. (2003) and Baker et al. (2005) suggest further investigation of the predatory activities of domestic cats is needed, particularly via detailed observations of cats in the field. A recent essay by Longcore et al. (2009) in Conservation Biology made a call to scientists to conduct research to address a critical need for information on the interactions and adverse ecological effects of domestic cats in the environment. Quantifying wildlife lost to cats and identifying the most susceptible types of prey constitute important first steps to understanding how wildlife populations may respond to this emerging threat. Combined with existing knowledge on species natural history (e.g., annual productivity), this information can predict which aspects of suburban communities may be most at risk of additive mortality due to cat predation. Recording the diversity and seasonality of suburban cat prey can provide further insight into the extent and variation of the threat. The rate of wildlife capture has been a point of dispute in public debates. Previous studies rely on homeowner reports of prey take and other indirect methods that may under-represent captures and research using improved methodology is needed. Additionally, there is concern about the welfare of free-roaming, domestic cats (American Veterinary Medical Association is one example: http://www.avma.org/issues/policy/animal_welfare/feral_cats.asp), yet the type and frequency of risks experienced by indoor/outdoor pet cats has never been examined. Cat age, sex, roaming habits and habitat may influence both hunting and risk behaviors.

A substantial increase in public education is urgently needed to educate citizens about responsible pet ownership. Pet owners may not be aware of the possible negative effects and risks associated with allowing their pet to roam free outdoors. The statistics and video footage resulting from this project can be utilized in the development of educational materials to encourage the practice of keeping cats indoors for their own health and safety. Despite previous efforts at educating the public about the benefits of keeping cats indoors (e.g.: American Bird Conservancy's Cats Indoors campaign, the Humane Society of the US "A Safe Cat is a Happy Cat" publications), free-roaming cats remain a common occurrence. Results from a human dimensions survey conducted in Athens, Georgia can help develop appropriate educational materials by providing baseline information on public awareness of risks experienced by free-roaming cats and perceptions of depredation of wildlife by pet cats.

METHODOLOGY

Animal-borne video systems have been used previously to study habitat use, food habits and general animal behavior in a variety of species including: marine mammals, sea turtles, and even penguins (Ponganis et al. 2000, Heithaus et al. 2002, Hays et al. 2007, Herman et al. 2007). More recently, National Geographic Remote Imaging engineers constructed a system for terrestrial use in lions (Moll et al. 2007). Animal-borne video systems record an animal-eye view of activities without disrupting behavior. Such systems provide broad benefits to investigating specific behavioral hypotheses such as food selection and species interactions.

Because of the controversial nature of the activities of free-roaming cats (especially with regards to interactions with native wildlife), I aimed to collect substantial amounts of objective data using animal-borne video systems. In order to detect hunting behaviors and to fairly extrapolate the frequencies of risk and predation events, a minimum of seven to ten full days of

outdoor footage was requested per participating cat. Whereas most animal behavior research is limited by very small samples sizes, I also aimed to include a representative sample of free-roaming pet cats in our study area. A larger sample size helped identify the range of hunting and risk activity exhibited by most free-roaming cats.

RESEARCH OBJECTIVES

I surveyed Athens-Clarke County residents to examine perceptions of domestic cats, and preferences for management of feral cats (Chapter 2). Specific objectives for this research included: 1) Determining Athens-Clarke County residents' perceptions of domestic cats, attitudes towards feral cats and preferences for management, 2) investigating residents' experiences with and knowledge of feral cats, 3) exploring relationships between residents' experiences with feral cats and attitudes towards feral cats, 4) exploring relationships between residents' knowledge of cats and attitudes towards feral cats, and 5) examining attitudes towards, experiences with, and knowledge of domestic cats as predictors of support for TNR legislation.

I also measured the outdoor activities of domestic cats by monitoring owned, free-roaming cats equipped with point-of-view video cameras (KittyCams) (Chapters 3 and 4). Research goals included: 1) identifying the percentage of owned domestic cats stalking, chasing and capturing wildlife 2) documenting the frequency of predation events, 3) identifying common prey species of suburban cats, considering the heterogeneity of habitat types and season, 4) examining the frequency of risk behaviors exhibited by free-roaming pet cats and 5) investigating characteristics of cats as predictors of hunting and risk behaviors (including age, sex, health status, roaming habitat, time spent outside).

LITERATURE CITED

Adamec, R. E. 1976. The interaction of hunger and preying in the domestic cat (*Felis catus*): An adaptive hierarchy. Behavioral Biology 18:263-272.

Afonso, E., P. Thulleiz, D. Pontier, and E. Gilot-Freemont. 2007. Toxoplasmosis in prey species and consequences for prevalence in feral cats: not all prey species are equal. Parasitology 134:1963-1971.

Akucewich, L. H., K. Philman, A. Clark, J. Gillespie, G. Kunkle, C. F. Nicklin, and E. C. Greiner. 2002. Prevalence of ectoparasites in a population of feral cats from north central Florida during the summer. Veterinary Parasitology 109:129-139.

Al-Kappany, Y., M. R. Lappin, O. Kwok, S. Abu-Elwafa, M. Hilali, and J. P. Dubey. 2011. Seroprevalence of *Toxoplasma Gondii* and concurrent *Bartonella*, Feline Immunodeficiency Virus, Feline Leukemia Virus and *Dirofliaria* Immitis infections in Egyptian cats. Journal of Parasitology 97: 256- 258.

Alley Cat Allies. 2009. What's best for cats: Being dead or alive? *in* Alley Cat Allies, Bethesda, Maryland. <http://www.alleycat.org/Page.aspx?pid=402> Accessed on 1 July 2011.

American Bird Conservancy. 1997. Human attitudes and behaviors regarding cats. *in* Cats Indoors: the campaign for safer birds and cats. Washington, DC.

American Pet Products Association. 2012. Industry statistics and trends. <http://www.americanpetproducts.org/press_industrytrends.asp> Accessed on 11 June 2012.

Andersen, M. C., B. J. Martin, and G. W. Roemer. 2004. Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats. Journal of the American Veterinary Medical Association 225:1871-1876.

Anderson, T. C., G. W. Foster, and D. J. Forrester. 2003. Hookworms of feral cats in Florida. Veterinary Parasitology 115:19-24.

Angier, N. 2009. Give birds a break, Lock up the Cat. *in* New York Times. New York City, NY. <http://www.nytimes.com/2009/09/29/science/29angi.html?_r=1&th&emc=th> Accessed on 11 June 2012.

Angold, P. G., J. P. Sadler, M. O. Hill, A. Pullin, S. Rushton, K. Austin, E. Small, B. Wood, R. Wadsworth, R. Sanderson, and K. Thompson. 2006. Biodiversity in urban habitat patches. Science of the Total Environment 360:196-204.

Ash, S. J., and C. E. Adams. 2003. Public preferences for free-ranging domestic cat (*Felis catus*) management options. Wildlife Society Bulletin 31:334-339.

American Veterinary Medical Association. 2007. Market reseach statistics on U.S. pet ownership. < http://www.avma.org/reference/marketstats/ownership.asp> Accessed 11 June 2012.

Baker, P. J., A. J. Bentley, R. J. Ansell, and S. Harris. 2005. Impact of predation by domestic cats, *Felis catus*, in an urban area. Mammal Review 35:302-312.

Baker, P. J., S. E. Molony, E. Stone, I. C. Cuthill, and S. Harris. 2008. Cats about town: is predation by free-ranging pet cats *Felis catus* likely to affect urban bird populations? Ibis 150:86-99.

Balogh, A. L., T. B. Ryder, and P. P. Marra. 2011. Population demography of Gray Catbirds in the suburban matrix: sources, sinks and domestic cats. Journal of Ornithology 152: 717-726.

Barratt, D. G. 1997. Predation by house cats, *Felis catus*, in Canberra, Australia .1. Prey composition and preference. Wildlife Research 24:263-277.

_____. 1998. Predation by house cats, *Felis catus*, in Canberra, Australia. II. Factors affecting the amount of prey caught and estimates of the impact on wildlife. Wildlife Research 25:475-487.

Barrows, P. L. 2004. Professional, ethical and legal dilemmas of trap-neuter-release. Journal of the American Veterinary Medical Association 225:1365-1372.

Bateson, P. 2000. Behavioral development in the cat. Pages 10-22 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K. .

Birkenheuer, A., J. Le, A. Valenzisi, M. Tucker, M. Levy, and E. Breitschwerdt. 2006. Cytauxzoon felis infection in cats in the mid-Atlantic states: 34 cases (1998-2004). Journal of the American Veterinary Medical Association 228:568-571.

Calver, M. C., J. Grayson, M. Lilith, and C. R. Dickman. 2011. Applying the precautionary principle to the issue of impacts by pet cats on urban wildlife. Biological Conservation 144:1895-1901.

Case, J. B., B. Chomel, W. Nicholson, and J. E. Foley. 2006. Serological survey of vector-borne zoonotic pathogens in pet cats and cats from animal shelters and feral colonies. Journal of Feline Medicine & Surgery 8:111-117.

Childs, J. E., and L. Ross. 1986. Urban cats: characteristics and estimation of mortality due to motor vehicles. American Journal of Veterinary Resources 47:1643-1648.

Churcher, P. B., and J. H. Lawton. 1987. Predation by domestic cats in an English-village. Journal of Zoology 212:439-455.

Clavero, M., and E. Garcia-Berthou. 2005. Invasive species are a leading cause of animal extinctions. Trends in Ecology & Evolution 20:110-110.

Comer, J. A., C. D. Paddock, and J. E. Childs. 2004. Urban zoonoses caused by *Bartonella*, *Coxiella*, *Ehrlichia* and *Rickettsia* species. Vector Borne and Zoonotic Diseases 1:91-118.

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.

Czech, B., P. R. Krausman, and P. K. Devers. 2000. Economic associations among causes of species endangerment in the United States. BioScience 50:593-601.

Dabritz, H. A., and P. A. Conrad. 2010. Cats and Toxoplasma: Implications for Public Health. Zoonoses and Public Health 57:34-52.

Darwin, C. 1859. On the origin of species by means of natural selection. John Murray, London, U.K.

Dauphiné, N., and R. J. Cooper. 2009. Impacts of free-ranging domestic cats (*Felix catus*) on birds in the United States: A review of recent research with conservation and management recommendations. Pp. 205-219 in Rich, T, and C. J. Ralph, (eds.). Proceedings of the Fourth International Partners in Flight Conference.

Davis, D. E. 1957. The Use of Food as a Buffer in a Predator-Prey System. Journal of Mammalogy 38:466-472.

Dickman, C. R. 1996. Impact of generalist predators on the native fauna of Australia. Wildlife Biology 2:185-195.

Dubey, J. P., W. J. A. Saville, J. F. Stanek, and S. M. Reed. 2002. Prevalence of Toxoplasma gondii antibodies in domestic cats from rural Ohio. Journal of Parasitology 88:802-803.

Erickson, W., G. Johnson, and D. Young. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report PSW-GTR-191:1029-1042.

Faeth, S. H., C. bang and S. Saan. 2011. Urban biodiversity: patterns and mechanisms. Annals of the New York Academy of Sciences 1223: 69-81.

Fitzgerald, B. M., and B. J. Karl. 1979. Foods of the feral house cat in forest of Orongorongo Valley, Wellington New Zealand Journal of Zoology 6:107-126.

Fitzgerald, B. M., and B. J. Karl. 1986. Home range of feral house cats in forests of the Orongorongo Valley, Wellington, New Zealand. New Zealand Journal of Ecology 9:71-81.

Fitzgerald, B. M., and D. C. Turner. 2000. Hunting behavior of domestic cats and their impact on prey populations. Pages 152-175 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

George, W. G. 1974. Domestic cats as predators and factors in winter shortages of raptor prey. Wilson Bulletin 86:384-396.

Gillies, C., and M. Clout. 2003. The prey of domestic cats in two suburbs of Auckland City, New Zealand. Journal of Zoology 259:309-315.

Gray, L. B. 1997. Keeping your cat indoors. *in* The Avocet. Santa Clara county Audubon Society, Cupertino, CA.

Grimm, N.B., S.H. Faeth, N.E. Golubiewski, C.L. Redman, J. Wu, X. Bai and J.M. Briggs. 2008. Global Change and the Ecology of Cities. Science 319: 756-760.

Grindem, C. B., W. T. Corbett, and M. T. Tomkins. 1990. Risk factors for *Haemobartonella felis* infection in cats. Journal of the American Veterinary Medical Association 196:96-99.

Grubbs, S. E., and P. R. Krausman. 2009. Observations of coyote-cat interactions. Journal of Wildlife Management 73:683-685.

Guttilla, D. A., and P. Stapp. 2010. Effects of sterilization on movements of feral cats at a wildland–urban interface. Journal of Mammalogy 91:482-489.

Hawkins, C. C., W. E. Grant, and M. T. Longnecker. 2004. Effect of house cats, being fed in parks, on California birds and rodents. Proceedings of the 4th International Urban Wildlife Symposium: 164–169.

Hays, G. C., G. J. Marshall, and J. A. Seminoff. 2007. Flipper beat frequency and amplitude changes in diving green turtles, *Chelonia mydas*. Marine Biology 150:1003-1009.

Heithaus, M.R., L.M Dill, G. J.Marshall, and B. Buhleier. 2002. Habitat use and foraging behavior of tiger sharks in a seagrass ecosystem. Marine Biology 140:237-248.

Herman, E K., L. M. Herman, A. A. Pack, G. Marshall, M. C. Shepard, and M. Bakhtiari. 2007. When Whales Collide: Crittercam Offers Insight into the Competitive Behavior of Humpback Whales on Their Hawaiian Wintering Grounds. Marine Technology Society Journal 41:35-43.

Hill, S. L., J. M. Cheney, G. F. Taton-Allen, J. S. Reif, C. Bruns, and M. R. Lappin. 2000. Prevalence of enteric zoonotic organisms in cats. Journal of the American Veterinary Medical Association 216:687-692.

Horn, J. A., N. Mateus-Pinilla, R. E. Warner, and E. J. Heske. 2011. Home range, habitat use, and activity patterns of free-roaming domestic cats. The Journal of Wildlife Management 75:1177-1185.

HSUS. 2009. Humane Society of the United States "A safe cat is a happy cat". The Humane Society of the United States, Washington, D.C., USA.

Jessup, D. A. 2004. The welfare of feral cats and wildlife. Journal of the American Veterinary Medical Association 225:1377-1383.

Kays, R. W., and A. A. DeWan. 2004. Ecological impact of inside/outside house cats around a suburban nature preserve. Animal Conservation 7:273-283.

Keitt, B. S., C. Wilcox, B. R. Tershy, D. A. Croll, and C. J. Donlan. 2002. The effect of feral cats on the population viability of balck-vented shearwaters (*Puffinus opisthomelas*) on Natividad Island, Mexico. Animal Conservation 5:217-223.

Konecny, M. J. 1987. Food habits and energetics of feral house cats in the Galapagos Islands. Oikos 50:24-32.

Lauber, T. B., B. A. Knuth, J. A. Tantillo, and P. D. Curtis. 2007. The role of ethical judgments related to wildlife fertility control. Society & Natural Resources 20:119-133.

Lepczyk, C.A., N. Dauphiné, D. M. Bird, S. Conant, R. J. Cooper, D. C. Duffy, P. J. Hatley, P. P. Marra, E. Stone, and S. A. Temple. 2010. What Conservation Biologists Can Do to Counter Trap-Neuter-Return: Response to Longcore et al. Conservation Biology 24:627-629.

Lepczyk, C. A., A. G. Mertig, and J. G. Liu. 2004. Landowners and cat predation across rural-to-urban landscapes. Biological Conservation 115:191-201.

Levy, J. K., and P. C. Crawford. 2004. Humane strategies for controlling feral cat populations. Journal of the American Veterinary Medical Association. 225:1354-1360.

Levy, J. K., D. W. Gale, and L. A. Gale. 2003. Evaluation of the effect of a long-term trap-neuter-return and adoption program on a free-roaming cat population. Journal of the American Veterinary Medical Association 222:42-46.

Liberg, O. 1984. Food-habits and prey impact by feral and house-based domestic cats in a rural area in southern Sweden. Journal of Mammalogy 65:424-432.

Liberg, O., M. Sandell, D. Pontier, and E. Natoli. 2000. Density, spatial organization and reproductive tactics in the domestic cat and other felids. Pages 120-147 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

Longcore, T., C. Rich, and L. M. Sullivan. 2009. Critical Assessment of Claims Regarding Management of Feral Cats by Trap-Neuter-Return. Conservation Biology 23:887-894.

Lord, L. K. 2008. Attitudes toward and perceptions of free-roaming cats among individuals living in Ohio. Journal of the American Veterinary Medical Association 232:1159-1167.

Lowe, S., M. Browne, S. Boudjelas, and M. DePoorter. 2000. 100 of the world's worst invasive alien species; A selection from the global invasive species database.

Loyd, K. A. T., and S. M. Hernandez. In press. Public perceptions of domestic cats and preferences for feral cat management in the southeastern United States. Anthrozöös 25.

Lucas, S. R., M. K. Hagiwara, V. S. Loureiro, J. Y. H. Ikesaki, and E. H. Birgel. 1999. *Toxoplasma gondii* infection in brazilian domestic outpatient cats. Review of Institutional Medicine in tropical Sao Paulo 41:221-224.

MacDonald, D. W., N. Yamaguchi, and G. Kerry. 2000. Group-Living in the domestic cat: its sociobiology and epidemiology. Pages 96-115 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

Maruyama, S., H. Kabeya, R. Nakao, S. Tanaka, T. Sakal, X. Xuan, Y. Katsube, and T. Mikami. 2003. Seroprevalence of *Bartonella henselae*, *Toxoplasma gondii*, FIV and FeLV Infections in domestic cats in Japan. Microbiology and Immunology 47:147-153.

McElroy, K. M., B. L. Blagburn, E. B. Breitschwerdt, P. S. Mead, and J. H. McQuiston. 2010. Flea-associated zoonotic diseases of cats in the USA: bartonellosis, flea-borne rickettsioses, and plague. Trends in Parasitology 26:197-204.

Meckstroth, A. M., A. K. Miles, and S. Chandra. 2007. Diets of introduced predators using stable isotopes and stomach contents. Journal of Wildlife Management 71:2387-2392.

Mendl, M., and R. Harcourt. 2000. Individuality in the domestic cat: origins, development and stability. Pages 48-64 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

Mitchell, J. C., and R. A. Beck. 1992. Free-ranging domestic cat predation on native vertebrates in rural and urban Virginia. Virginia Journal of Science 43:197- 207.

Moll, R. J., J. J. Millspaugh, J. Beringer, J. Sartwell, and Z. He. 2007. A new view of ecology and conservation through animal-borne video systems. Trends in Ecology & Evolution 22:660-668.

Molsher, R., A. Newsome, and C. R. Dickman. 1999. Feeding ecology and population dynamics of the feral cat in relation to the availability of prey in central-eastern New South Wales. Wildlife Research 26:593-607.

Mott, M. 2004. U.S. faces growing feral cat problem. *in* National Geographic News. National Geographic Society. <http://news.nationalgeographic.com/news/2004/09/0907_040907_feralcats.html> Accessed on 1 July 2011.

Nassar, R., and J. E. Mosier. 1982. Feline population dynamics - A study of the Manhattan, Kansas, feline population. American Journal of Veterinary Research 43:167-170.

Nogales, M., A. Martin, B. R. Tershy, C. J. Donlan, D. Witch, N. Puerta, B. Wood, and J. Alonso. 2004. A review of feral cat eradication on islands. Conservation Biology 18:310-319.

Nogales, M., and F. M. Medina. 1996. A review of the diet of feral domestic cats on the Canary Islands, with new data from the laurel forest of LaGomera. International Jounral of Mammalian Biology 61:1-6.

Norris, J. M., E. T. Bell, L. Hales, J. A. L. Toribio, J. D. White, D. I. Wigney, R. M. Baral, and R. Malik. 2007. Prevalence of feline immunodeficiency virus infection in domesticated and feral cats in eastern Australia. Journal of Feline Medicine and Surgery 9:300-308.

Nutter, F. B. 2005. Evaluation of a Trap-Neuter-Return Mangement Program for Feral Cat Colonies: Population Dynamics, Home Ranges and Potentially zoonotic Diseases. North Carolina State University, Raleigh, NC.

Nutter, F. B., J. P. Dubey, J. F. Levine, E. B. Breitschwerdt, R. B. Ford, and M. K. Stoskopf. 2004a. Seroprevalences of antibodies against *Bartonella henselae* and *Toxoplasma gondii* and fecal shedding of *Cryptosporidium* spp, *Giardia* spp, and *Toxocara cati* in feral and pet domestic cats. Journal of the American Veterinary Medical Association 225:1394-1398.

Nutter, F. B., J. F. Levine, and M. K. Stoskopf. 2004b. Reproductive capacity of free-roaming domestic cats and kitten survival rate. Journal of the American Veterinary Medical Association 225:1399-1402.

Paltridge, R., D. Gibson, and G. Edwards. 1997. Diet of the feral cat in central Australia. Wildlife Research 24:67-76.

People for the Ethical Treatment of Animals. 2009. Feral cats: How you can help them. *in* PETA publications, Norfolk, VA.

Ponganis, P. J., R. P. Van Dam, G. Marshall, T. Knower, and D. H. Levension. 2000. Sub-ice foraging behavior of emperor penguins. Journal of Experimental Biology 203:3275-3278.

Robertson, S. A. 2008. A review of feral cat control. Journal of Feline Medicine and Surgery 10:366-375.

Rochlitz, I. 2003. Study of factors that may predispose domestic cats to road traffic accidents: part 1. Veterinary Record 153:549-553.

Serpell, J. A. 2000. Domestication and history of the cat. Pages 180-192 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

Stracey, C. M. 2011. Resolving the urban nest predator paradox: The role of alternative foods for nest predators. Biological Conservation 144:1545-1552.

Turner, D. C. 1999. Human-cat interactions: relationships with and breed differences between non-pedigree, Persian and Siamese cats. *in* A. L. Podberscek, E. S. Paul, and J. A. Serpell, editors. Companion animals and us: Exploring the relationships between people and pets. Cambridge University Press, Cambridge, U.K.

van Heezik, Y., A. Smyth, A. Adams, and J. Gordon. 2010. Do domestic cats impose an unsustainable harvest on urban bird populations. Biological Conservation 143: 121-130.

Wade, N. 2007. Study traces cats ancestry to Middle East. *in* New York Times. New York, New York. < http://www.nytimes.com/2007/06/29/science/29cat.html > Accessed 11 une 2012.

Warner, R. E. 1985. Demography and movements of free-ranging domestic cats in rural Illinois. Journal of Wildlife Management 49:340-346.

Webster, J. P. 2001. Rats, cats, people and parasites: the impact of latent toxoplasmosis on behaviour. Microbes and Infection 3:1037-1045.

Wilcove, D.-S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48:607-615.

Williams, T. 2009. Feline Fatales:. Pages 30-38 *in* Audubon Magazine. September-October 2009 Issue.

Woods, M., R. A. McDonald, and S. Harris. 2003. Predation of wildlife by domestic cats Felis catus in Great Britain. Mammal Review 33:174-188.

Yamaguchi, N., D. W. MacDonald, W. C. Passanisi, D. A. Harbour, and C. D. Hopper. 1996. Parasite Prevalence in Free-Ranging Farm Cats, *Felis silvestris catus*. Epidemiology and Infection 116:217-223.

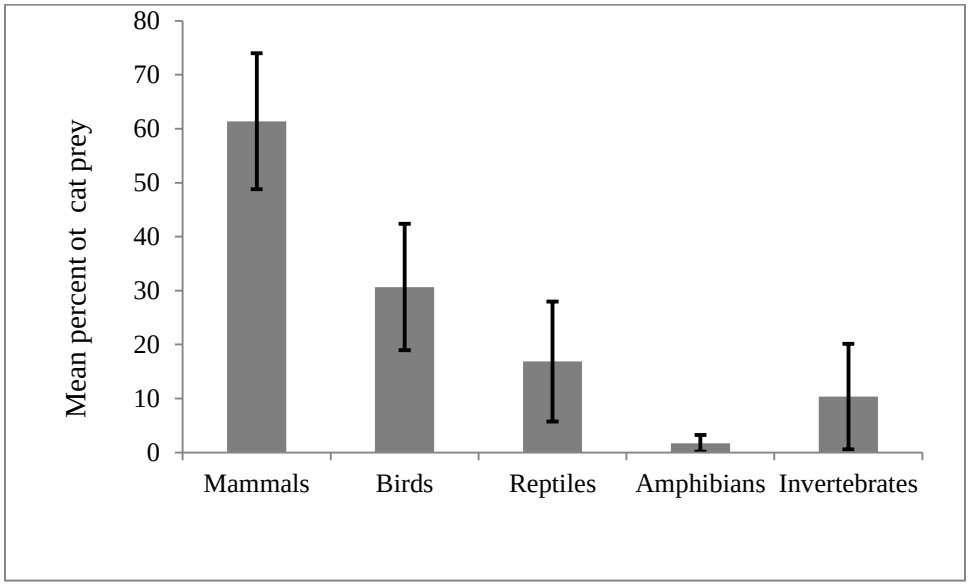

Figure 1.1: Prey classes captured by owned, free-roaming domestic cats as reported in published literature; percentage of captures with 95% confidence bars presented. (Mitchell and Beck 1992, Barratt 1998, Crooks and Soulé 1999, Woods et al. 2003, Kays and DeWan 2004, Baker et al. 2008, van Heezik et al. 2010)

Table 1.1: Annual mean prey returned to households by monitored hunting cats, from estimates reported in the published literature.

Average annual prey per hunting cat	Number of cats studied	Location	Reference
14.4	70	Great Britain	Churcher and Lawton 1987
10.2	138	Australia	Barratt 1997
56	223	California	Crooks and Soulé 1999
54.6	118	Michigan, USA	Lepczyk et al. 2003
27.1	986	Great Britain	Woods et al. 2003
21	144	Great Britain	Baker et al. 2005
13.4	97	New Zealand	Van Heezik et al. 2010
Mean= 28.1 ± 14.4			

CHAPTER 2

PUBLIC PERCEPTIONS OF DOMESTIC CATS AND PREFERNCES FOR FERAL CAT MANAGEMENT IN THE SOUTHEASTERN UNITED STATES [1]

[1]K.A.T. Loyd and S.M. Hernandez. Accepted by *Anthrozöös*. Reprinted here with permission of publisher.

ABSTRACT

Populations of feral, domestic cats and owned, free-roaming cats have increased throughout the United States, affecting wildlife and public health and warranting attention from a variety of management agencies. The contentious issue of feral cat management requires a greater understanding of public attitudes and preferences towards cats. We used an anonymous Internet survey of randomly selected households in Athens-Clarke County, Georgia to identify general public perceptions of domestic cats and preferences for cat management. We examined factors that may influence attitudes towards cats and management including: knowledge about cats, experiences with cats and demographic variables. Results indicate that more residents had positive than negative experiences with feral cats, cat owners had greater knowledge of cats than non-cat owners, and animal welfare or conservation organization membership had a significant effect on attitudes towards cats. A majority of survey respondents agreed that more effective feral cat management is needed yet did not approve of recent Trap-Neuter-Release legislation recently passed in Athens-Clarke County. Logistic regression revealed that residents' attitudes were more important than their experiences or knowledge in determining their support for cat management legislation. Cat sanctuaries were found to be the most acceptable option to reduce feral cat populations (56%), followed by Trap-Neuter-Release (49%), and capture plus euthanasia (44%).

KEYWORDS: Domestic cats, feral cat management, public attitudes, public knowledge

BACKGROUND

The number of feral domestic cats (abandoned, stray, unowned cats) in the United States today is estimated to be in the tens of millions, ranging from 70 to 100 million (Jessup 2004, Mott 2004). Such high population estimates have implications for both wildlife and public health (Barrows 2004, Longcore et al. 2009) and there is broad interest from community groups, non-profits and management agencies in reducing cat populations. Biologically effective, yet socially acceptable management for feral cats is a matter of contention in the United States and in many developed countries abroad (Robertson 2008). Historically, management involved capturing and euthanizing unwanted feral cats at local shelters. A second strategy, growing in popularity throughout the developed world, involves trapping cats, sterilizing them and then releasing them at their capture site (Trap-Neuter-Release, TNR). This control method is considered more humane than euthanasia and is promoted by organizations such as Alley Cat Allies, The Best Friends Animal Society, The American Society for the Prevention of Cruelty to Animals (ASPCA), and The Humane Society of the United States (HSUS). Theoretically, cat colonies should decline over time as neutered members are not reproducing. Recently, cities (e.g., Baltimore, MD; Athens, GA) and states (Illinois) have adopted TNR as their sanctioned method of cat control; however, this process remains highly controversial (Longcore et al. 2009).

Domestic cats are extremely efficient and opportunistic predators and may pose a conservation threat to the birds, herpetofauna, and small mammals that they prey upon (Crooks and Soulé 1999, Kays and DeWan 2004, Lepczyk et al. 2004, Nogales et al. 2004, Dauphiné and Cooper 2009). Both feral cats and owned, free-roaming cats are especially abundant in urban/suburban areas, generally exceeding those of like-sized predators by a factor of 10-100

(Liberg et al. 2000a) and this predation pressure can be extreme. While some residents and biologists may harbor concerns about impacts of domestic predators on wildlife and the natural environment, there is also a large group of stakeholders concerned with the welfare of abandoned and feral cats. A few studies report higher disease prevalence among cats living in feral colonies than owned, free-roaming cats (Nutter et al. 2004a, Norris et al. 2007). Feral cats are subject to environmental extremes, vehicle trauma and predation, all of which contribute to high mortality rates (Nassar and Mosier 1982, Warner 1985, Andersen et al. 2004, Nutter et al. 2004b) and relatively short life spans (Warner 1985). This has led one animal rights groups to promote euthanasia as the most humane management option (People for the Ethical Treatment of Animals 2009); however, others favor the maintenance of feral cat colonies over any management actions that include lethal control (Alley Cat Allies 2009).

Whereas advocacy groups pressure policy makers to create cat management legislation relevant to their missions, agencies have little information on which management option the general public prefers or about underlying beliefs, knowledge and experiences that might be related to preferences. A few studies (Ash and Adams 2003; Lord 2008; Loyd and Miller 2010) have investigated the human dimensions behind the issue of feral cat management, but the extent of the research is geographically limited and general public perceptions of cats and knowledge about cats has not been examined. The controversy over management of feral cats seems to stem from positions of two polarizing groups, the pro-cat advocates (who argue for non-lethal solutions to feral cat overpopulation) and pro-wildlife advocates (who argue for cat removal from the environment as cats are an invasive species detrimental to wildlife) (Williams 2009). Similar disagreements occur regarding responsible pet ownership; many communities debate the

common practice of allowing cats to roam free outdoors (Angier 2009).The general public may or may not be as divided as representative wildlife and cat advocacy organizations.

Prior research has focused on public preference for TNR management. For example, preferences of Texas A & M University faculty and staff for cat removal versus TNR were almost equally split, however, respondents were most likely to support feral cat population control in areas where cats were near people, suggesting their primary concerns involved impacts on people (Ash and Adams 2003). Ohio residents who owned cats were more likely (than non-cat owners) to support using tax dollars to fund TNR programs as a method feral cat control (Lord 2008). Lord (2008) also reported significant differences in beliefs about free-roaming cats according to respondent's type of residential community. A majority of residents for each residential group agreed that TNR would be a good management tool for feral cats (Urban 79%, Suburban 71%, Rural 71%), however, specific preferences for other management strategies (i.e., removal, capture and euthanize) were not investigated (Lord 2008). Loyd and Miller (2010) recently examined predictors of preference by Illinois homeowners for TNR management and found that age, gender and support for wildlife rights significantly influenced public preference for this management option. Lauber et al. (2007) found ethical judgments of those supporting fertility control (TNR) for cats included concern over killing animals to satisfy human interests and protection of the individual cats. In contrast, lethal control is often advocated by people who believe fertility control (TNR) works too slowly (Lauber et al. 2007) or not at all.

Because there is limited information on public attitudes (or specific group attitudes) towards cats and their management, we aimed to investigate this issue in a previously unstudied geographic area (Athens, Georgia) where the controversy over cat management has been the subject of ongoing debate for several years. In April of 2010, after months of public hearings, the

Athens-Clarke County (ACC) Council approved TNR legislation exempting TNR groups from provisions of county animal law (that previously stated that anyone who feeds stray cats are the animals' owners and responsible parties), allowing registration of cat colonies with the county and providing $10,000 in vouchers for cat sterilizations. This legislation made TNR the only management option available to Athens' residents since the county cat shelter stopped accepting animals just a few months before.

Because demographic predictors of preference for feral cat management have already been identified (gender, age, residential community size, education level) (Lord 2008, Loyd and Miller 2010), we aimed to explore additional factors (experiences, knowledge of cats, attitudes towards cats) that may help policy makers understand the controversy, the possible influences on public opinion, and more generally, where public opinion falls.

Our research objectives were to:

1) Determine Athens-Clarke County residents' perceptions of domestic cats, attitudes towards feral cats and preferences for management,
2) investigate residents' experiences with and knowledge of feral cats
3) explore relationships between residents' experiences with feral cats and attitudes towards feral cats,
4) explore relationships between residents' knowledge of cats and attitudes towards feral cats, and
5) examine attitudes towards, experiences with, and knowledge of domestic cats as predictors of support for TNR legislation.

METHODS

We conducted this survey in ACC, a unified city-county government in northeastern Georgia, USA. ACC is home to the University of Georgia and includes a mixture of urban, suburban and rural areas.

Questionnare Design

We used an anonymous Internet survey to investigate perceptions of pet cats, determine preferences for management of feral cats, and identify public knowledge of cat interactions in the environment. "Feral" cats were defined as stray, unowned domestic cats—they may be somewhat tame strays or completely afraid of people. Owned, free-roaming cats were defined as cats owned by people, but which were allowed to roam outside without supervision. The survey included four sections of questions to collect information on respondents: past experiences with cats (7 questions), views about cats and their management (8 questions, some with multiple statements), knowledge about cats (12 statements and 5 concepts) and demographic information. Specific questions about past *experiences* included questions relevant to: positive experiences with feral cats (feral cat feeding, assistance and adoption) and negative experiences with cats on the respondent's property (killing wildlife, urinating or defecating on property). Specific questions about views of cats and their management (*attitudes*) included: lists of concepts and statements about cats and their management as well as about cats and wildlife and animal rights, questions about perceptions of trends in cat populations, questions about preference for cat management options and a comparison of acceptable management options for a variety of feral domestic animals and urban wildlife. Attitude and belief items were presented as 5-point, Likert-scale statements (Likert 1932) thus mean responses ranged from 1-5.

To assess *knowledge* of domestic cats, we included a list of statements asking respondents whether they were aware of each fact prior to receiving the survey. Respondents were also asked how comfortable they were with a variety of concepts related to conservation and cat management. Lastly, we requested information on pet ownership, whether respondents allowed their pet cat to free-roam unsupervised, whether they had donated to various animal rights, conservation or cat welfare organizations in the past year, and about demographics (i.e., respondent's age and gender). The survey was designed by the co-authors and reviewed for bias by social scientists with expertise in the human dimensions of natural resource management. It was pre-tested by a diverse group of 20 volunteers for understanding of wording and content, and required approximately 15 minutes to complete. The survey methods were approved by The University of Georgia Institutional Review Board (IRB # 2010 10758).

Participants and Procedure

Randomly selected ACC households received a mailed postcard (Appendix A) requesting participation in the online survey, hosted at www.surveymonkey.com. We acquired mailing addresses via systematic random sampling from the ACC phone book. Each postcard referred to a unique web address meant for the recipient only to enter responses one time. Postcards (n = 3,000) were mailed in early May 2010 and nonrespondents received a follow-up postcard request after 4 weeks.

Forty-two postcards were returned as non-deliverable and 298 total surveys were completed by July 1, 2020, giving a response rate of ~10%. The sample of 298 responses (from a population of approximately 39,239 households) provided statistically valid results with a 5.6% margin of error. Respondents had the following age distribution: 5% were between the ages of 18

and 25, 11% were 26-33, 11% were 34-41, 11% were 42-49, 21% were 50-57, 16% were 58-65, 10% were 66-73 and 7% were above 74 years old (Appendix B).

Statistical Analysis

We used one-way Analysis of Variance (ANOVA) with Tukey's Honestly Significant Difference (HSD) test to compare mean scores on knowledge items and the belief statement "cats do not harm wildlife" by group (cat owner, non-cat owner, birdwatcher, birdwatcher and cat owner). We also used one-way ANOVA to compare mean responses on several attitude items by group membership (animal welfare, conservation organization member, member of both types, or none). Respondents who contributed to animal welfare organizations (i.e., Alley Cat Allies, Best Friends Animal Society, People for the Ethical Treatment of Animals, HSUS, ASPCA) and those who contributed to wildlife/conservation organizations (i.e., The Nature Conservancy, National Audubon Society, The Sierra Club, The World Wildlife Fund, The National Wildlife Federation) were grouped together.

We used ordinal logistic regression to examine whether experiences with cats or total knowledge about cats served as a predictor of various attitude statements about feral cats (including: "feral cats have the right to live in my neighborhood"; "feral cats live healthy, happy lives"; "more effective management of feral cats is needed"; "free-roaming cats don't harm wildlife").

We conducted binary logistic regression to examine the relationship between support for the TNR legislation in Athens, Georgia and residents' experiences with cats, attitudes towards feral cat management and knowledge of domestic cats. We created a global model, including variables from experience, attitudes, and knowledge questions, and four subsequent models hypothesizing relationships about these constructs and support for legislation (Table 2.1). An

experience model represented the hypothesis that support for TNR legislation is influenced by positive or negative experiences with feral cats, an *attitudes* model suggested support for TNR legislation is influenced by attitudes towards cats and wildlife, a *knowledge* model examined whether support for TNR Legislation is influenced by knowledge of domestic cats, and an *activity* model explored whether support for TNR legislation is influenced by birdwatching and cat ownership (Table 2.1). To avoid multicollinearity, a series of Pearson Chi-square tests were conducted to check for independence among possibly related pairs of variables; thus only a percentage of many possible predictor variables were included in the analysis. We used an information theoretic approach (Burnham and Anderson 2002) to evaluate the plausibility of alternative regression models. A global model was created to predict the influence of all predictor variables on the probability of supporting TNR legislation. To evaluate the global model goodness-of-fit, a Hosmer-Lemeshow test was conducted (Hosmer and Lemeshow 1989). Since the global model adequately fit the data, we assumed subsequent models to be of adequate fit.

We used Akaike's Information Criteria (AIC) (Akaike 1973) to evaluate the relative support of each model. Relative fit was assessed via calculation of Akaike weights (Burnham and Anderson 2002), with the best-fitting model having the greatest weight. As the ratio of Akaike weights can be used to assess evidence for one model over another, the confidence set of models included candidate models with the top two Akaike weights. Parameters within the confidence set of models were included in the composite model and inferences within our results were based upon this composite model. Model-averaged estimates of regression coefficients and their standard errors were calculated to incorporate model selection uncertainty.

RESULTS

Descriptive results

Most respondents (62%) had seen a feral cat in their neighborhood during the past 12 months and 28% reported seeing a feral cat almost every day. Forty percent of respondents had at least one positive experience with a feral cat (Figure 2.1) while 34% had at least one negative experience (Figure 2.1). Many respondents (42%) thought Athens' feral cat population had increased during the past 5 years; 21% of these thought the increase was best explained by a lack of effective cat management, while 34% thought the increase was due to abandonment of cats in the area. Athens' recent TNR legislation (i.e., legalizing feral cat colonies, exempting feral cat care-takers from animal ordinances and providing funds to support TNR programs) was supported by 43% and opposed by 57% of respondents.

Fifty percent of survey respondents agreed that feral cats are a "nuisance", 65% agreed that more effective management of feral cats was needed in Athens, yet 50% of respondents agreed that pet cats should be allowed to roam outdoors. A majority of respondents (82%) thought that protecting wildlife was very or extremely important and 57% agreed that supporting animal rights was very or extremely important. Interestingly, a minority of respondents (38%) thought feral cat welfare or the prevention of cat euthanasia (31%) was very or extremely important (Table 2.2). Greater than 30% of respondents were "unsure" about the risk of contracting a disease from a feral cat as well as whether cats should be managed as a non-native species (Table 2.2). A majority of respondents (56%) thought feral cat sanctuaries were an acceptable management option; slightly fewer agreed that TNR (49%) or euthanasia (44%) was an acceptable option (Figure 2.2). Capturing and euthanizing cats was chosen by most respondents (47%) as more effective population control and more humane to wildlife (45%) than

TNR, while a majority (56.3%) found TNR to be a more humane management option for cats than euthanasia (Figure 2.3). TNR was also the most popular choice of an option for which respondents preferred taxpayer money be spent and which they would donate to support (Figure 2.3).

Fifty-one percent of respondents were cat owners and 45% of these allowed their pets to roam free outdoors. Most respondents (64%) had done some birdwatching during the past 12 months. Only 21% of respondents had donated to an animal welfare organization and 23% percent donated to a conservation organization within the past 12 months. Complete descriptive results for attitude items can be found in Table 2.2, beliefs about management options are summarized in Figures 2.2 and 2.3 and knowledge results in Table 2.3.

Comparisons of group means (ANOVAs)

Cat ownership had a significant effect on knowledge about cats; cat owners scored higher than non-cat owners with regards to general knowledge about cats [F (1,295) = 36.34, P = 0.000, $\eta^2 = 0.1$]. Cat owners were also more confident in their ability to explain the interactions between cats and wildlife [F (1,295) = 6.37, P = 0.012, $\eta^2 = 0.02$]. Cat ownership and birdwatching had an effect on beliefs about cats harming wildlife; there was a significant difference in belief by group (cat owner, non-cat owner, birdwatcher, birdwatcher and cat owner) [F (3,275) = 4.07, P = 0.007, η^2=0.04]. Cat owners were more likely to agree or be unsure about whether "free-roaming cats do not harm wildlife" (M = 2.5, SD = 1.1) while birdwatchers were more likely to disagree with this statement (M = 1.8, SD = 1.2).

Organization membership (animal welfare, conservation, both or none) had a significant effect on perceptions of the importance of preventing feral cat euthanasia [F (3,271) = 5.75, P = 0.001, $\eta^2 = 0.06$] as well as on the belief that feral cats should be offered food and shelter [F

(3,267) = 5.3, P = 0.007, η^2 = 0.06]. Supporters of animal welfare groups thought preventing euthanasia was more important (*M* = 3.4, *SD* = 1.4) than supporters of conservation organizations (*M* = 2.2, *SD* = 1.3) or respondents who did not belong to either type of organization (*M* = 2.7, *SD* = 1.3). Animal welfare supporters also had significantly higher mean responses (*M* = 3.5, *SD* = 1.2) regarding perceptions of feral cat welfare than conservation supporters (*M* = 2.4, *SD* = 1.2) or respondents who did not belong to either type of organization (*M* = 2.9, *SD* = 1.4). Attitudes about managing feral cats as invasive species were significantly related to group membership [*F* (3,269) = 3.81, P = 0.011, η^2 = 0.04]. Conservation supporters (*M* = 3.4 *SD* = 1.3) and respondents without membership in either type of organization (M= 3.1 SD= 1.1) were more likely to support management of cats as invasive species than were animal welfare supporters (*M* = 2.5, *SD* = 1.1). Lastly, group membership had a significant effect on support for TNR management [*F* (3,275) = 2.97, P = 0.032, η^2 = 0.03]; animal welfare supporters indicated more support for TNR (*M*= 3.5, *SD*= 1.3) than conservation supporters (*M* = 2.8, *SD* =1.5).

Ordinal Logistic Regression

Respondents with at least one positive experience with feral cats were 4.7 times more likely to agree that feral cats had the right to live in their neighborhood (β = 1.56, SE β = 0.24, odds ratio = 4.7). A Pearson Chi-square Goodness-of-Fit test indicated this model fit the data well (χ^2 = 2.57, P = 0.462). Respondents with at least one negative experience with feral cats were twice as likely to agree that feral cats were a nuisance (β = 0.725, SE β = 0.27, odds ratio = 2.1), although the model did not fit the data well (χ^2 = 11.74, P = 0.008). Surprisingly, total knowledge about cats was not a reliable predictor of attitudes about cat rights (β= -0.03, SE β = .04, odds ratio = 1.03, χ^2 = 37.12, P = 0.849), belief about whether feral cats live happy, healthy

lives (β = 0.14, SE β =0.05 odds ratio=1.16, χ^2 = 45.95, P = 0.514), belief about whether more effective management of feral cats was needed (β = -0.11, SE β =0.05, odds ratio = 1.12, χ^2= 33.78, P = 0.926) nor belief about cats harming wildlife (β = 0.12, SE β =0.04, odds ratio =1.14, χ^2 = 59.84, P = 0.099).

Binary Logistic Regression

The attitudes model (including importance of protecting wildlife, healthy ecosystems, cat rights and beliefs about feral cat management and whether feral cats harm wildlife as predictor variables) was the most plausible logistic regression model. This model was just slightly (2%) more probable than the next best model, the global model (Table 2.4). The composite logistic regression model contained predictor variables from both models in the confidence set.

Beliefs about the importance of protecting wildlife, healthy ecosystems, cat rights, and preventing cat euthanasia had the greatest influence on support for feral cat legislation (Table 2.5). Respondents that did not think protecting wildlife was important were 8 times more likely to support the Athens TNR legislation. Those residents who agreed that cat rights *were* important were 2.3 times more likely to support the TNR legislation whereas those disagreeing with the notion that more-effective feral cat management was needed were twice as likely to support TNR. In contrast, respondents that did not believe preventing cat euthanasia was important were 3 times *less* likely to support TNR, while those uninterested in cat rights were 5 times less likely to support it. Residents who agreed that healthy ecosystems were important were also 3 times less likely to support the TNR management legislation. Other parameters were less influential and had 90% confidence intervals which included zero (Table 2.5).

DISCUSSION

Our results indicate that public perceptions of domestic cats in Athens were mixed and approximated information collected from the general public in Texas (Ash and Adams 2003) and Illinois (Loyd and Miller 2010). Results suggested that most Athens residents were very fond of animals, including wildlife, but many perceived feral cats more negatively than their own pet cats. Many agreed that feral cats should be cared for (offered food and water) and that they did not live happy, healthy lives, suggesting the public may not view cats as wild animals. In fact, more than half of respondents viewed feral cats as a nuisance including many cat owners.

In accordance with animal rights orientations reflected in our sample, most respondents preferred the sanctuary management option. A cat sanctuary would protect the welfare of cats, possibly helping them live a happier, healthier life, as well as help protect wildlife, which was an important item to an overwhelming majority of respondents. Cat sanctuaries may provide a solution for managing smaller cat colonies and this option should be explored by more cites and non-profit organizations. Cats could be trapped, neutered and then released only within the boundaries of a fenced sanctuary where they are safe from vehicles and coyotes (*Canis latrans*) and where wildlife outside the fence is protected. Sanctuary property, fence and shelter would require a large initial cost, and maintenance and staffing would require a large continued cost; however, many organizations (e.g., Alley Cat Allies), corporations (e.g., PetSmart) and local county and city jurisdictions that donate millions of dollars annually to TNR lobbying and education might contribute funding to a cat sanctuary in addition to standard TNR. Additionally, TNR programs already utilize dozens of dedicated volunteers (Centonze and Levy 2002) who could instead focus their efforts on care and adoption of cats at the sanctuary. Through sanctuary adoption programs, homes can be found for tame cats while semi-tame cats are socialized until

they are adoptable. Currently, there are just a few examples of successful sanctuary efforts (Chico Cat Coalition, Chico, California; Blind Cat Rescue and Sanctuary, St. Pauls, North Carolina). Before sanctuaries can be promoted as an alternative solution, scientific evaluation of the feasibility of creating and maintaining sanctuaries is recommended.

Twice as many respondents thought TNR was more humane to feral cats than capturing and euthanizing cats, though many acknowledge this option may not be as effective and that euthanizing feral cats was more humane to wildlife [releasing cats into the environment through TNR does not prevent cat predation of wildlife; (Guttilla and Stapp 2010)]. Results suggested that membership in either animal welfare or conservation organizations can provide insight into beliefs about feral cat management. With regards to the "feral cats versus wildlife" debate, several indicators suggested many respondents appeared aware of the impact that cats may have on wildlife, though a proportion were not willing to relinquish the freedom of their own cats to roam and hunt wildlife. Cat owners were more likely to disagree that cats were doing harm to wildlife, though they may see predation events or even receive "gifts" of wildlife prey from their hunting pets. Considering the issue of cats and wildlife may result in cognitive dissonance among many cat owning respondents. Generally, respondents appeared fond of both wildlife *and* cats, suggesting that ACC residents may not fall on either side of the polarizing management debates and many may have a hard time deciding what management option to support.

Regression analysis confirmed relationships between experiences with cats and attitudes towards feral cats. This analysis explored whether support for feral cat legislation was most related to experiences, attitudes or knowledge and found attitudes towards feral cats to be the strongest predictor of support for feral cat legislation. As expected, favorable attitudes towards feral cats were related to support for TNR management. Managers may be able to discern public

support for future TNR legislation by considering public attitudes towards feral cats. In Athens, Georgia, favorable attitudes towards cats were in a slight minority and, while TNR was an acceptable management option to many respondents, a majority of our sampled public did not support the recent TNR legislation, suggesting it may not be the most ideal option. The TNR legislation was eagerly passed by the ACC Council, therefore, we predicted a majority of Athens residents would support the bill. Our results revealed the opposite and suggest that this council vote did not accurately represent a majority of public opinion.

General knowledge of domestic cats did not appear to influence beliefs about cats nor was it a strong predictor of support for management legislation in Athens, yet direct education efforts should still be examined for cognitive and affective impact using a pre-post survey design. Our results suggested there was broad public support for increased education regarding domestic cats and their management. Education should target pet owners (many residents felt the increase in stray cat populations in Athens during the past 5 years was due to pet abandonment) and should address a number of issues related to feral cats. Almost all respondents supported the idea of increased education about feral cats and wildlife by local managers. Low public awareness of survey items related to cats and disease (rabies, toxoplasmosis) indicates education about the risk of zoonotic diseases posed by feral cats should also be considered.

Study limitations include a lack of information collected from non-respondents to assess possible non-respondent bias. Non-response bias would introduce an additional source of error in our work. Although sample size is sufficient to ensure accurate representation of the population, the lack of strong response increases a risk that responses are non-random and may not be representative of the general public. Some selection bias may occur as a result of using telephone book listings (i.e., publicly listed landlines are more commonly used by older residents and this

may limit access to younger residents; Dillman et al. 2008). Additionally, our survey methodology (i.e., postcards requesting residents complete an Internet survey) did not prove as successful as repeated paper mailings of surveys or telephone interviews. These alternative, yet more costly methods, may have resulted in higher response rate and even lower error associated with responses. Publicizing the survey in advance or providing incentives for completion may contribute to an increased response.

CONCLUSION

Perceptions by ACC residents of domestic cats, and their experiences with and attitudes towards feral cats were almost equally positive and negative. Opinions were split and general public preferences were not clearly in favor of cat advocacy or wildlife conservation management preferences (TNR, euthanasia) in ACC. One of the most critical needs to guide management of feral cats has been information on public attitudes towards feral cats and their control. Though our results suggest some new influences on perceptions of cats and preferences for management, this issue warrants further research attention.

Public policy decisions continue to be made based on inadequate information (Longcore et al. 2009) and influenced by loud and passionate advocacy groups. General public attitudes towards cats, experiences with feral cats and preference for management should be examined across a broader scale. The sociopolitical aspects of feral cat management is the greatest challenge (Lepczyk et al. 2010) because the highly charged emotions associated with both sides of the issue inhibit progress on actual population reduction. Additional study of public perceptions of feral cats can help local managers make more informed decisions and aid in understanding the growing public debate regarding feral cat management. Furthermore, research

into domestic cat impacts on wildlife as well as biological efficacy of alternative feral cat management options should be explored.

LITERATURE CITED

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. in *Proceedings from the Second International Symposium on Information Theory,* eds. B. N. Petrov and F. Csádki . September 2-8, 1971. Akademiai, Budapest.

Alley Cat Allies. 2009. What's best for cats: Being dead or alive? <http://www.alleycat.org/Page.aspx?pid=402> Accessed on 1 July 2011.

Andersen, M. C., Martin, B. J., & Roemer, G. W. 2004. Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats. *Journal of the American Veterinary Medical Association,* 225: 1871-1876.

Angier, N. 2009. Give birds a break, Lock up the Cat. *New York Times*. <http://www.nytimes.com/2009/09/29/science/29angi.html?_r=1&th&emc=th> Accessed on 1 July 2011.

Ash, S. J., & Adams, C. E. 2003. Public preferences for free-ranging domestic cat (*Felis catus*) management options. *Wildlife Society Bulletin* 31*:* 334-339.

Barrows, P. L. 2004. Professional, ethical and legal dilemmas of trap-neuter-release. *Journal of the American Veterinary Medical Association* 225: 1365-1372.

Burnham, K. P., & Anderson, D. R. 2002. *Model Selection and Multi-Model Inference: A Practical Information-Theoretic Approach* (2nd ed.). New York: Springer Science.

Centonze, L. A., & Levy, J. K. 2002. Characteristics of free-roaming cats and their caretakers. *Journal of the American Veterinary Medical Association* 220: 1627-1633.

Crooks, K. R., & Soulé, M. E. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* 400: 563-566.

Dauphiné, N., & Cooper, R. J. 2009. Impacts of free-ranging domestic cats (Felix catus) on birds in the United States: A review of recent research with conservation and management recommendations. p. 205-219 in Rich, T, and C. J. Ralph, (eds.). Proceedings of the Fourth International Partners in Flight Conference.

Dillman, D.A., Smith, J.D., & L.M. Christian. 2008. Internet, mail and mixed-mode surveys: The tailored design method. Wiley Publishing, New Jersey, USA.

Guttilla, D. A., & Stapp, P. 2010. Effects of sterilization on movements of feral cats at a wildland–urban interface. *Journal of Mammalogy* 91: 482-489.

Hosmer, D. H., & Lemeshow, S. 1989. *Applied Logistic Regression*. New York, New York: Wiley.

Jessup, D. A. 2004. The welfare of feral cats and wildlife. *Journal of the American Veterinary Medical Association* 225: 1377-1383.

Kays, R. W., & DeWan, A. A. 2004. Ecological impact of inside/outside house cats around a suburban nature preserve. *Animal Conservation* 7: 273-283.

Lauber, T. B., Knuth, B. A., Tantillo, J. A., & Curtis, P. D. 2007. The role of ethical judgments related to wildlife fertility control. *Society & Natural Resources* 20: 119-133.

Lepczyk, Dauphiné, N., Bird, D. M., Conant, S., Cooper, R. J., Duffy, D. C. 2010. What Conservation Biologists Can Do to Counter Trap-Neuter-Return: Response to Longcore et al. *Conservation Biology* 24: 627-629.

Lepczyk, C. A., Mertig, A. G., & Liu, J. G. 2004. Landowners and cat predation across rural-to-urban landscapes. *Biological Conservation* 115: 191-201.

Liberg, O., Sandell, M., Panther, D., & Natoli, E. 2000. Density, spatial organization and reproduction in the domestic cat. In D.C. Turner and P. Bateson (Eds.), *The Domestic Cat: the Biology of its Behaviour,120-147,* Cambridge, U.K.: University Press.

Likert, R. 1932. *A Technique for the Measurement of Attitudes*. New York, New York: Archives of Psychology.

Longcore, T., Rich, C., & Sullivan, L. M. 2009. Critical Assessment of Claims Regarding Management of Feral Cats by Trap-Neuter-Return. *Conservation Biology* 23: 887-894.

Lord, L. K. 2008. Attitudes toward and perceptions of free-roaming cats among individuals living in Ohio. *Journal of the American Veterinary Medical Association* 232: 1159-1167.

Loyd, K.A.T., and Miller, C. A. 2010. Factors Related to Preferences for Trap–Neuter–Release Management of Feral Cats among Illinois Homeowners. *Journal of Wildlife Management* 74:160-165.

Mott, M. 2004. U.S. faces growing feral cat problem. *National Geographic News* <http://news.nationalgeographic.com/news/2004/09/0907_040907_feralcats.html> Accessed on 1 July 2011.

Nassar, R., & Mosier, J. E. 1982. Feline population dynamics - A study of the Manhattan, Kansas, feline population. *American Journal of Veterinary Research* 43: 167-170.

Nogales, M., Martin, A., Tershy, B. R., Donlan, C. J., Witch, D., Puerta, N., et al. 2004. A review of feral cat eradication on islands. *Conservation Biology* 18: 310-319.

Norris, J. M., Bell, E. T., Hales, L., Toribio, J. A. L., White, J. D., Wigney, D. I., et al. 2007. Prevalence of feline immunodeficiency virus infection in domesticated and feral cats in eastern Australia. *Journal of Feline Medicine and Surgery* 9: 300-308.

Nutter, F. B., Dubey, J. P., Levine, J. F., Breitschwerdt, E. B., Ford, R. B., & Stoskopf, M. K. 2004. Seroprevalences of antibodies against Bartonella henselae and Toxoplasma gondii and fecal shedding of *Cryptosporidium spp, Giardia spp,* and *Toxocara cati* in feral and pet domestic cats. *Journal of the American Veterinary Medical Association* 225: 1394-1398.

Nutter, F. B., Levine, J. F., and Stoskopf, M. K. 2004. Reproductive capacity of free-roaming domestic cats and kitten survival rate. *Journal of the American Veterinary Medical Association* 225: 1399-1402.

People for the Ethical Treatment of Animals. 2009. Feral cats: How you can help them. Norfolk, VA: PETA.

Robertson, S. A. 2008. A review of feral cat control. *Journal of Feline Medicine and Surgery* 10: 366-375.

Warner, R. E. 1985. Demography and movements of free-ranging domestic cats in rural Illinois. *Journal of Wildlife Management 49*: 340-346.

Williams, T. 2009. Feline Fatales: *Audubon,* Sept-Oct. 2009: 30-38.

Table 2.1: Hypotheses and associated logistic regression models (Global, Experiences, Attitudes, Knowledge and Activity) predicting support for TNR legislation by residents of Athens-Clarke County, Georgia, 2010.

Hypotheses	Variables in each model
GLOBAL MODEL Support for TNR legislation is influenced by experiences with feral cats, attitudes towards feral cats and their management, knowledge of TNR and domestic cats, cat ownership	Seen feral cat + fed feral cat +feral cat fighting pet + see feral cat kill wildlife +called animal control to complain about feral cat+ adopted feral cat + protect wildlife importance + healthy ecosystems importance + cat rights importance + preventing cat euthanasia importance + removing invasives importance + more effective cat management needed + cats don't harm wildlife +total knowledge of cats + knowledge of cats and wildlife + birdwatch + own cat
EXPERIENCE MODEL Support for TNR legislation is influenced by positive or negative experiences with feral cats	Seen feral cat + fed feral cat +feral cat fighting pet + see feral cat kill wildlife +called animal control to complain about feral cat+ adopted feral cat
ATTITUDES MODEL Support for TNR legislation is influenced by attitudes towards cats and wildlife	protect wildlife importance + healthy ecosystems importance + cat rights importance + preventing cat euthanasia importance + removing invasives importance + more effective cat management needed + cats don't harm wildlife
KNOWLEDGE MODEL Support for TNR Legislation is influenced by knowledge of domestic cats	total knowledge of cats + knowledge of cats and wildlife + own cat
ACTIVITY MODEL Support for TNR legislation is influenced by birdwatching and cat ownership	birdwatch + own cat

Table 2.2: Attitudes of Athens-Clarke County, GA residents related to feral cats and their management (percentages reported, n=298), 2010.

Issues	Not At All Important	Slightly Important	Moderately Important	Very Important	Extremely Important
Healthy ecosystems	0.7	1.8	5.4	36.2	55.8
Cat welfare (cats are fed and sheltered)	22.0	16.1	23.8	20.9	17.2
Protecting wildlife	0.4	3.6	12.0	41.1	42.9
Removing non-native, invasive species	9.3	17.5	28.6	25.7	19.0
Supporting animal rights	6.3	11.9	24.4	30.0	27.4
Preventing euthanasia of feral cats	34.2	14.9	20.0	17.8	13.1
Statements	**Strongly Disagree**	**Disagree**	**Unsure**	**Agree**	**Strongly Agree**
I feel that feral cats have the right to live in my neighborhood.	32.1	18.1	22.7	19.9	7.2
I worry about problems feral cats might cause for my pets.	10.9	18.0	12.0	36.0	23.2
The risk of contracting a disease from a feral cat is low.	18.0	24.1	30.2	22.7	5.0
Feral cats should be offered food and shelter.	25.5	12.2	20.7	33.6	8.1
Feral cats live healthy, happy lives	22.1	33.7	33.3	9.8	1.1
Non-native species should be removed if they harm native species.	3.6	6.9	27.3	41.5	20.7
Feral cats should be managed as non-native species	11.7	18.3	36.3	20.5	13.2
I feel feral cats are a nuisance.	10.5	26.1	13.0	28.3	22.1
More effective management of feral cats is needed in Athens.	2.9	5.8	25.7	34.4	31.2
Feral cats should be protected and managed as wildlife.	28.7	21.8	22.9	21.1	5.5
Pet cats should be allowed to roam free outdoors	18.8	17.9	14.0	33.7	15.8
Free-roaming cats (feral or owned pet cats) do not harm wildlife.	35.1	33.0	16.5	12.2	3.2
Euthanizing feral cats is inhumane.	27.9	27.5	17.5	18.2	8.9
Pet cats should be kept indoors.	13.2	26.3	16.4	22.1	22.1

Table 2.3: ACC residents' perceived knowledge about items related to domestic cats (percentages reported (n=298) 2010).

Before receiving this survey, were you aware that:	**No**	**Yes**
Feral cats are the leading domestic animal carrier of the rabies virus in the US	79.1	20.9
Indoor cats live significantly longer than outdoor	18.1	81.9
An unspayed female cat can produce up to 10 kittens every year	22.0	78.0
Cats can see in the dark	10.5	89.5
Free-ranging cats will capture prey even if well-fed	18.8	81.2
Cats are the only animal in which the parasite *Toxoplasma gondii* can complete its life-cycle.	75.1	24.9
Cats can run up to 30 miles per hour.	77.6	22.4
Cats are the most popular pet in the US.	64.0	36.0
Free-roaming cats can become prey for urban coyotes.	31.9	68.1
Free- ranging cats can contract disease or parasites from wildlife.	12.8	87.2
Outdoor and feral cats will prey upon more small rodents than birds	44.6	55.4

Concepts	**Could not explain**	**Could somewhat explain**	**Could explain well**
How non-native species impact an ecosystem	22.7	54.9	22.4
The interactions between cats and wildlife	20.9	57.0	22.0
Transmission of the parasite "Toxoplasmosis"	66.9	21.1	12.0
Causes of songbird decline in the US	54.3	31.9	13.8
Trap-Neuter-Release	7.9	49.8	42.2

Table 2.4: Predictor variables, number of parameters (K), AIC, ΔAIC and Akaike weights (*Wi*) for the set of models predicting the influence of resident experiences with and attitudes towards feral cats on support for TNR legislation in Athens-Clarke County, Georgia, 2010.

	K	**AIC**	**ΔAIC**	**W*i***
Attitudes model	8	273.914	0	0.533
Global model	18	274.176	0.2623	0.467
Experience model	7	317.516	43.601	1.81E-10
Activities model	3	327.587	53.673	1.18E-12
Knowledge model	4	328.828	54.914	6.34E-13

Table 2.5: Model averaged parameter estimates, standard errors (SE), confidence intervals (CI) and odds ratios for the composite logistic regression model predicting support for TNR legislation by respondents in Athens-Clarke County, Georgia, 2010.

Model Averaged Parameters	**Coefficient**	**Unconditional SE**	**Upper CI**	**Lower CI**	**Odds Ratio**
(Intercept)	1.26	0.765	2.518	0.002	
Protecting wildlife is not important	2.1	1.25	4.156	0.044	8.166
Cat rights are important	0.822	0.487	1.623	0.021	2.275
Cats harm wildlife	0.504	0.493	1.315	-0.307	1.655
Adopted feral cat	0.308	0.266	0.746	-0.13	1.361
Preventing cat euthanasia is important	0.283	0.449	1.022	-0.456	1.327
Own cat	0.166	0.172	0.449	-0.117	1.181
Knowledge of cats and wildlife	0.063	0.058	0.16	-0.033	1.065
More effective cat management is needed	0.058	0.389	0.698	-0.582	1.06
Total knowledge of cats	0.009	0.028	0.054	-0.036	1.009
Birdwatch	-0.007	0.119	0.188	-0.203	0.993
Protecting wildlife is important	-0.061	0.555	0.852	-0.974	0.941
Cats don’t harm wildlife	-0.081	0.593	0.894	-1.057	0.922
Seen feral cat fight with pet	-0.105	0.188	0.204	-0.414	0.9
Seen feral cat kill wildlife	-0.148	0.196	0.174	-0.47	0.862
Fed feral cat	-0.158	0.192	0.158	-0.474	0.854
Called animal control about a feral cat	-0.234	0.292	0.246	-0.714	0.791
Seen feral cat	-0.275	0.224	0.093	-0.643	0.76
Invasive species should be removed	-0.3	0.404	0.365	-0.965	0.741
Invasive species should not be removed	-0.912	0.467	-0.144	-1.68	0.402
Preventing cat euthanasia is not important	-1.07	0.452	-0.326	-1.814	0.343
Healthy ecosystems are important	-1.1	0.722	0.088	-2.288	0.333
Cat rights are not important	-1.57	0.438	-0.849	-2.291	0.208
Healthy ecosystems are not important	-1.65	1.63	1.031	-4.331	0.192

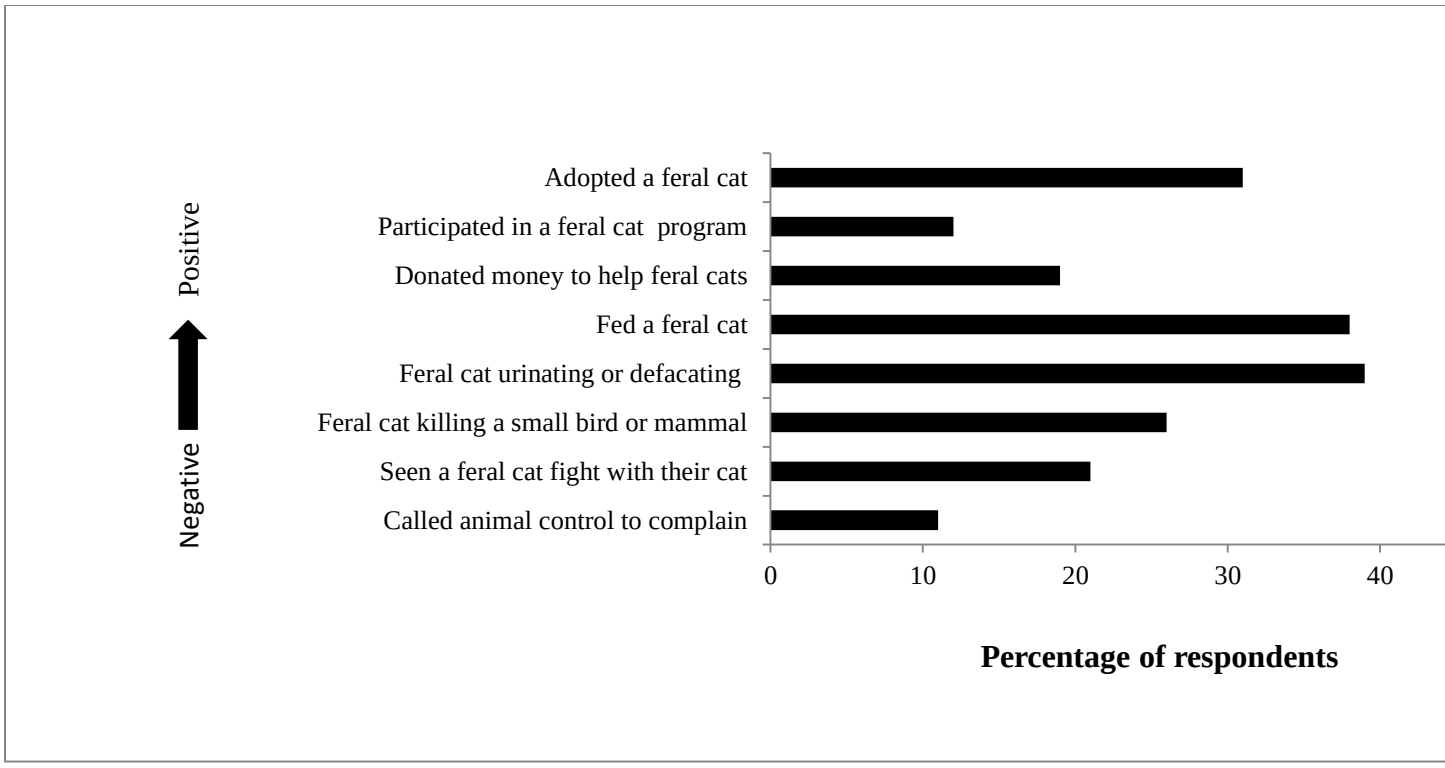

Figure 2.1: Athens-Clarke County, Georgia residents' negative and positive experiences with feral cats (percentages of respondents with experiences reported), 2010.

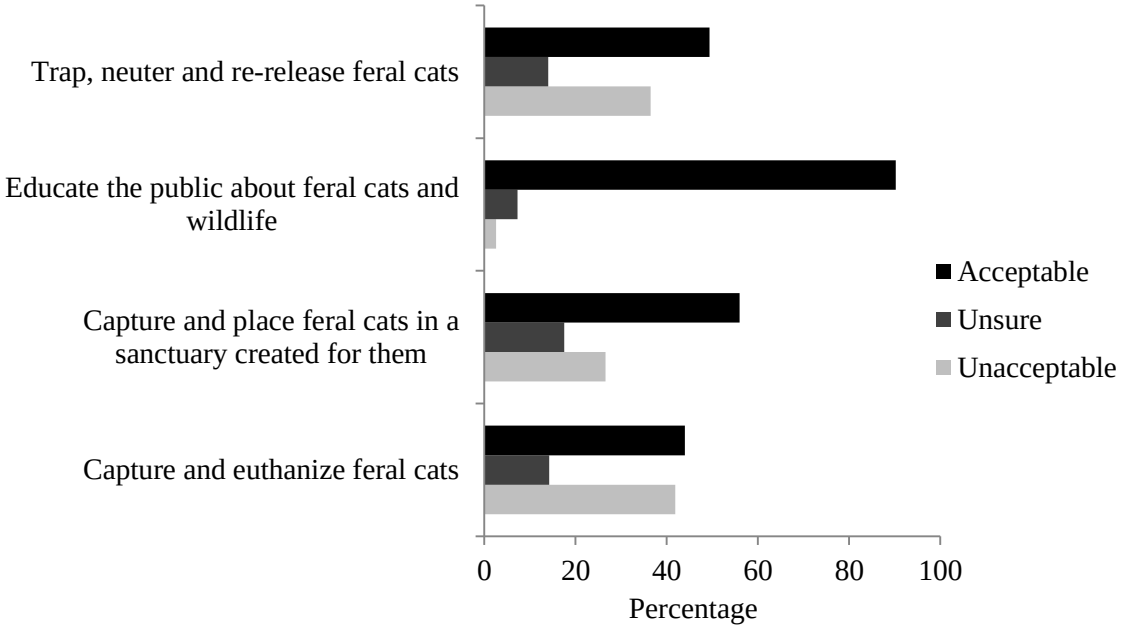

Figure 2.2: Athens-Clarke County, Georgia residents' beliefs about acceptability of feral cat management actions (percentages of respondents reported), 2010.

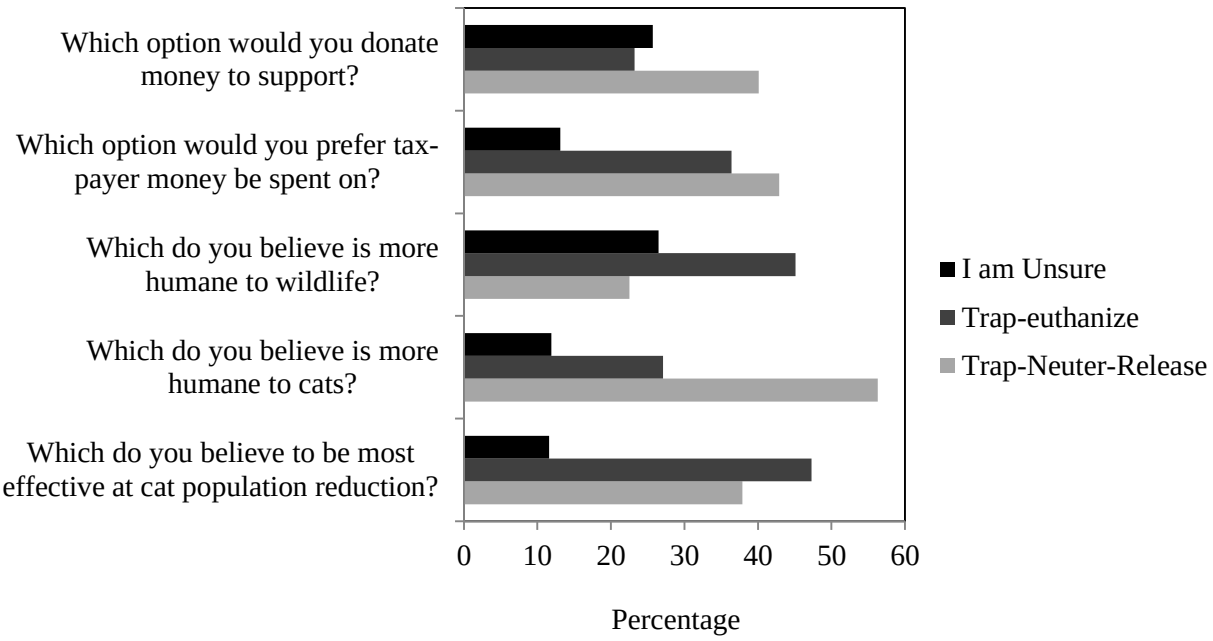

Figure 2.3: Athens-Clarke County, Georgia residents' beliefs about Trap-euthanize and Trap-Neuter-Release feral cat management options (percentages of respondents reported), 2010.

CHAPTER 3

ADDRESSING FREE-ROAMING DOMESTIC CAT PREDATION USING A NOVEL TECHNIQUE[1]

[1]K.A.T. Loyd, S.M. Hernandez, J.P. Carroll, K.J. Abernathy and G.J. Marshall. To be submitted to Biological Conservation.

ABSTRACT

Domestic cats (*Felis catus*) are extremely efficient and abundant non-native predators. Predation by domestic cats remains a topic of considerable social and scientific debate and warrants attention using improved methodology. Predation is likely a function of cat behavior, opportunity to hunt and local habitat. Previous predation studies relied on homeowner reports of wildlife captures from prey returns to the household. We investigated hunting of wildlife by owned, free-roaming cats in a suburban area of the southeastern USA. Specific research goals included: (1) quantifying the frequency of cat interactions with native wildlife, (2) identifying common prey species of suburban cats, and (3) examining predictors of outdoor behavior. We monitored 55 cats during a 1-year period (Nov. 2010- Oct. 2011) using KittyCam video cameras. Participating cats wore a video camera for 7-10 total days and all outdoor activity was recorded for analysis. We collected an average of 37 hours of footage from each project cat. Results demonstrated that 44% of free-roaming cats hunted wildlife, of which reptiles, mammals, and invertebrates constituted the majority of prey. Successful hunting cats captured an average of 2.1 prey items during 7 days of roaming, with Carolina anoles (*Anolis carolinensis*) being the most common prey species. Most wildlife captures (85%) occurred during the warm season (March-November in the southern USA). Twenty-three percent of cat prey items were returned to households; 49% of items were left at the site of capture, and 28% were consumed. Our results suggest that previous studies of pet cat predation on wildlife using owner surveys significantly underestimated capture rates.

INTRODUCTION

Domestic cats are abundant generalist predators that may exploit a wide range of prey. Cats are thought to pose a significant threat to the birds, herpetofauna, and small mammals that

they prey upon (Crooks and Soulé 1999, Lepczyk et al. 2004, Nogales et al. 2004, Dauphiné and Cooper 2009). While feral domestic cats are deemed responsible for much of the documented decline in some wildlife populations (especially on islands), the contribution of *owned* domestic cat predation on the mainland is in need of further attention. Previous studies of pet cat predation (Churcher and Lawton 1987, Barratt 1997, Crooks and Soulé 1999, Woods et al. 2003, Lepczyk et al. 2004, Baker et al. 2005, van Heezik et al. 2010) collected information directly from homeowners on the type and frequency of prey returned to the home by cats. The methodology used in these studies inherently underestimates predation as cats do not bring all prey items home; some animals are likely eaten or abandoned on site. Kays and DeWan (2004) observed the behavior of 11 indoor-outdoor cats and suggested actual cat predation rates may be more than 3 times higher than rates measured by prey returns to owners. Additionally, previous cat capture data are subject to sources of error including: misidentifying prey, under-reporting predation, and lack of willingness by participants to report predation on rare or native species (Baker et al. 2008, van Heezik et al. 2010).

In general, prior studies found mammals to be the most common prey item of domestic cats (approximately 60% of prey), followed by birds (23% on average) reptiles, amphibians and invertebrates (less than 10% each) [Baker et al. 2008 (U.K), Barratt 1998 (Australia) , Crooks and Soulé 1999 (California), van Heezik et al. 2009 (New Zealand), Woods et al. 2003 (U.K)]. The impact of cats on native wildlife in urban and suburban American systems remains understudied. While Lepczyk et al. (2003) identified several suburban bird species of conservation concern that were depredated by cats in southern Michigan [including Ruby-throated Hummingbirds (*Archilochus colubris)* and American Bluebirds (*Sialia sialis*)], predation is likely to affect numerous other backyard wildlife species. Recent research in

suburban Washington, DC reported domestic cats to be responsible for nearly half of all documented predation events on nestling and juvenile Gray Catbirds (*Dumatella carolinensis*) (Balogh et al. 2011). Domestic cats were also found to be a dominant nest predator of urban Northern Mockingbirds (*Mimus polyglottos*) in Florida (Stracey 2011). Because of their visibility and popularity, depredation of songbirds has received some attention in the literature and media (see review in Dauphiné and Cooper 2009, Williams 2009) but information on predation of other taxonomic groups remains deficient. Lizards constitute a significant part of feral cat diets on some islands (e.g., Canary Islands, Nogales and Medina 1996; Galapagos, Konecny 1987). However, the number of herpetofauna taken seasonally in the urban/suburban USA has never been studied. The number and type of suburban prey captured may be influenced by factors such as habitat, time spent roaming or even demographic factors of the cats.

Cat hunting behavior may also differ by season in temperate climates. For example, cats may be more active during mild weather months than during periods of extreme cold or mid-day summer heat. The amount of time spent hunting varies widely by individual (Panaman 1981) and some cats appear to be more active or successful hunters than others (Kays and DeWan 2004). Additionally, Churcher and Lawton (1987) and Barratt (1998) reported that older cats in Europe and Australia tended to hunt less. With such little previous work on predictors of hunting behavior it is important to explore factors (e.g., cat age, sex, roaming habitat, roaming season) that predispose suburban cats to become frequent or more successful predators.

Given the significance to wildlife conservation (Dauphiné and Cooper, 2009) and the current problematic evidence, domestic cat predation necessitates research using improved methodology to reduce error and accurately represent the impact of a free-roaming, hunting cat. Baker et al. (2008) stressed the need to validate current estimates of predation by prey returns

through new methods in future investigations. Woods et al. (2003) and Baker et al. (2005) suggest detailed observations of cats in the field are needed to substantiate previous studies that rely on prey returns and Longcore et al. (2009) encouraged scientists to conduct research to address a critical need for information on the interactions and adverse ecological effects of domestic cats in the environment. As natural areas are in decline throughout the USA, wildlife species increasingly depend upon suburban and urban fragments to fulfill habitat requirements. Suburban backyard habitats and parks may provide valuable resources to native wildlife, but they may also become ecological traps if they harbor abundant predators. Quantifying the prey of suburban free-roaming cats has potential to identify new conservation threats to some wildlife species, identifying significant future research needs. Understanding predictors of cat hunting behavior will help inform management recommendations and public education efforts. The objectives of this study were (1) to quantify the frequency of cat interactions with native wildlife (2) to identify common prey species of suburban cats and (3) to examine predictors of outdoor behavior (including cat age, sex, video hours, cat roaming habitat and season).

METHODS

Study Area

Athens-Clarke County (ACC) is a unified city-county located at 33.9608° N, 83.3781° W in northeastern Georgia. It covers 125 square miles (201.2 km^2), is the 5^{th} largest city in the state of Georgia and is home to The University of Georgia. The most recent USA Census estimate (2010) placed the population at 116,714. The number of owned, free-roaming cats is estimated to be 13,500 animals [calculated using ACC data, Humane Society estimates of pet ownership and our own survey data (Chapter 2)]. The weather in this region is typical of the Southern Piedmont

Physiographic Region with relatively hot summers and mild winters; inclement weather is rarely a reason to keep pet cats indoors.

Technology

Animal-borne video systems (CritterCams) have previously been used to study habitat use, food habits and general animal behavior in a variety of species, including marine mammals, sea turtles, penguins and lions (Ponganis et al. 2000, Heithaus et al. 2002, Hays et al. 2007, Herman et al. 2007, Moll et al. 2007). CritterCam video systems record an animal-eye view of activities without disrupting behavior. We used point-of-view cameras (KittyCams) to monitor 60 roaming cats. Recording took place from November 2010- October 2011 to cover all four seasons and 12-15 cats participated each season. We mapped all participating cat households (Figure 1). Volunteer cat owners placed a KittyCam on their pet for up to 10 days during a 4-week period (Figure 2). Volunteers switched the camera on before placing it on their pet, charged the camera at the end of each recording day and downloaded video to a portable external hard drive. We recruited volunteer cat owners through a human dimensions survey (conducted during the Summer of 2010), as well as through advertisements in two local newspapers. As incentive for participation, we offered a free total feline health screen and annual vaccinations. We recorded cat age and sex at these screenings.

The KittyCam system (National Geographic Remote Imaging, Washington, D.C.) is 7.5 cm by 5 cm by 2.5 cm, weighs 90 grams and is mounted on commercially available break-away cat collars. The lithium-ion battery can record 10-12 hours of cat activity before recharging. The KittyCam contains a motion-sensor to stop recording while cats are inactive or resting. Video data were stored onto a 16GB microSD card. The KittyCam plastic casing slides open so volunteers can access the USB charger, flash storage card and turn the unit on and off. The

camera has LED lights for exploration of cat activity in dimly lit places and at night. KittyCams also include a VHF transmitter so each may be located if a cat loses its collar outdoors. The KittyCams are water resistant though required some care to prevent water damage.

Video Analysis

We reviewed all outdoor recordings for each participating cat. We recorded weather, roaming habitat, video recording hours, and predation events for each cat for each day. Roaming habitat was categorized as rural or suburban based upon percentage of greenspace identified via 2006 National Land Use Dataset for Clarke County, Georgia and proximity (to the household) of neighbors or other urban structures. "Rural" locations were considered households isolated from other significant structures by a minimum 0.4-km radius and with open space as the primary land-use cover. We summed the video hours collected for each participating cat to define the "total video hours" variable. We identified cat prey to species and grouped them by class and natural history traits (terrestrial, arboreal, fossorial species).

Statistical Analysis

We calculated descriptive statistics for hunting cats and prey and used Fisher's exact test to examine any difference between two proportions for classes of prey, prey fate (whether prey was brought home, eaten or left at the capture site), and season of capture. We considered March-November the "warm" season in Georgia, while December-February was labeled the "cool" season. We used Program PRESENCE 4.1 (Hines 2006) to calculate detection probability for capture events. We calculated detection probability and percentage of hunters from a model assuming constant (no heterogeneity in) detection across cats from the KittyCam technology.

We used multinomial regression to examine the influence of predictors (habitat and season) on the type of prey captured (terrestrial, arboreal, and fossorial). These categories

reduced the groups of prey to allow a sufficient sample size for analysis. We also used multinomial regression to investigate the influence of predictors (prey size and habitat) on prey fate (whether prey was eaten, left at the capture site or brought home). We used binomial (logistic) regression to examine the influence of predictors (cat age, sex, total video hours, roaming season and roaming habitat) on hunting behavior (whether a cat is a hunter). Due to biological significance to wildlife, we relaxed our definition of hunting cats to include those witnessed stalking, chasing and/or capturing prey (i.e., exhibiting hunting behavior). We used Poisson regression to examine the influence of demographic predictors (including age, sex and video hours) on the number of prey captured by cats exhibiting hunting behavior.

We used a Hosmer-Lemeshow Goodness-of-Fit test to evaluate the binomial regression model. An adequate fit is observed with $P>0.05$ (Hosmer and Lemeshow 1989). Pearson χ^2 and deviance Goodness-of-Fit measures were used to evaluate multinomial and Poisson models respectively. To interpret the multinomial and binomial logistic regression estimates, we calculated Odds Ratios for each model parameter. Inferences were made from parameters with $P < 0.05$. We used R (R 2009) to conduct statistical analysis.

RESULTS

We collected 7-10 days of footage from 55 of our 60 cats and included these 55 in our video analysis. We had an average of 37 hours of outdoor footage per roaming cat. Thirty participants were male and 25 female, and all participants were sterilized. Eight cats (15%) roamed in a rural area and 47 roamed in suburban neighborhoods. Twenty-four cats were witnessed stalking or chasing prey, but only 16 (30%) made successful captures. We recorded 30 independent stalking or chasing events that did not result in a capture. Detection probability for prey captures in 7 days of analyzed roaming behavior was 0.25 and the percentage of “successful

hunters" was calculated to be 37%. This is slightly higher than our directly observed 30% and suggests a few of our cats may be misclassified (i.e., some cats are successful hunters, but we did not witness a capture during filming). The number of hours monitored before witnessing hunting behavior varied widely by cat (Mean= 19.3 ± 6.4, Range 2-55) (Figure 3.3). Most successful hunters captured just one or two prey items in 7 days of roaming footage (37%), whereas a smaller percentage (17%) captured 4 or 5 items during a week (Figure 3.4). The average capture rate was 2.1/items/successfully hunting cat/week of footage, which resulted in 0.06 ±0.01 prey captured/successfully hunting cat/hour monitored.

We identified 39 prey items. Reptiles were the most common class of prey captured (n=14; 36%) and 8 of these prey items were Carolina anoles (*Anolis carolinensis;* 21% of total captures). The second most common class of prey included mammals (26%), followed by invertebrates (21%), birds (13%), and amphibians (5%) (Table 3.1). Only one of the 31 vertebrates was a non-native species (a house mouse, *Mus musculus*). The majority of prey (85%) was captured during the warm season (March- November, Figure 3.4), with a difference (χ^2=34.667, df=1, P<0.001) between the proportions of prey captured during the warm and cool seasons. A significant difference was also found between the proportions of birds and herpetofauna captured (χ^2=6.516, df=1, P=0.01), yet there were no differences between the proportions of other prey classes. The multinomial logistic regression model used to examine the influence of season or habitat on prey type was an adequate fit (P>0.05). The model revealed that prey was more likely to be terrestrial than fossorial in the warm season (Table 3.2). There was no effect of habitat or season on the ratio of arboreal to terrestrial prey.

Forty-nine percent of the prey items were left at the capture site, 28% were eaten and 23% were brought home to the residence. The proportions of prey brought home versus

abandoned were significantly different (χ^2=4.51, df=1, P=0.03). Individual cats manipulated prey in more than one way, such that a cat might eat one item, and bring the next one home. The multinomial regression model is estimated to be of adequate fit (P>0.05). The model suggests that prey size has a significant influence on prey fate (i.e., what the cat did with the item); prey was more likely to be left than eaten if it was larger in size (Table 3.3).

The binomial logistic regression model used to examine the influences of predictors on whether a cat was a hunter also was found to fit the data well (P>0.05). The estimates for most predictors were close to zero and had confidence intervals crossing zero (Table 3.4). Interpreting the Odds Ratios for significant predictors, participating cats roaming during the warm season were 5.6 times more likely to exhibit hunting behavior than those roaming during the cool season. The total number of video hours recorded was also related to cat hunting behavior (Table 3.4). Cat age, sex, and roaming habitat did not influence hunting behavior. However, cat age was found to be a significant influence on the number of prey captured by hunting cats; the number of captures is predicted to decrease with increasing cat age (Table 3.5).

DISCUSSION

KittyCams recorded cats bringing less than a quarter of their captures back to their residence. These results suggest that previous studies of cat predation, which depended on information collected from prey returns, may have vastly underestimated the total take of successfully hunting cats. Additionally, in contrast to prior work documenting mammals and birds as the most prevalent prey classes, KittyCam recordings found that the largest proportion of captures in suburban Athens were reptiles. Suburban reptiles were captured almost three times as often as birds and 1.6 times more frequently than mammals. Similarly, in a survey from southern California (Crooks and Soulé 1999), more lizards than birds were reported as prey captured by

owned cats. Prey type and prey fate may be intimately connected, leading to discrepancies between our results and some previous work. For example, prior prey counts may have underestimated captures because studies were based on prey returns; our study found that 14 of 16 reptiles and amphibians (88%) were either eaten or left at the capture site. Discrepancies may also be due to our suburban study site. Carolina anoles are abundant and widely available in suburban habitats in the southeastern US, but were not present in previously studied urban areas of the UK. Additionally, our cats were more likely to exhibit hunting behavior during warm weather seasons, increasing anole susceptibility to predation because these reptiles are active during warm weather seasons.

Our observations may confirm previous suggestions that cats are opportunistic predators and that prey selection is correlated with prey availability (Liberg 1984, Molsher et al. 1999). In addition to captures of common herpetofauna, four of the 10 depredated mammals were Woodland Voles (*Microtus pinetorum*), another common suburban vertebrate. Ten cats were witnessed watching birds at feeders or baths and KittyCams recorded five total predation events involving birds (from just three of these cats). Since the hunting approach of the domestic cat is very slow, including lengthy waiting periods, birds frequently fly away before the pounce (Fitzgerald and Turner, 2000). Songbirds also have increased mobility and unpredictability in movements as compared to other groups of taxa (Fitzgerald and Turner, 2000), making them more difficult to capture. However, specific life history characteristics may make some bird groups more susceptible to cat predation (for example, use of feeders and ground-foraging behavior) (Cooper et al. 2012). The Hermit Thrush (*Catharus guttarus*) and American Robin (*Turdus migratorius*) (birds which are ground foragers) depredated in our study provide an example of this susceptibility.

Interestingly, we found no influence of age, sex and habitat on cat hunting behavior. These findings contradict some prior reports. Churcher and Lawton (1987) and Barratt (1998) reported that, in general, older cats in Europe and Australia were less likely to be hunters. However, our results do substantiate prior findings in the UK and New Zealand; younger pet cats are more likely to capture a significantly greater number of prey than older cats (Woods et al. 2003, van Heezik et al. 2010). The heterogeneity in the behavior of our study cats may suggest that some pet cats are instinctive hunters whereas others have no inclination to hunt while roaming.

Our research had a few limitations. Examining the predation behavior and prey selection of hunting cats (only) would likely result in a larger sample of captures, allowing further analysis and comparison of prey. Studying prey by taxonomic groups may identify patterns with important management implications, for example, confirming a seasonal influence on depredation of songbirds. Specifically, depredation of suburban reptiles should receive further research attention to determine if there is any population-level impact due to this mortality factor. Hamer and McDonnell (2010) suggest herpetofauna are negatively affected by urbanization and Gibbons et al. (2000) reported a widespread decline in reptile abundance and distribution. The necessary habit of basking in warm sunlight allows skinks, anoles and small snakes to be very visible to domestic predators, increasing risk of mortality. Additionally, many owned cats regularly roam during the day (George 1974, Barratt 1997). Seventy-five percent of our participants collected daytime footage exclusively, exposing them to this wider prey base. Lizards in Australia were found to be frequent victims of suburbia (road accidents, domestic dog and cat prey) (Koenig et al. 2002) and, when combined with a reduction in natural habitats, these

threats may have a negative effect on these reptiles. The impact of cats on herpetofauna has been overlooked in the past and warrants further attention.

Our study results suggest that increased recording time may have captured additional hunting behaviors or revealed that a slightly higher percentage of roaming cats are hunters. It took more than 50 monitored video hours for us to witness hunting behavior from a few participating cats. One limitation of our research involves uneven sampling intensity. A more homogenous sample in terms of continuous, equal recording times across the sample of cats could allow stronger interpretation of results. In the future, research could address this limitation in design and similar technology could be used to study free-roaming cats in other geographic areas and for longer periods of time to corroborate our findings. Collecting video from the same participants over multiple seasons could help determine whether behavior of individuals differs by season, again, providing important management implications.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

A minority of owned, free-roaming cats in ACC were witnessed hunting, similar to the findings of Baker et al. (2008) in the UK. However, if we were to extrapolate our findings (1.6 prey captured/week/ hunting cat) to the entire estimated population of free-roaming cats in Athens, greater than 300,000 wildlife prey (including > 40,000 birds) may be lost to pet cats each year in ACC, Georgia alone. While such an extrapolation may not be scientifically justified without a larger sample size and normal distribution of prey captures, we can be certain that the collective impact of free-roaming cats in Athens affects several hundred thousand individual wild animals. It is also important to consider the possible impact of non-successful hunting behavior on native wildlife. Even if an animal was not depredated, indirect negative effects on fecundity and behavior (due to cat stalking and chasing) are possible. Beckerman et al. (2007) suggest

there may be “sub-lethal” effects on urban birds as a result of cat presence in the system including negative behavioral responses (i.e., bird reproductive performance) to fear of predation risk even at low levels of predation mortality. As such, adopting the precautionary principle for cat management (Calver et al. 2011) is a valid suggestion while further research addresses the magnitude of impact and determines whether predation is additive or compensatory for common prey species.

Additional public education efforts should be developed to encourage cat owners to minimize the impact of hunting cats by keeping pets indoors, supervising outdoor roaming time or providing outdoor enclosures for their pets. Cats which are known to be avid hunters should be kept either completely indoors or supervised while outdoors if at all possible to protect wildlife. Cat pounce protectors (CatBibs®; www.catgoods.com) are another option to reduce potential impacts of roaming pets. These inexpensive devices that attach to cat collars have been found to significantly reduce mean prey captures of birds and mammals by hunting cats while bells have not (Calver et al. 2007). Because we found predation events to be more common during warmer seasons, special efforts should be made to restrict the roaming or predation behavior of hunting cats during warm weather.

LITERATURE CITED

Baker, P. J., A. J. Bentley, R. J. Ansell, and S. Harris. 2005. Impact of predation by domestic cats *Felis catus* in an urban area. Mammal Review 35:302-312.

Balogh, A. L., T. B. Ryder, and P. P. Marra. 2011. Population demography of Gray Catbirds in the suburban matrix: sources, sinks and domestic cats. Journal of Ornithology. 152: 717-726.

Barratt, D. G. 1997. Predation by house cats, *Felis catus*, in Canberra, Australia .1. Prey composition and preference. Wildlife Research 24:263-277.

Beckerman, A. P., M. Boots, and K. J. Gaston. 2007. Urban bird declines and the fear of cats. Animal Conservation 10:320-325.

Calver, M., S. Thomas, S. Bradley, and H. McCutcheon. 2007. Reducing the rate of predation on wildlife by pet cats: The efficacy and practicability of collar-mounted pounce protectors. Biological Conservation 137:341-348.

Calver, M. C., J. Grayson, M. Lilith, and C. R. Dickman. 2011. Applying the precautionary principle to the issue of impacts by pet cats on urban wildlife. Biological Conservation 144:1895-1901.

Churcher, P. B., and J. H. Lawton. 1987. Predation by domestic cats in an English-village. Journal of Zoology 212:439-455.

Cooper, C. B., K. A. T. Loyd, T. Murante, M. S. Savoca, and J. L. Dickinson. 2012. Natural history traits associated with detecting mortality within residential bird communities: can citizen science provide insights? Journal of Environmental Management 50: 11-20.

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.

Dauphiné, N., and R. J. Cooper.2009.Impacts of free-ranging domestic cats (*Felix catus*) on birds in the United States: A review of recent research with conservation and management recommendations. Pp. 205-219 in Rich, T, and C. J. Ralph, (eds.). Proceedings of the Fourth International Partners in Flight Conference.

Fitzgerald, B. M., and D. C. Turner. 2000. Hunting behavior of domestic cats and their impact on prey populations. Pages 152-175 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville, B. S. Metts, J. L. Greene, T. Mills, Y. Leiden, S. Poppy, and C. T. Winne. 2000. The Global Decline of Reptiles, Déjà Vu Amphibians. BioScience 50:653-666.

Hamer, A. J., and M. J. McDonnell. 2010. The response of herpetofauna to urbanization: Inferring patterns of persistence from wildlife databases. Austral Ecology 35:568-580.

Hays, G. C., G. J. Marshall, and J. A. Seminoff. 2007. Flipper beat frequency and amplitude changes in diving green turtles, *Chelonia mydas*. Marine Biology 150:1003-1009.

Heithaus, M.R., L.M Dill, G. J.Marshall, and B. Buhleier. 2002. Habitat use and foraging behavior of tiger sharks in a seagrass ecosystem. Marine Biology 140:237-248.

Herman, E. Y. K., L. M. Herman, A. A. Pack, G. Marshall, M. C. Shepard, and M. Bakhtiari. 2007. When Whales Collide: Crittercam Offers Insight into the Competitive Behavior of Humpback Whales on Their Hawaiian Wintering Grounds. Marine Technology Society Journal 41:35-43.

Hines, J. E. 2006. PRESENCE2: Software to estimate patch occupancy and related parameters. United States Geological Survey, Patuxent Wildlife Research Center, Maryland.

Hosmer, D. H., and S. Lemeshow. 1989. Applied Logistic Regression. Wiley, New York, New York.

Kays, R. W., and A. A. DeWan. 2004. Ecological impact of inside/outside house cats around a suburban nature preserve. Animal Conservation 7:273-283.

Koenig, J., R. Shine, and G. Shea. 2002. The dangers of life in the city: Patterns of activity, injury and mortality in suburban lizards. Journal of Herpetology 36:62-68.

Lepczyk, C. A., A. G. Mertig, and J. G. Liu. 2004. Landowners and cat predation across rural-to-urban landscapes. Biological Conservation 115:191-201.

Liberg, O. 1984. Food-habits and prey impact by feral and house-based domestic cats in a rural area in southern Sweden. Journal of Mammalogy 65:424-432.

Loyd, K. A. T., and S. M. Hernandez. In press. Public perceptions of domestic cats and preferences for feral cat management in Athens-Clarke County, Georgia. Anthrozöös 25.

Moll, R. J., J. J. Millspaugh, J. Beringer, J. Sartwell, and Z. He. 2007. A new view of ecology and conservation through animal-borne video systems. Trends in Ecology & Evolution 22:660-668.

Molsher, R., A. Newsome, and C. R. Dickman. 1999. Feeding ecology and population dynamics of the feral cat in relation to the availability of prey in central-eastern New South Wales. Wildlife Research 26:593-607.

Nogales, M., A. Martin, B. R. Tershy, C. J. Donlan, D. Witch, N. Puerta, B. Wood, and J. Alonso. 2004. A review of feral cat eradication on islands. Conservation Biology 18:310-319.

Panaman, R. 1981. Behavior and ecology of free-ranging female farm cats. Zeitschrift für Tierpsychologie 56: 59-73.

Ponganis, P. J., R. P. Van Dam, G. Marshall, T. Knower, and D. H. Levension. 2000. Sub-ice foraging behavior of emperor penguins. Journal of Experimental Biology 203:3275-3278.

R. 2009. The R Foundation, The University of Auckland, New Zealand.

Stracey, C. M. 2011. Resolving the urban nest predator paradox: The role of alternative foods for nest predators. Biological Conservation 144:1545-1552.

van Heezik, Y., A. Smyth, A. Adams, and J. Gordon. 2010. Do domestic cats impose an unsustainable harvest on urban bird populations. Biological Conservation 143: 121-130.

Woods, M., R. A. McDonald, and S. Harris. 2003. Predation of wildlife by domestic cats *Felis catus,* in Great Britain. Mammal Review 33:174-188.

Table 3.1: Animal species captured by 16 successfully hunting owned, free-roaming cats monitored with KittyCam video cameras for 7-10 days in Athens-Clarke County, Georgia 2011, by taxonomic group.

Species	Number captured
Reptiles	1
Ringneck Snake (*Diadophis sp.)*	1
Brown Snake (*Storeria dekayi*)	1
Unidentified small snake	8
Carolina Anole (*Anolis carolinensis*)	2
SE Five-lined Skink (*Eumeces fasciatus*)	1
Unidentified lizard	
Mammals	
House Mouse (*Mus musculus*)	1
Woodland Vole (*Microtus pinetorum*)	4
Short-tailed Shrew (*Blarina brevicauda*)	1
Eastern Chipmunk (*Tamias striatus*)	3
Grey Squirrel (*Sciurus carolinensis*)	1
Invertebrates	
Unidentified Butterfly	1
Walking Stick	1
Unidentified Dragonfly	2
Worm	3
Unidentified insect (possibly Cicada)	1
Avian	
Robin (*Turdus migratorius*)	1
Unknown nestling (Mockingbird?)	2
Hermit Thrush (*Catharus guttatus*)	1
Eastern Phoebe (*Sayornis phoebe)*	1
Amphibians	
Southern Leopard Frog (*Lithobates sphenocephalus)*	2

Table 3.2: The influence of season and habitat on prey type captured by 16 free-roaming owned cats monitored with KittyCam video cameras for 7-10 days in Athens-Clarke County, Georgia, 2011.

Predictor	Coefficient	SE	P	Odds Ratio	Lower CI	Upper CI
Logit 1: (fossorial/terrestrial)						
Constant	0.907	1.592	0.569		-2.213	4.027
(Warm)Season	-2.822	1.241	0.023	0.06	-5.254	-0.39
(Suburban)Habitat	0.593	1.426	0.678	1.809	-2.202	3.388
Logit 2: (arboreal/terrestrial)						
Constant	-0.36	1.732	0.835		-3.755	3.035
(Warm)Season	-0.084	1.478	0.571	0.43	-2.981	2.813
(Suburban)Habitat	-0.451	1.234	0.715	0.637	-2.87	1.968

Goodness of Fit: Pearson χ^2= 1.35, df=2, P=0.51

Table 3.3: Influence of habitat on prey size and prey fate of animals captured by 16 owned, free-roaming cats monitored by KittyCam video cameras for 7-10 days in Athens-Clarke County, Georgia, 2011.

Predictor	Coefficient	SE	P	Odds Ratio	Lower CI	Upper CI
Logit 1: (home/left)						
Constant	-0.914	1.251	0.465		-3.366	1.538
(Suburban)Habitat	-0.467	1.42	0.741	0.627	-3.25	2.316
Prey Size	0.677	0.522	0.195	1.968	-0.346	1.7
Logit 2: (ate/left)						
Constant	-0.492	1.243	0.693		-2.928	1.944
(Suburban)Habitat	0.932	1.33	0.484	2.54	-1.675	3.539
Prey Size	-1.261	0.603	0.037	0.283	-2.443	-0.079

GOF : Pearson χ^2= 3.19, df=4, P=0.53

Table 3.4: Parameter estimates for the coefficients of predictors influencing free-roaming cat hunting behavior (stalking, chasing or capturing prey) identified by KittyCam video cameras in Athens-Clarke County, Georgia, 2011.

Predictors	Estimate	SE	Odds Ratio	P	Lower CI	Upper CI
(Intercept)	-0.246	1.488		0.869	-3.164	2.671
Male SEX	-0.095	0.644	0.910	0.883	-1.357	1.167
AGE	-0.150	0.099	0.860	0.130	-0.345	0.044
Warm SEASON	1.738	0.867	5.687	0.045	0.038	3.438
VIDEOHOURS	0.035	0.017	1.035	0.044	0.001	0.069
Suburban HABITAT	-2.036	1.068	0.131	0.057	-4.129	0.056

Goodness of Fit: χ^2: 8.869, P=0.35

Table 3.5: Parameter estimates for coefficients of predictors influencing the number of prey captured by free-roaming cats exhibiting hunting behavior (stalking, chasing or capturing prey) witnessed via KittyCam video cameras in Athens-Clarke County, Georgia, 2011

	Estimate	SE	p	Lower CI	Upper CI
(Intercept)	-2.055	1.800	0.254	-5.583	1.473
VIDEOHOURS	0.830	0.491	0.091	-0.133	1.792
AGE	-0.132	0.064	0.039	-0.257	-0.007
MaleSEX	0.086	0.335	0.797	-0.570	0.742

Goodness of Fit: Residual Deviance: 31.341, df=20, P=0.05

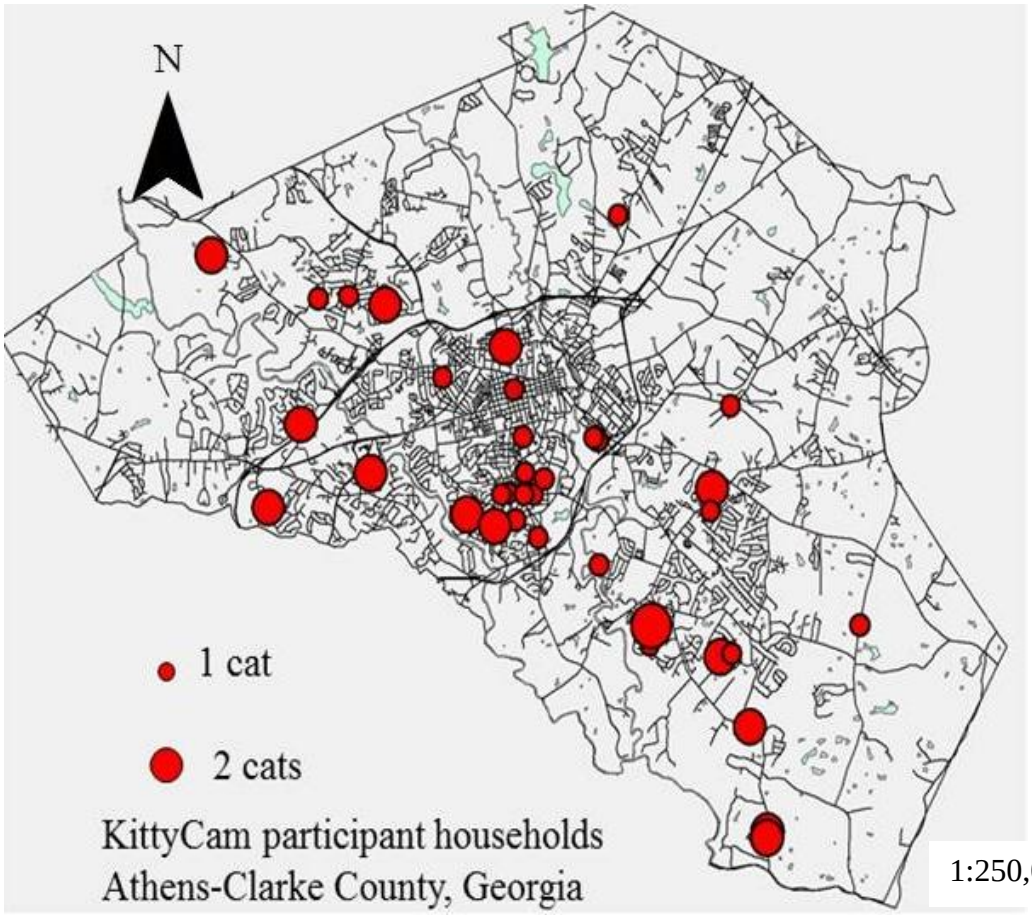

Figure 3.1: Location of residences housing owned, free-roaming cats monitored by KittyCams video cameras for 7-10 days in Athens-Clarke County, Georgia 2011

Figure 3.2: Owned, free-roaming cat wearing a KittyCam video camera on a break-away collar in Athens-Clarke County, Georgia, 2011.

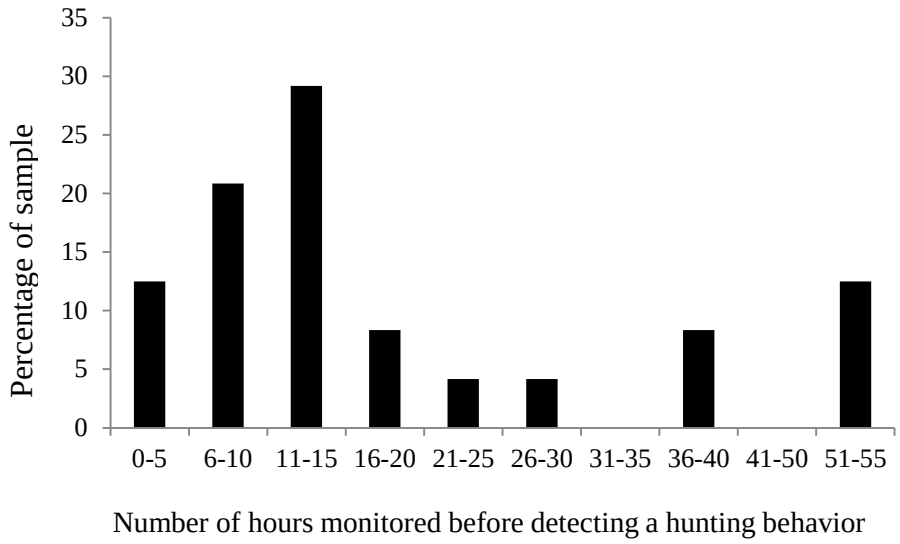

Figure 3.3: The number of recorded video hours monitored via KittyCams before witnessing hunting behavior (stalking, chasing or capture) by owned cats (N=24) roaming in Athens-Clarke County, Georgia, 2011.

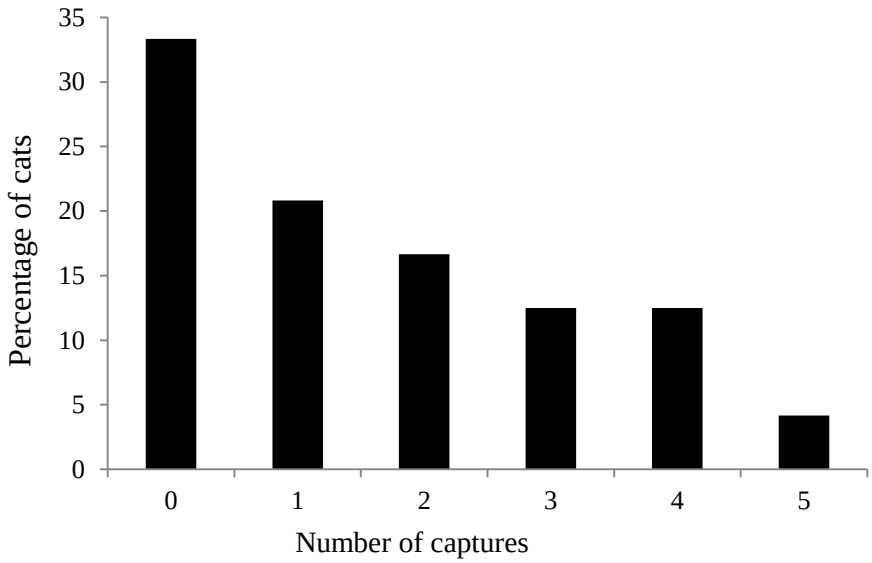

Figure 3.4: Frequency of prey captures by 24 owned cats exhibiting hunting behavior (stalking, chasing or capturing prey) in 7 days of roaming. Activities monitored via KittyCam video cameras in Athens-Clarke County, Georgia, 2011.

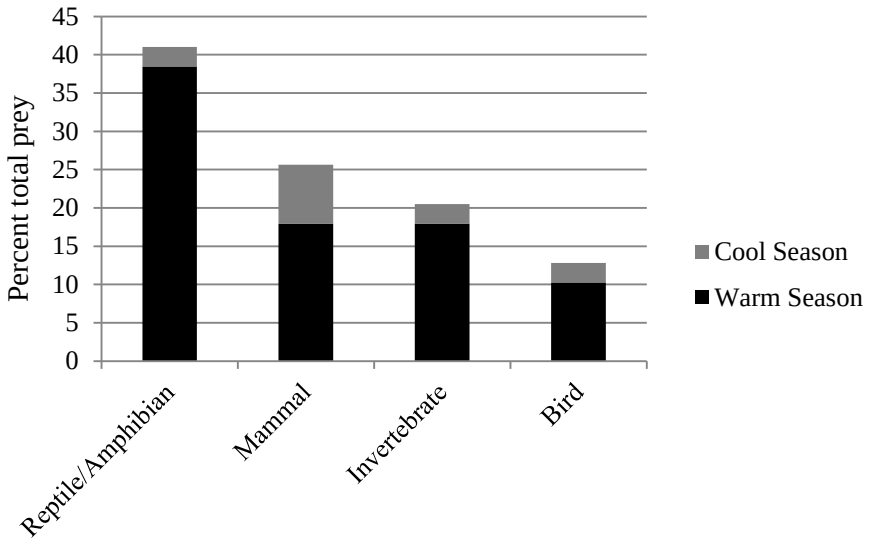

Figure 3.5: Prey type and season of capture for owned, free-roaming cat prey (n=39) identified by KittyCam video cameras over 7-10 days of roaming in Athens-Clarke County, Georgia, 2011.

CHAPTER 4

RISK FACTORS EXPERIENCED BY FREE-ROAMING CATS IN A SUBURBAN SOUTHEASTERN USA TOWN[1]

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ABSTRACT

There are more than 85 million pet cats in the United States today, a minority of which are maintained exclusively indoors. Free-roaming cats may experience numerous hazardous encounters in the outdoor environment, including: vehicular accidents, aggression from other animals, exposure to infectious disease etc., each of which reduce longevity. This research quantitatively examined the outdoor activities of 55 owned cats by monitoring pets outfitted with "KittyCam" video cameras. KittyCams are a type of CritterCam, a special device designed by National Geographic to allow recording of a cat-eye view without disrupting behavior. We investigated the activities of free-roaming cats in suburban Athens-Clarke County, Georgia during all four seasons. Research objectives included documenting the type and regularity of risk factors experienced by free-roaming cats and identifying characteristics of pet cats (e.g., age, sex, roaming habitat) which predict risky behavior in the outdoors. The most common risk factors experienced by suburban free-roaming cats included crossing roads (45% of our sample), encountering strange cats (25%), eating and drinking substances away from home (25%), exploring storm drain systems (20%), and entering crawlspaces of houses (20%). Eighty-five percent of project cats were witnessed exhibiting at least one risk behavior. Male cats were more likely to engage in risk behavior than female cats and older cats engaged in fewer risk behaviors than younger individuals.

INTRODUCTION

There are an estimated 50-60 million owned, free-roaming pet cats in the USA today (American Veterinary Medical Association 2007) . According to the Humane Society of the United States (HSUS), free-roaming pet cats have an average lifespan of 3 years, while indoor cats live 12-18 years. Factors contributing to the reduced longevity of roaming cats include:

vehicular accidents, aggression from other cats, exposure to poison, infectious disease, parasites, domestic dogs and wild predators (Nutter 2005, HSUS 2009).

Exposure to infectious disease may be one of the most underestimated risks that free-roaming cats encounter. Free-roaming cats host numerous parasites and infectious diseases and interactions with cats, either feral or from other households, increases exposure risk. Outdoor cats have been found to have a higher rate of Feline Immunodeficiency Virus (FIV), *Dirofilaria immitis* (heartworm), as well as infection with *Bartonella henselae* (the causative agent of Cat Scratch Disease) when compared to indoor cats (Maruyama et al. 2003). Access to the outdoor environment is also an important predisposing factor to risk of *Toxoplasma* infection (Lucas et al. 1999, Dubey et al. 2002). Regionally, outdoor cats are exposed to infectious diseases carried by ectoparasites such as ticks and fleas. Cat fleas can serve as a vector for Haemobartonellosis *(Mycoplasma haemofelis), Bartonella henselae*, *Coxiella burnetti*, *Rickettsia felis* (and other flea-born rickettsioses) and *Yersinia pestis* (the bacteria that causes potentially fatal plague) (Comer et al. 2004, Case et al. 2006). Ticks can also serve as a vector for C*ytauxzoon felis,* an emerging protozoan parasite that is nearly always fatal for domestic cats (Birkenheuer et al. 2006).

Owned, free-roaming cats may acquire infectious diseases and parasites via encounters with other cats, wildlife or through exposure to contaminated environments. Investigating interactions with other roaming cats and wildlife can help identify the reality of this risk. The prevalence of parasites and infectious disease among unowned feral cats has been well documented and may pose a risk to pet cats (Yamaguchi et al. 1996). A high percentage of feral cats in the UK had antibodies to Feline Immunodeficiency Virus (FIV) (53%) and Feline parvovirus (FPV) (84%); 62% had been infected with *Toxoplasma gondii* and the feces of greater than 80% of these cats contained eggs of the roundworm genus *Toxocara* (Yamaguchi et al.

1996). Almost all cats (92%) in one colony studied by MacDonald et al. (2000) were infected with *T. cati* (the feline roundworm). Moreover, a recent study reported 96% of feral cats tested in Egypt had antibodies to *T. gondii*, while 60% had antibodies to *Bartonella* (Al-Kappany et al. 2011). Similarly, of the proportion of feral cats that were seropositive for antibodies against *B. henselae* and *T gondii* was significantly higher (93% and 63%, respectively) than those found in pet cats (75% and 34%) in North Carolina (Nutter et al. 2004). Seroprevalence rates of FIV and Feline Leukemia (FeLV) in unowned cats brought to a Colorado shelter were significantly greater than sampled owned cats, and these strays also hosted greater numbers of zoonotic parasites (Hill et al. 2000). Akucewich et al. (2002) documented a high prevalence of ectoparasites such as fleas (93%) among feral cats in Florida while Anderson et al. (2003) recorded 75% of sampled feral cats to host hookworms. Many of the aforementioned pathogens of free-roaming cats are also zoonotic (Dabritz and Conrad 2010, McElroy et al. 2010). These include *Bartonella henselae (*causing Cat Scratch Disease), *Salmonella spp., T. gondii, T. cati*, tapeworms, hookworms, *Sarcoptes scabei*, and ringworm.

Other common risks free-roaming cats encounter are car collisions or becoming trapped or lost. Rochlitz (2003) estimated that 14 - 36% of adopted pet cats were once strays, suggesting a large number of owned cats become lost. Road accidents constitute a common cause of injury for domestic cats. Rochlitz (2003) estimated vehicle accidents to be the fourth most common cause of cat death in Great Britain. The Santa Clara County California Humane Society reported that 57% of all animals found dead on county roads were cats (Gray 1997). Baltimore, Maryland annually removes over 500 owned cats found dead on city roads (Childs and Ross 1986). While cats are usually wary of their surroundings, they often stand little chance against fast-moving vehicles. Furthermore, the Humane Society (HSUS 2009) also provides warnings about the

threat of free-roaming cat exposure to common poisons, such as anti-freeze and rat poison. Age and gender characteristics may be predictors of such risky behavior in the outdoors. Hill et al. (2000) and Yamaguchi et al. (1996) documented higher rates of disease in male cats. A majority of cats in the road mortality study were males (Childs and Ross 1986).

Assertions that indoor cats live longer, healthier lives are not uncommon, though it is expected that about half of cat owners in our study area keep their cats indoors (Chapter 2). Thus far, campaigns to promote cats maintained indoors (by the American Bird Conservancy and the Humane Society) have had a marginal effect on the general public. Risk factors experienced by free-roaming cats have received minimal research attention in the past, thus these campaigns have few convincing statistics to present to a public audience. Identifying risks experienced while roaming in suburban environments and quantifying the frequency of such risks is vital information for both veterinary and public (pet-owning) audiences. Investigating such behaviors could help quantify risk of contracting a zoonotic disease and possible repercussions for owners. No previous study has examined the interactions of owned, free-roaming cats with other (potentially) stray cats, and the potential health threats resulting from these interactions should not be underestimated. The objectives of this research included documenting the type and regularity of risk factors experienced by owned, free-roaming cats and identifying characteristics of pet cats (e.g., age, gender, roaming habitat) which predict risky behavior in the outdoors.

METHODS

Study Site

Athens-Clarke County (ACC) is a unified city-county, in northeastern Georgia. ACC is 125 square miles, the 5th largest city in the state of Georgia and home to The University of Georgia. The most recent US Census estimate (2010) placed the population at 116,714. The

number of owned, free-roaming cats is estimated to be 13,500 (calculated using ACC data, Humane Society estimates of pet ownership and our own survey data; Chapter 2). The weather in Athens is relatively mild, such that inclement weather is rarely a reason to keep pet cats indoors. A map of participant households is included in Figure 1.

Technology

Animal-borne video systems have been previously used to study habitat use, food habits and general animal behavior in a variety of species including: marine mammals, sea turtles, penguins and lions (Ponganis et al. 2000, Heithaus et al. 2002, Hays et al. 2007, Herman et al. 2007, Moll et al. 2007). These video systems record an animal-eye view of activities without disrupting behavior. Point-of-view cameras were used to monitor 60 cats (recording took place from November 2010- October 2011). Volunteer cat owners placed a KittyCam on their pet for up to 10 days during a 4-week period. The volunteers switched the camera on before placing it on their pet, charged the camera at the end of the day and download video to a portable external hard drive. This methodology depended on interested and dedicated volunteer cat owners recruited through a human dimensions survey as well as through advertisements in two local newspapers. As incentive for participation, free annual vaccinations and a total feline health screen were offered to participants. The health screen included: a complete physical exam, body weight, body temperature, Complete Blood Count (CBC), Chemistry profile, and in-house Feline Immunodeficiency Virus (FIV), Feline Leukemia (FeLV) and heartworm tests (IDEXX Snap Combo). Rabies and FVRCP vaccines were administered in a standard manner if the cat had not received it within the previous 12 months. The following information was collected for each participant: age, sex, breed, type of husbandry (indoor/outdoor), medical history and use of ectoparasite preventative treatment. Results of the health screens were used in the development

of a health predictor to investigate the potential influence of health issues on roaming cat behavior. All procedures abided by an animal use proposal approved by the University of Georgia's Institutional Animal Care and Use Committee (#A2010 05-091-R1). If the results of the CBC or chemistry profile suggested any anomaly or if a cat tested positive for FIV (without previous FIV vaccination) or FeLV, then the health variable for that cat was coded as 1 for dichotomous analysis; no indication of any health issues were coded as 0. If the lab results were abnormal, the owner was contacted and a recommendation was made to have the cat examined by their regular veterinarian.

The KittyCam system is a rectangular box, approximately 7.5 cm by 5 cm by 2.5 cm and weighs 90 grams. KittyCams are mounted on commercially available break-away cat collars. Each unit contains a lithium-ion battery that can record 10-12 hours of cat activity before recharging. The KittyCam contains a motion-sensor that will stop recording while cats are inactive or resting longer than 10 seconds. Video data are stored onto a 16GB microSD card. The KittyCam plastic casing slides open so that volunteers can access the USB charger, flash storage card and turn the unit on and off. The on/off switch allowed the recording to be compatible with each individual household schedule. For example, some cats roam early morning to evening while some are allowed outside at night. The KittyCam has LED lights for recording in dark places and at night. KittyCams also include a VHF transmitter that allows the camera to be located if a cat loses its collar outdoors. The video cameras were water-resistant, though required some care to prevent damage. A participant wearing the video camera can be seen in Figure 4.2.

Video Analysis

A list of possible risk factors was made *a priori* and this list was reviewed by two additional veterinarians. All outdoor video footage was viewed for analysis. The number and

type of risk factors witnessed in the video for each cat was recorded for each day. Additionally, roaming habitat characteristics and the total hours that cats spent outside each recording day were documented. Roaming habitat was categorized as rural or suburban based upon percentage of greenspace identified via 2006 National Land Use Cover Database for Clarke County, Georgia and proximity (to the household) of neighbors or other urban structures. "Rural" locations were considered households isolated from other significant structures by a minimum 0.4 km radius and with open space as primary land-use. A negative binomial regression was used to examine the influence of predictors on the number of risks a cat experienced while roaming. This method was chosen due to the over-dispersed nature of the Poisson-distributed count data; where-in the conditional variance exceeded the conditional mean. Negative binomial regression has the same structure as Poisson regression but includes an extra parameter to model this overdispersion. This type of model was also used to investigate influences on the number of times project cats crossed roads. Cats witnessed crossing the road at least once were included in this analysis and the number of predictor variables was reduced based on results of the first regression.

RESULTS

Health Screen Results

Participating cats included 31 males and 29 females ranging from 0.5 to 19.5 years of age (mean age = 5.8). Two cats were infected with FIV, one with FeLV, and no cats tested positive for heartworms, *C. felis*, *Babesia* or *Bartonella*. Two cats had values on the chemistry profile consistent with renal insufficiency, three had an elevated white cell count indicative of an infection, and two had a significant eosinophilia, consistent with parasitism. Six cats were considered overweight though this was not included as a "health issue" in analysis.

Video Analysis Results

A minimum of 7 days of footage was collected from 55 of our 60 cats and these cats were included in the video analysis. All participants were sterilized. Eight cats (15%) roamed in a rural area and 47 roamed in urban or suburban neighborhoods. An average of 37 hours of footage for each participating cat was collected.

Most cats (85%) experienced at least one risk factor during 1 week of roaming. The most common risk factors experienced by suburban owned, free-roaming cats in ACC included: crossing roads (45% of our sample), encountering cats that were not from the same household (25%), eating and drinking away from their home (25%), exploring storm drain systems (20%), entering crawlspaces (20%), and climbing onto the roof and trees (20%) (Figure 3). Fifty-two percent of cats witnessed crossing the road did so <5 times while the remaining (48%) cats crossed roads >5 times, in one case up to 24 times during the recording period for one cat. All cats witnessed crossing the road lived in suburban areas of the county. Most participants encountering cats (not a housemate) had friendly encounters, two were recorded hissing and growling at other roaming cats but no fights were recorded. The range of items that cats ate away from home included: trash, compost, road kill or other dead animals, and cat food left for stray cats. Cats were witnessed drinking from pools, puddles in parking lots, old kiddie pools filled with rainwater, and from puddles in the storm drain system. Table 4.1 lists the type of risk factors witnessed via KittyCams and includes the collective sum for the number of times each was counted.

The first regression model included the following predictors: age, sex, health status, roaming season, roaming habitat and video hours recorded. A deviance goodness of fit test found the model fit the data well ($P > 0.05$). Sex was found to have a significant influence on risk

behavior such that roaming males were more likely to undertake more risks than females (β = 0.605, SE β = 0.248, P=0.02) (Table 4.2). The number of risk behaviors was predicted to decrease slightly with each one year increase in age (β=0.122, SE β= 0.037, P=0.001). An increase in recorded video hours was related to an increase in the number of risk behaviors exhibited (β = 0.728, SE β = 0.20, P<0.001), implying there is a relationship between the time spent outdoors and risks experienced. Habitat also had a significant influence on risks (β= 0.819, SE β= 0.384, P=0.03); roaming in a suburban habitat, compared to rural, increased the likelihood of risk behaviors. The number of risk behaviors experienced by participants was not significantly influenced by having a negative finding on the health screen or the season of roaming. Similar results were found in the simpler model used to predict influences on the frequency of crossing roads (Table 4.3). Males were more likely to cross roads more frequently than females (β = .844, SE β = 0.308, P = 0.01) and an increase in video hours recorded was positively related to an increase in the number of times a cat crossed the road (β = 0.559, SE β= 0.211, P=0.01). Age did not significantly influence the number of times road crossings were witnessed. This model was also found to fit the data well (P>0.05).

DISCUSSION AND MANAGEMENT IMPLICATIONS

The KittyCams project provides baseline information on the types and frequencies of free-roaming cat activities in suburban neighborhoods. Many cats engaged in a dangerous activity on a daily basis. Road traffic seems to pose the greatest hazard to free-roaming cats as almost half of our cats were witnessed crossing roads. Threat of contracting an infectious disease is another concern since one quarter of participating cats were witnessed in close contact with an unknown (possibly stray) cat. It is likely that infection with FIV or FeLV is due to the roaming lifestyle and limiting roaming behavior protects pets from exposure due to contact with other

roaming cats. Twenty percent of free-roaming cats were exposed to possible poisons through consumption of liquids and solids away from home. Drinking from parking lot puddles and storm drain puddles may expose cats to ethylene glycol (anti-freeze) or other chemical run-off from vehicles or suburban lawns. Most cats roamed close to home thus providing fresh water outdoors for pets may alleviate the consumption of other liquids while roaming. A percentage of our sample frequented risky locations including crawlspaces (where they could become trapped) and storm drains (where they could experience flooding during a rain event). Owners should be aware that many free-roaming pet cats engage in such activities. The threat of losing their pet may influence their choice to allow their pet to roam free for long periods of time each day.

While many veterinarians and animal welfare organizations [for example: (HSUS 2010, American Animal Rescue Society 2011, PAWS Companions 2012)] encourage owners to keep cats safely indoors, a minority of American cat owners do so. This is true even though many municipalities, including ACC, have written codes requiring domestic animals be kept under the control of owners. The common risk factors identified through KittyCams and the evidence through videos can be used in public education campaigns to influence future management of some pets. In addition to threats identified by the KittyCams research, cats may also become lost while roaming. In fact, of 76 cats originally signed up to enroll in the KittyCams project, two cats became lost and one was a victim of a car accident before actual participation could be initiated. Since we found age (younger) and sex (male) positively influenced the number of risks experienced by roaming pets, owners may especially consider keeping younger males indoors, in outdoor enclosures or only providing supervised outdoor time. Our finding of sex as a predictor of increased risk behavior supports previous findings related to road death (Childs and Ross 1986, Yamaguchi et al. 1996). Our results also demonstrate that reducing the total roaming time

may reduce the number of risks that roaming cats experience. These new insights into cat behavior can be used to inform future educational campaigns and feline veterinarians.

LITERATURE CITED

American Animal Rescue Society. 2011. Safe Cats. *in* American Animal Rescue Society. < http://www.aarsociety.org/safe-cats > Accessed on 11 June 2012.

Akucewich, L. H., K. Philman, A. Clark, J. Gillespie, G. Kunkle, C. F. Nicklin, and E. C. Greiner. 2002. Prevalence of ectoparasites in a population of feral cats from north central Florida during the summer. Veterinary Parasitology 109:129-139.

Al-Kappany, Y., M. R. Lappin, O. Kwok, S. Abu-Elwafa, M. Hilali, and J. P. Dubey. 2011. Seroprevalence of *Toxoplasma Gondii* and concurrent *Bartonella*, Feline Immunodeficiency Virus, Feline Leukemia Virus and *Dirofliaria immitis* infections in Egyptian cats. Journal of Parasitology. Journal of Parasitology 97: 256- 258.

Anderson, T. C., G. W. Foster, and D. J. Forrester. 2003. Hookworms of feral cats in Florida. Veterinary Parasitology 115:19-24.

AVMA. 2007. Market reseach statistics on U.S. pet ownership. < http://www.avma.org/reference/marketstats/ownership.asp> Accessed 11 June 2012.

Birkenheuer, A., J. Le, A. Valenzisi, M. Tucker, M. Levy, and E. Breitschwerdt. 2006. *Cytauxzoon felis* infection in cats in the mid-Atlantic states: 34 cases (1998-2004). Journal of the American Veterinary Medical Association 228:568-571.

Case, J. B., B. Chomel, W. Nicholson, and J. E. Foley. 2006. Serological survey of vector-borne zoonotic pathogens in pet cats and cats from animal shelters and feral colonies. Journal of Feline Medicine & Surgery 8:111-117.

Childs, J. E., and L. Ross. 1986. Urban cats: characteristics and estimation of mortality due to motor vehicles. American Journal of Veterinary Resources 47:1643-1648.

Comer, J. A., C. D. Paddock, and J. E. Childs. 2004. Urban zoonoses caused by *Bartonella*, *Coxiella*, *Ehrlichia* and *Rickettsia* species. Vector Borne and Zoonotic Diseases 1:91-118.

Dabritz, H. A., and P. A. Conrad. 2010. Cats and Toxoplasma: Implications for Public Health. Zoonoses and Public Health 57:34-52.

Dubey, J. P., W. J. A. Saville, J. F. Stanek, and S. M. Reed. 2002. Prevalence of *Toxoplasma gondii* antibodies in domestic cats from rural Ohio. The Journal of Parasitology 88:802-803.

Gray, L. B. 1997. Keeping your cat indoors. *in* The Avocet. Santa Clara county Audubon Society, Cupertino, CA.

Hays, G. C., G. J. Marshall, and J. A. Seminoff. 2007. Flipper beat frequency and amplitude changes in diving green turtles, *Chelonia mydas*. Marine Biology 150:1003-1009.

Heithaus, M.R., L.M Dill, G. J.Marshall, and B. Buhleier. 2002. Habitat use and foraging behavior of tiger sharks in a seagrass ecosystem. Marine Biology 140:237-248.

Herman, E. Y. K., L. M. Herman, A. A. Pack, G. Marshall, M. C. Shepard, and M. Bakhtiari. 2007. When Whales Collide: Crittercam Offers Insight into the Competitive Behavior of Humpback Whales on Their Hawaiian Wintering Grounds. Marine Technology Society Journal 41:35-43.

Humane Society of the United States. 2009. "A safe cat is a happy cat". HSUS publications.

_____. 2010. "Keep your cat happy indoors". < http://www.humanesociety.org/animals/cats/tips/cat_happy_indoors.html > Accessed 11June 2012.

Loyd, K. A. T., and S. M. Hernandez. In press. Public perceptions of domestic cats and preferences for feral cat management in the southeastern United States. Anthrozöös 25.

Lucas, S. R., M. K. Hagiwara, V. S. Loureiro, J. Y. H. Ikesaki, and E. H. Birgel. 1999. *Toxoplasma gondii* infection in brazilian domestic outpatient cats. Review of Institutional Medicine in tropical Sao paulo 41:221-224.

MacDonald, D. W., N. Yamaguchi, and G. Kerry. 2000. Group-Living in the domestic cat: its sociobiology and epidemiology. Pages 96-115 *in* D. C. Turner, and P. Bateson, editors. The domestic cat: The biology of its behavior. Cambridge University Press, Cambridge, U.K.

Maruyama, S., H. Kabeya, R. Nakao, S. Tanaka, T. Sakal, X. Xuan, Y. Katsube, and T. Mikami. 2003. Seroprevalence of *Bartonella henselae*, *Toxoplasma gondii*, FIV and FeLV Infections in domestic cats in Japan. Microbiology and Immunology 47:147-153.

McElroy, K. M., B. L. Blagburn, E. B. Breitschwerdt, P. S. Mead, and J. H. McQuiston. 2010. Flea-associated zoonotic diseases of cats in the USA: bartonellosis, flea-borne rickettsioses, and plague. Trends in Parasitology 26:197-204.

Moll, R. J., J. J. Millspaugh, J. Beringer, J. Sartwell, and Z. He. 2007. A new view of ecology and conservation through animal-borne video systems. Trends in Ecology & Evolution 22:660-668.

Nutter, F. B. 2005. Evaluation of a Trap-Neuter-Return Mangement Program for Feral Cat Colonies: Population Dynamics, Home Ranges and Potentially Zoonotic Diseases., North Carolina State University, Raleigh, NC.

Nutter, F. B., J. P. Dubey, J. F. Levine, E. B. Breitschwerdt, R. B. Ford, and M. K. Stoskopf. 2004. Seroprevalences of antibodies against *Bartonella henselae* and *Toxoplasma gondii*

and fecal shedding of *Cryptosporidium* spp, *Giardia* spp, and *Toxocara cati* in feral and pet domestic cats. Journal of the American Veterinary Medical Association 225:1394-1398.

PAWS Companions. 2012. Keeping your cat happy indoors. < http://www.paws.org/happy-indoor-cat.html > Accessed 11 June 2012.

Ponganis, P. J., R. P. Van Dam, G. Marshall, T. Knower, and D. H. Levension. 2000. Sub-ice foraging behavior of emperor penguins. Journal of Experimental Biology 203:3275-3278.

Rochlitz, I. 2003. Study of factors that may predispose domestic cats to road traffic accidents. Veterinary Record 153:549-553.

Yamaguchi, N., D. W. MacDonald, W. C. Passanisi, D. A. Harbour, and C. D. Hopper. 1996. Parasite Prevalence in Free-Ranging Farm Cats, *Felis silvestris catus*. Epidemiology and Infection 116:217-223.

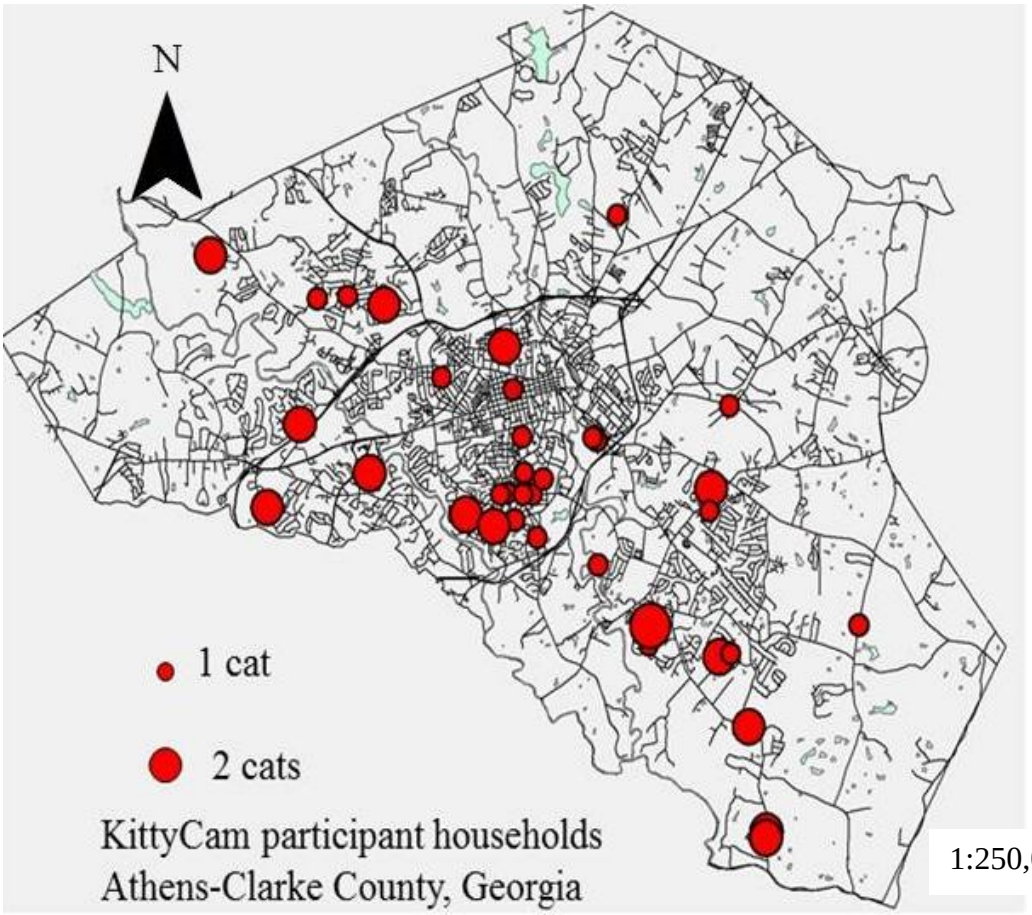


Figure 3.1: Map of free-roaming pet cats' households monitored by a KittyCam video camera for 7-10 days in Athens-Clarke County, Georgia, 2011.

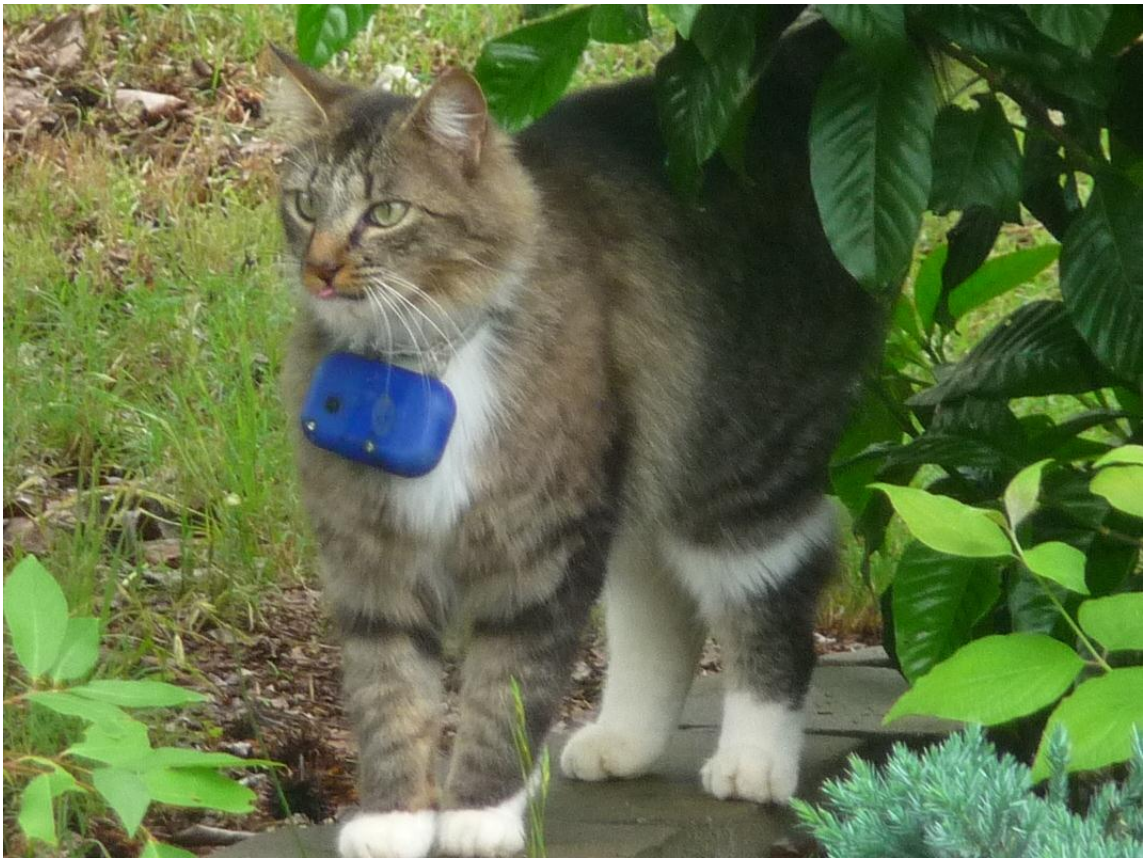


Figure 4.2: Owned, free-roaming cat wearing a KittyCam video camera in Athens-Clarke County Georgia 2011.

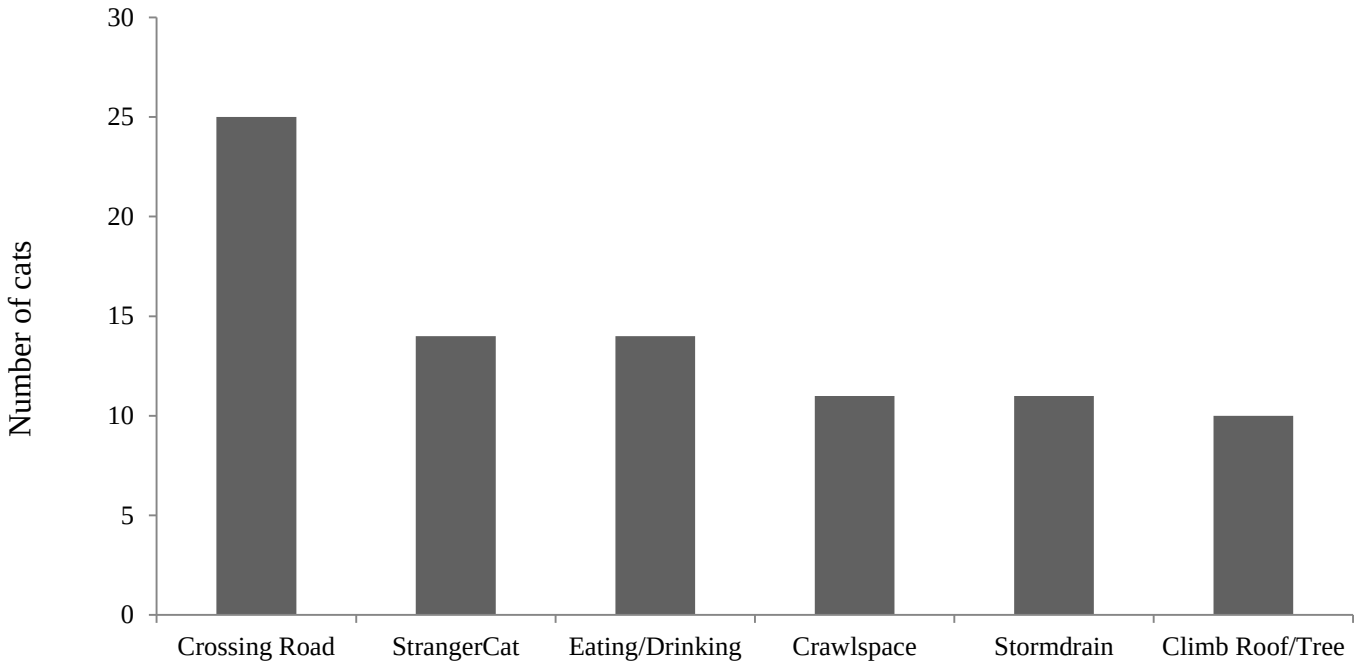


Figure 4.3: The number of pet cats (n=55) witnessed engaging in common risk behaviors via KittyCam video cameras while roaming in Athens-Clarke County, Georgia, 2011.

Table 4.1: Risk factors experienced by 55 free-roaming cats monitored via KittyCams video cameras in Athens-Clarke County, Georgia, 2011.

Risk Factor	**Cumulative count**
Crossing 2-lane road	178
Nonaggressive contact with a stranger cat (infectious disease risk)	28
Consuming solids or liquids not left by owner	20
Entering storm drain	19
Climbing tree	13
Climbing on roof	7
Contact with other medium sized wild animal (injury, disease risk)	1
Crawling into car engine	1

Table 4.2: Influence of predictors on the number of risks experienced by free-roaming cats monitored with KittyCam video cameras in Athens-Clarke County, Georgia, 2011.

Coefficients	Estimate	SE	z	P	Lower CI	Upper CI
(Intercept)	-1.583	0.913	-1.734	0.083	-3.373	0.206
Male(SEX)	0.605	0.248	2.441	0.015	0.119	1.090
AGE	-0.122	0.037	-3.299	0.001	-0.194	-0.049
HEALTH ISSUE	-0.574	0.345	-1.665	0.096	-1.250	0.102
Warm(SEASON)	0.467	0.285	1.641	0.101	-0.091	1.026
VIDEOHOURS	0.728	0.200	3.635	0.000	0.335	1.120
Suburban(HABITAT)	0.819	0.384	2.135	0.033	0.067	1.572

Table 4.3: The influence of cat age, sex and video hours collected by KittyCam video cameras on the number of times owned, free-roaming cats were witnessed crossing roads in Athens-Clarke County, Georgia, 2011.

Coefficient	Estimate	SE	z	p	Lower CI	Upper CI
(Intercept)	-0.385	0.791	-0.487	0.626	-1.935	1.165
AGE	-0.050	0.044	-1.121	0.262	-0.137	0.037
(Male)SEX	0.844	0.308	2.743	0.006	0.241	1.447
VIDEOHOURS	0.559	0.211	2.652	0.008	0.146	0.973

CHAPTER 5

CONCLUSIONS AND FUTURE RESEARCH RECOMMENDATIONS

Free-roaming domestic cats are abundant in areas occupied by humans throughout the world. Further investigation of cat activities in our natural environment is needed, particularly attention to cat predation in suburban areas (Longcore et al. 2009), implications for cat welfare (Jessup 2004), and human health (Barrows 2004, Dabritz and Conrad 2010, Gerhold 2011). Free-roaming cats have sparked a passionate debate in the past few years, in Athens-Clarke County, Georgia (Dauphiné and Cooper 2011) and beyond (Williams 2009, Lepczyk et al. 2011). The debate often pits biologists against cat advocates and many of the disagreements are a result of incomplete scientific information on the activities of free-roaming cats and public knowledge and attitudes about cats. Understanding public perceptions of domestic cats as well as documenting the reality of their interactions with wildlife is critical to future management and policy decisions.

The KittyCams technology provided a creative solution to answer widespread and controversial questions about the interactions and behaviors of cats in the environment. I measured cat predation on suburban wildlife and quantified common factors threatening the health of owned, free-roaming cats. I found that a significant minority of my cats were actively hunting. This substantiates findings in one prior study of owned cats (Baker et al. 2008) while other studies recorded a much higher percentage of roaming cats capturing prey (Crooks and Soulé 1999, van Heezik et al. 2010). Animal-borne video camera methodology allowed me to capture a complete record of cats' outdoor activities during 7-10 days, thus improving upon

estimates of wildlife kills based upon catches returned to the households. My results indicate that cats returned less than a quarter of their captures, often preferring to consume or leave their prey at the capture site. Notably, this suggests the cumulative impact of hunting cats may be much greater than estimates provided by (Woods et al. 2003, van Heezik et al. 2010). The suburban prey types documented via KittyCams also differed from prior reports. Whereas (Barratt 1998, Crooks and Soulé 1999, Woods et al. 2003, van Heezik et al. 2010) documented mammals and birds to be the prominent taxa of prey, I found reptiles to be the most commonly captured class of animals in suburban Athens-Clarke County. Conservation of suburban herpetofauna in the USA remains understudied. My results suggest anoles, skinks and small snakes may be disproportionately represented in cat prey. Cat predation may affect the population viability of such species. While anoles, in particular, may seem abundant in suburban areas of the USA, we cannot determine whether mortality due to free-roaming cats is additive or compensatory without careful analysis of the dynamics of the prey population. Future research using improved methodology like KittyCams is needed to address impact in different geographic areas. Predation rate of subsidized and unsubsidized feral cats also needs attention (Longcore et al. 2009) as population estimates are expected to rival the numbers of owned cats in the USA (Winter 2004).

My results on cat-wildlife interactions may help facilitate new dialogue by previously polarized cat advocacy representatives and wildlife and conservation biologists. Because my results suggest many owned cats may not be directly contributing to wildlife demise, biologists may consider revising (common) recommendations that *all* domestic cats be removed from the environment. Cat advocacy groups should be aware that some cats capture wildlife frequently, almost daily and can help encourage owners of efficient hunters to reduce or supervise time spent outdoors. Offering compromises related to pet management may help the two groups unite

and work together. My research results, images and videos will open the door to improved communication.

Through KittyCams monitoring, I also collected baseline data on risk factors experienced by domestic cats roaming in suburban areas. Several studies acknowledge the threats to cats associated with roaming, including road accidents (Rochlitz 2003b), infectious disease (Maruyama et al. 2003) and predators (Nutter 2005), yet new methodology was needed to identify the complete range of risk behaviors that suburban cats experience and measure the frequency of risky activities. KittyCams video revealed that an overwhelming majority of participating cats experienced at least one risk factor while roaming during one week. Crossing two-lane roads was the most frequent risk behavior witnessed, followed by encountering other roaming (potentially stray cats) and consuming substances away from home. I found age (young), sex (male), and roaming habitat (suburban) characteristics had a significant positive influence on the number of risk factors experienced. Males were previously found to engage in more risky behaviors than females with increased mortality due to roads (Childs and Ross 1986). The predictors of increased risk behavior have important implications for pet owners. Cat owners can reduce the likelihood of their cat becoming injured, sick, trapped or lost due to a roaming lifestyle by reducing the amount of time pets spend roaming, especially younger male individuals. I suggest cat owners also consider supervising outdoor time (a leash is one option) or constructing an outdoor enclosure to keep their cat contained and safe outdoors. Similar management improvements should also be considered for cats that are known to hunt wildlife. A pounce protector (CatBib®) is one option to reduce captures of some wildlife taxa. While scientists delve further into the issue of cat/wildlife interactions, the precautionary principle is recommended (Calver et al. 2011).

There were some challenges to my research related to the KittyCams technology and to the citizen science aspect. We originally envisioned a larger sample size of close to 100 participating cats in our study area but data collection was limited by both camera failures and the volunteer cat owners. While water resistant, the KittyCams were not completely waterproof, thus often needed repair if submerged in bowl of water while the cat was drinking. Additionally, cat activities were hard on the cameras, causing them to malfunction and require attention from National Geographic engineers. We lost recording time throughout the year due to the need to frequently send cameras for repair. Additionally, we had numerous volunteers who did not follow through with collecting the 7-10 days of video footage we requested. Both issues limited our total sample size. Other limitations to my research involve the somewhat homogenous sample of indoor-outdoor housecats. All participating cats were well-cared for (regularly saw veterinarians), valued pets. The time spent outdoors and the nature of activities recorded while roaming are unlikely to represent all owned cats. Barn cats or strictly outdoor cats may experience additional or more frequent risk behaviors and may spend additional time hunting wildlife.

The results of my human dimensions survey found that an overwhelming majority of Athens' residents agreed that protecting wildlife was very important. However, a significant percentage of these respondents were cat owners that allowed their pets to roam free. This segment of the public audience is the target for some of our KittyCams project educational materials. Online tools and printed brochures are meant to raise awareness about the possible negative impacts of hunting cats on native suburban biodiversity. I plan to share images, videos and statistics with the general public and pet owners through our website www.kittycams.uga.edu as well as through dissemination of a tri-fold brochure (Appendix C).

The educational materials focus on improving the welfare of both cats and wildlife by sharing information on cat-wildlife interactions and the risks associated with allowing pets to roam free. In addition to my project results and images, the website links to additional online resources. Future human dimensions research is needed on the efficacy of such materials. My survey indicated that public knowledge about domestic cats did not appear to influence beliefs about cats. Considering the cognitive hierarchy (which suggests that beliefs influence behaviors) (Fulton et al. 1996), it may be unlikely that increasing knowledge about domestic cats alone will lead to changes in behavior regarding management of owned cats. The additional exposure to graphic images and videos (such as those collected via the KittyCams project) may have a stronger effect on public attitudes and behaviors. An evaluation to assess the cognitive and affective impact of alternative cat education materials could provide greater insight into public perceptions and ultimately help protect native wildlife and pet cats.

LITERATURE CITED

Baker, P. J., S. E. Molony, E. Stone, I. C. Cuthill, and S. Harris. 2008. Cats about town: is predation by free-ranging pet cats *Felis catus* likely to affect urban bird populations? Ibis 150:86-99.

Barratt, D. G. 1998. Predation by house cats, *Felis catus*, in Canberra, Australia. II. Factors affecting the amount of prey caught and estimates of the impact on wildlife. Wildlife Research 25:475-487.

Barrows, P. L. 2004. Professional, eithcal and legal dilemmas of trap-neuter-release. Journal of the American Veterinary Medical Association 225:1365-1372.

Calver, M. C., J. Grayson, M. Lilith, and C. R. Dickman. 2011. Applying the precautionary principle to the issue of impacts by pet cats on urban wildlife. Biological Conservation 144:1895-1901.

Childs, J. E., and L. Ross. 1986. Urban cats: characteristics and estimation of mortality due to motor vehicles. American Journal of Veterinary Resources 47:1643-1648.

Crooks, K. R., and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.

Dabritz, H. A., and P. A. Conrad. 2010. Cats and Toxoplasma: Implications for Public Health. Zoonoses and Public Health 57:34-52.

Dauphiné, N., and R. J. Cooper. 2011. Pick One: Outdoor Cats or Conservation. Pages 50-56 *in* The Wildlife Professional. The Wildlife Society, Bethesda Maryland.

Fulton, D. C., M. J. Manfredo, and J. Lipscomb. 1996. Wildlife Value Orientations: A conceptual and measurement approach. Human Dimensions of Wildlife 1:24-27.

Gerhold, R. 2011. Cats as Carriers of Disease. Pages 58-61 *in* The Wildlife Professional. The Wildlife Society, Bethsda, MD.

Jessup, D. A. 2004. The welfare of feral cats and wildlife. Journal of the American Veterinary Medical Association 225:1377-1383.

Lepczyk, C. A., Y. van Heezik, and R. J. Cooper. 2011. An Issue with All-Too-Human Dimensions. Pages 68-70 *in* The Wildlife Professional. The Wildlife Society, Bethesda, MD.

Longcore, T., C. Rich, and L. M. Sullivan. 2009. Critical Assessment of Claims Regarding Management of Feral Cats by Trap-Neuter-Return. Conservation Biology 23:887-894.

Maruyama, S., H. Kabeya, R. Nakao, S. Tanaka, T. Sakal, X. Xuan, Y. Katsube, and T. Mikami. 2003. Seroprevalence of *Bartonella henselae*, *Toxoplasma gondii*, FIV and FeLV Infections in domestic cats in Japan. Microbiology and Immunology 47:147-153.

Nutter, F. B. 2005. Evaluation of a Trap-Neuter-Return Mangement Program for Feral Cat Colonies: Population Dynamics, Home Ranges and Potentially Zoonotic Diseases. North Carolina State University, Raleigh, NC.

Rochlitz, I. 2003. Study of factors that may predispose domestic cats to road traffic accidents: part 1. Veterinary Record 153:549-553.

van Heezik, Y., A. Smyth, A. Adams, and J. Gordon. 2010. Do domestic cats impose an unsustainable harvest on urban bird populations. Biological Conservation 143: 121-130.

Williams, T. 2009. Feline Fatales:. Pages 30-38 *in* Audubon Magazine. September-October 2009 Issue.

Winter, L. 2004. Trap-neuter-release programs: the reality and the impacts. Journal of the American Veterinary Medical Association 225:1369-1376.

Woods, M., R. A. McDonald, and S. Harris. 2003. Predation of wildlife by domestic cats *Felis catus* in Great Britain. Mammal Review 33:174-188.

APPENDIX A

Text from the postcard requesting participation with our human dimensions survey on perceptions of domestic cats.

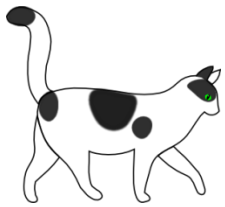
Summer 2010
Dear Athens-Clarke County Resident,

Domestic cats provide us with love and companionship; however stray cats can also become a problem if they are not managed. In an effort to understand how residents of Athens Clarke County view cats and their management we are undertaking a survey of households throughout the county. **You are one of a select group of residents** asked to provide information about your experiences, views and knowledge of cats, and your preferences for stray cat management. Even if you have not interacted with cats around your home, we ask you to please complete our online questionnaire as soon as possible. The information you and other recipients furnish is vital to future management. Responses are also important in developing educational information about cats. This survey is limited to selected recipients. We do not ask your name and confidentiality will be maintained when responses are used. Please take 15 minutes to provide your opinions. We value your cooperation and thank you for your time and assistance. Please go to: www.surveymonkey.com/s/Athenscats?c=
to fill out the survey.

Sincerely,

Sonia M. Hernandez, DVM, PhD
Warnell School of Forestry and Natural Res.
The University of Georgia

Warnell School of Forestry and Natural Resources
University of Georgia
180 Green St. Athens, GA 30602



NON-PROFIT
ORGANIZATION
U.S. POSTAGE
PAID
ATHENS, GA
PERMIT NO. 165

APPENDIX B

Survey distributed to randomly selected households in our study area, Athens-Clarke County, Georgia, 2010. Descriptive results are included below.

Public perceptions of domestic cats and preferences for feral cat management

1. I am 18 years of age or older. I agree to take part in this research study entitled "Public perceptions of domestic cats and preferences for feral cat management". My participation is voluntary. I understand that the risks involved in participating in this survey research are minimal and that I can exit the survey at any time. I can ask to have information removed from the research records.

	Response Percent	Response Count
Yes	100.0%	296
No	0.0%	0
answered question		296
skipped question		2

2. Do you think you have seen a feral cat in your neighborhood in the past 12 months?

	Response Percent	Response Count
Yes (Please go to question 2)	62.9%	183
No (Please go to question 4)	37.1%	108
answered question		291
skipped question		7

3. About how often do you think you have seen a feral cat during the last 12 months?

	Response Percent	Response Count
about 4-5 times	36.5%	70
about once a month	18.8%	36
about once a week	17.2%	33
almost every day	27.6%	53
answered question		192
skipped question		106

4. About how many different feral cats do you see?

	Response Percent	Response Count
1-2	63.4%	123
3-5	25.8%	50
6-8	6.7%	13
9-12	1.5%	3
more than 12	2.6%	5
answered question		194
skipped question		104

5. Have you had any of the following experiences with feral cats? (Please choose all that apply)

	Response Percent	Response Count
Fed a feral cat	38.1%	75
Seen a neighbor feeding feral cats	34.0%	67
Experienced a feral cat fight with your own pet cat	20.8%	41
Participated in a feral cat management program (ex: Trap-neuter-Release)	12.2%	24
Seen a feral cat kill a small mammal, bird or other animal	25.9%	51
Experienced feral cats urinating or defecating in your yard	**38.6%**	**76**
Donated money to an organization or project aiming to help feral cats	18.8%	37
Called animal control or another government agency to complain about feral cats	10.7%	21
Adopted a feral cat	31.0%	61
answered question		197
skipped question		101

6. Have you seen or heard information about feral cats in Athens in any of the following?

	Response Percent	Response Count
newspaper stories	84.0%	204
brochures	9.1%	22
from a friend or relative	41.2%	100
on the internet	18.5%	45
answered question		243
skipped question		55

7. Were you aware of the recent changes to the Athens Clarke County animal control ordinances legalizing feral cat colonies, exempting feral cat caretakers from animal ordinances and providing funds to support feral cat Trap-Neuter-Release programs?

	Response Percent	Response Count
Yes	57.8%	167
No	42.2%	122
answered question		289
skipped question		9

8. Did you support this legislation?

	Response Percent	Response Count
Yes	43.3%	109
No	56.7%	143
answered question		252
skipped question		46

9. How important is each of the following to you?

	Not At All Important	Slightly Important	Moderately Important	Very Important	Extremely Important	Response Count
Healthy ecosystems	0.7% (2)	1.8% (5)	5.4% (15)	36.2% (100)	**55.8% (154)**	276
Feral cat welfare (cats are fed and sheltered)	22.0% (60)	16.1% (44)	**23.8% (65)**	20.9% (57)	17.2% (47)	273
Protecting wildlife	0.4% (1)	3.6% (10)	12.0% (33)	41.1% (113)	**42.9% (118)**	275
Removing non-native species	9.3% (25)	17.5% (47)	**28.6% (77)**	25.7% (69)	19.0% (51)	269
Supporting animal rights	6.3% (17)	11.9% (32)	24.4% (66)	**30.0% (81)**	27.4% (74)	270
Preventing euthanasia of feral cats	**34.2% (94)**	14.9% (41)	20.0% (55)	17.8% (49)	13.1% (36)	275
					answered question	**281**
					skipped question	**17**

10. Please indicate how strongly you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	Response Count
I feel that feral cats have the right to live in my neighborhood.	**32.1% (89)**	18.1% (50)	22.7% (63)	19.9% (55)	7.2% (20)	277
I worry about problems feral cats might cause for my pets.	10.9% (29)	18.0% (48)	12.0% (32)	**36.0% (96)**	23.2% (62)	267
The risk of contracting a disease from a feral cat is low.	18.0% (50)	24.1% (67)	**30.2% (84)**	22.7% (63)	5.0% (14)	278
Feral cats should be offered food and shelter.	25.5% (69)	12.2% (33)	20.7% (56)	**33.6% (91)**	8.1% (22)	271
Non-native species should be removed if they harm native species.	3.6% (10)	6.9% (19)	27.3% (75)	**41.5% (114)**	20.7% (57)	275
Feral cats live healthy, happy lives.	22.1% (61)	**33.7% (93)**	33.3% (92)	9.8% (27)	1.1% (3)	276
Feral cats should be managed as a non-native species.	11.7% (32)	18.3% (50)	**36.3% (99)**	20.5% (56)	13.2% (36)	273
I feel feral cats are a nuisance.	10.5% (29)	26.1% (72)	13.0% (36)	**28.3% (78)**	22.1% (61)	276
More effective management of feral cats is needed in Athens.	2.9% (8)	5.8% (16)	25.7% (71)	**34.4% (95)**	31.2% (86)	276
Feral cats should be protected and managed as wildlife.	**28.7% (79)**	21.8% (60)	22.9% (63)	21.1% (58)	5.5% (15)	275
Free-roaming cats (feral OR owned, pet cats) do not harm wildlife.	**35.1% (98)**	33.0% (92)	16.5% (46)	12.2% (34)	3.2% (9)	279
Pet cats (owned cats, not feral) should be allowed by law to roam outdoors.	18.6% (52)	17.9% (50)	14.0% (39)	**33.7% (94)**	15.8% (44)	279
Euthanizing feral cats is inhumane.	**27.9% (78)**	27.5% (77)	17.5% (49)	18.2% (51)	8.9% (25)	280
Pet cats should be kept indoors.	13.2% (37)	**26.3% (74)**	16.4% (46)	22.1% (62)	22.1% (62)	281
					answered question	**281**
					skipped question	**17**

11. Which of the following describes how you think feral cat population numbers in Athens-Clarke County have changed over the past five years?

	Response Percent	Response Count
Decreased	1.8%	5
Remained the same	7.1%	20
Increased	42.1%	118
Unsure	48.9%	137
answered question		280
skipped question		18

12. If you think feral cat populations have decreased in Athens-Clarke County over the past 5 years, which of the following reasons do you think best explains their decline?

	Response Percent	Response Count
Not applicable	88.4%	137
Feral cat spay-neuter programs	4.5%	7
Animal control trap-and-remove programs	2.6%	4
Car collisions	1.3%	2
Disease	1.9%	3
Coyote predation	1.3%	2
answered question		155
skipped question		143

13. If you think feral cat populations have increased in Athens-Clarke County over the past 5 years, which of the following reasons do you think best explains their increase?

	Response Percent	Response Count
Not applicable	35.8%	76
Lack of effective cat management	20.8%	44
Feeding of feral cats	9.4%	20
An increase in trash	0.5%	1
Increase in abandonment of pet cats	33.5%	71
answered question		212
skipped question		86

14. How much do you support the following actions by local managers in Athens?

	Unacceptable in all cases	Unacceptable in most cases	Unsure	Acceptable in most cases	Acceptable in all cases	Response Count
Capture and euthanize feral cats	5.5% (15)	**36.4% (100)**	14.2% (39)	30.5% (84)	13.5% (37)	275
Capture and place feral cats in a sanctuary created for them	11.3% (31)	15.3% (42)	17.5% (48)	**46.2% (127)**	9.8% (27)	275
Educate the public about feral cats and wildlife	0.4% (1)	2.2% (6)	7.3% (20)	28.7% (79)	**61.5% (169)**	275
Trap, sterilize (neuter) and re-release feral cats	17.9% (50)	18.6% (52)	14.0% (39)	**35.8% (100)**	13.6% (38)	279
Discourage people from feeding feral cats	4.7% (13)	17.0% (47)	25.0% (69)	24.6% (68)	**28.6% (79)**	276
Leave cats alone	24.6% (67)	**34.9% (95)**	24.6% (67)	13.6% (37)	2.2% (6)	272
Enforce existing animal ordinances	1.5% (4)	1.5% (4)	**42.8% (116)**	29.5% (80)	24.7% (67)	271
					answered question	**280**
					skipped question	**18**

15. Please pick the choice that corresponds to the management option you choose to answer each question.

	Trap-Neuter-Release (Capture, Sterilize and Re-release the cats)	Capture and Euthanize	I am Unsure	Other	Response Count
Which do you believe to be most effective at cat population reduction?	37.9% (105)	**47.3% (131)**	11.6% (32)	3.2% (9)	277
Which do you believe is more humane to cats?	**56.3% (156)**	27.1% (75)	11.9% (33)	4.7% (13)	277
Which cat management option do you believe is more humane to wildlife?	22.5% (62)	**45.1% (124)**	26.5% (73)	5.8% (16)	275
Which option would you prefer tax-payer money be spent on?	**42.9% (118)**	36.4% (100)	13.1% (36)	7.6% (21)	275
Which option would you donate money to support? (NOTE: We are not soliciting donations; we only care about your potential to donate money)	**40.1% (109)**	23.2% (63)	25.7% (70)	11.0% (30)	272
				answered question	**278**
				skipped question	**20**

16. For each of the animals below, would you support destroying the animal if it caused a problem to people?

	Unacceptable in all cases	Unacceptable in most cases	Unsure	Acceptable in most cases	Acceptable in all cases	Response Count
Deer	13.0% (36)	**34.8% (96)**	12.0% (33)	29.7% (82)	10.5% (29)	276
Coyotes	7.2% (20)	27.3% (76)	10.8% (30)	**34.2% (95)**	20.5% (57)	278
Feral Cats	9.7% (27)	25.8% (72)	9.0% (25)	**35.5% (99)**	20.1% (56)	279
Feral Dogs	6.1% (17)	21.1% (59)	9.3% (26)	**38.4% (107)**	25.1% (70)	279
Feral Horses	14.1% (39)	**27.1% (75)**	23.1% (64)	23.5% (65)	12.3% (34)	277
Feral Hogs	5.0% (14)	20.1% (56)	13.3% (37)	**36.0% (100)**	25.5% (71)	278
					answered question	**279**
					skipped question	**19**

17. Before you received this survey were you aware that:

	No	Yes	Response Count
Feral cats are the leading domestic animal carrier of the rabies virus in the US	**79.1% (219)**	20.9% (58)	277
Indoor cats live significantly longer than outdoor cats	18.1% (50)	**81.9% (226)**	276
An unspayed female cat can produce up to 10 kittens every year	22.0% (61)	**78.0% (216)**	277
Cats can see in the dark	10.5% (29)	**89.5% (247)**	276
Free-ranging cats will capture prey even if well-fed	18.8% (52)	**81.2% (224)**	276
Cats are the only animal in which the parasite Toxoplasma gondii can complete its life-cycle	**75.1% (208)**	24.9% (69)	277
Cats can run up to 30 miles per hour	**77.6% (215)**	22.4% (62)	277
Cats are the the most popular pet in the US	**64.0% (176)**	36.0% (99)	275
Free-roaming cats can become prey for urban coyotes	31.9% (88)	**68.1% (188)**	276
Feral cats are not territorial in the presence of abundant food	**80.4% (222)**	19.6% (54)	276
Free- ranging cats can contract disease or parasites from wildlife	12.8% (35)	**87.2% (239)**	274
Outdoor and feral cats kill more small rodents than birds	44.6% (123)	**55.4% (153)**	276
		answered question	**277**
		skipped question	**21**

18. How well would you be able to explain the following concepts to a friend?

	Could not explain	Could somewhat explain	Could explain well	Response Count
How non-native species impact an ecosystem	22.7% (63)	**54.9% (152)**	22.4% (62)	277
The interactions between cats and wildlife	20.9% (58)	**57.0% (158)**	22.0% (61)	277
Transmission of the parasite "Toxoplasmosis"	**66.9% (184)**	21.1% (58)	12.0% (33)	275
Causes of songbird decline in the US	**54.3% (150)**	31.9% (88)	13.8% (38)	276
Trap-Neuter-Release	7.9% (22)	**49.8% (138)**	42.2% (117)	277
			answered question	**277**
			skipped question	**21**

19. Do you own pets?

	Response Percent	Response Count
Yes (Please continue to question 2)	**77.9%**	**215**
No (Please continue to question 4)	22.1%	61
	answered question	**276**
	skipped question	**22**

20. Please check the type of pets owned.

	Response Percent	Response Count
Dogs (Please continue to question 4)	57.7%	124
Cats (Please continue to question 3)	70.7%	152
Birds (Please continue to question 4)	6.5%	14
Other (Please continue to question 4)	10.2%	22
answered question		215
skipped question		83

21. Do you allow your cat to roam free outdoors?

	Response Percent	Response Count
Yes (Please be sure to read #7!)	44.7%	72
No	55.3%	89
answered question		161
skipped question		137

22. Which of the following activities did you participate in during the past 12 months?

	Response Percent	Response Count
bird-watching	**64.2%**	**167**
wildlife viewing	63.1%	164
adopting a dog	10.0%	26
bird-feeding	62.3%	162
fishing	19.2%	50
adopting a cat	15.0%	39
hiking	60.0%	156
hunting	8.5%	22
other	28.1%	73
answered question		**260**
skipped question		**38**

23. Please choose your age range:

	Response Percent	Response Count
18-25	5.1%	14
26-33	12.0%	33
34-41	11.6%	32
42-49	12.4%	34
50-57	22.9%	63
58-65	17.1%	47
66-73	10.9%	30
above 74	8.0%	22
answered question		275
skipped question		23

24. Are you a member of any of the following organizations or have you donated money to any of these in the past 12 months?

	Response Percent	Response Count
PETA	5.4%	7
Alley Cat Allies	0.8%	1
ASPCA	22.5%	29
The Nature Conservancy	26.4%	34
The National Audubon Society	16.3%	21
The Sierra Club	17.8%	23
Ducks Unlimited	2.3%	3
World Wildlife Fund	23.3%	30
The Best Friends Animal Society	6.2%	8
The Humane Society of the United States	**36.4%**	**47**
National Wild Turkey Federation	1.6%	2
The National Wildlife Federation	21.7%	28
Quality Deer Management Association	0.8%	1
Other	31.0%	40
	answered question	**129**
	skipped question	**169**

25. If you own a pet cat that roams outdoors daily and are interested in participating in a research study to explore the activities of pet cats in the environment please provide your contact information below. This information is confidential, will not be associated with your survey answers nor will it be shared with anyone but the research team. We are offering a free total feline health screening by a licensed veterinarian for participating cats. If interested, we will follow up with details on the study and health screening.

	Response Percent	Response Count
Name:	97.1%	34
Address:	94.3%	33
Address 2:	5.7%	2
City/Town:	94.3%	33
State:	100.0%	35
ZIP:	94.3%	33
Email Address:	94.3%	33
Phone Number:	77.1%	27
answered question		35
skipped question		263

26. Thank you for your cooperation! Please do not share this web survey, any unique web address with more than one response associated with it will have to be deleted. Please do provide any comments below!

	Response Count
	89
answered question	89
skipped question	209

APPENDIX C

Educational brochure (full size is 8.5 x 11 inches), featuring results and images from the KittyCams project. This is available as a PDF online for download at www.kittycams.uga.edu

About the KittyCams project:

A team of researchers partnered up in 2009 to have a look at the activities of free-roaming cats using innovative new technology.

Project collaborators included wildlife biologists, veterinarians and National Geographic Remote Imaging engineers. The team monitored 60 pet cats roaming in suburban Athens, Georgia by outfitting them with KittyCam video cameras. Scientists were interested in risk and predation behaviors exhibited by pet cats and the video cameras provided a cats-eye-view of outdoor activities. Take a look inside to find out more!

Bird capture from a KittyCam point-of-view video camera

Additional resources

On our research:
www.kittycams.uga.edu
On keeping cats indoors:
www.abcbirds.org/cats
www.indoorpet.osu.edu

This material was produced by the KittyCams team at The University of Georgia. We thank the following supporters for funding KittyCams research:
National Geographic
Kenneth C. Scott Charitable Trust
Morris Animal Foundation
Oconee Rivers Audubon Society
Pender Pet Caring Foundation

WARNELL CRITTERCAM

Keep pet cats and wildlife safe:

New research based information and images

The University of Georgia

Dangers of roaming outside:

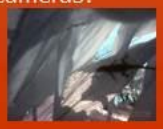
- **CROSSING 2 LANE ROADS** 45% of project cats were witnessed crossing roads
- **RISK OR INJURY OR DISEASE** 25% came in close contact with another cat
- **RISK OF INGESTING CHEMICALS** 25% were eating or drinking substances away from home
- **DANGEROUS LOCATIONS** 20% explored the storm drain system, 20% entered crawlspaces, 18% climbed trees or walked along roofs




Predation on wildlife:

- 44% of cats were witnessed stalking or chasing prey; 30% captured wildlife
- Reptiles (lizards and small snakes) were the most common suburban prey item in our study followed by mammals (voles and chipmunks)
- While only a few bird captures were viewed via KittyCams, many cats stalked birds- this can negatively impact bird behavior
- Most prey was captured during warm seasons

Stalking and capture of wildlife as viewed via KittyCams video cameras:




Recommendations for cat owners:

- Keep younger male cats indoors as much as possible- we found age and sex to be predictors of risk behaviors. Information on keeping kitties happy indoors: http://indoorpet.osu.edu/
- Keep hunting cats indoors to protect wildlife, especially during warm seasons, or consider a "CatBib" www.catgoods.com
- Remove bird baths, houses and feeders from your yard if you allow your cat to roam
- Take advantage of available vaccinations to prevent roaming cats from contracting disease
- Consider outdoor enclosures or leash-training to keep your pet safe while outdoors