The Cost of the Outdoor Cat and Dog: Wildlife Rehabilitation in South Central Pennsylvania

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Abstract: Invasive species pose a threat to native wildlife species worldwide. Through predation, competition, disturbance, hybridization, and disease transmission, invasive mammals interrupt natural ecosystem functions. Domestic dogs and cats affect wild populations of mammal, avian, and reptile species. Wildlife rehabilitation centers accept wild animals as patients for treatment after they have had contact with a domestic animal with the goal of releasing them back into the environment. The authors' objective was to evaluate the impacts of domestic cats and dogs on small mammals and birds located in south central Pennsylvania. Wildlife rehabilitators rely on the public to bring them injured animals. Species bias exists among rescuers, as such, this study was not a comprehensive assessment of the problem in Pennsylvania.

Survival of patients admitted to Raven Ridge Wildlife Center in Lancaster County, PA between July 2015 and June 2016 was analyzed based on species, reason for admission, location, and season. Survival of patients who had been attacked by cats was significantly lower than those admitted for any other reason. Cats and dogs impacted 23 species, including three rabies vector species. Eastern cottontails accounted for a majority of cat and dog attacks. Moreover, no admitted avian species survived a dog or cat attack on any occasion. Attacks by both dogs and cats increased during breeding season (March–August) for many species, with most attacks occurring in urban areas. Care for wildlife injured by dogs and cats cost Raven Ridge Wildlife Center an estimated $7,557.00 in one year. Wildlife rehabilitators should focus on reducing the likelihood of these attacks through public outreach. Both cat and dog attacks occurred near locations identified as important breeding habitat for threatened or endangered birds, making prevention of these events a priority.

Keywords: Cat attack, wildlife rehabilitation, dog attack, invasive species

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Introduction

Invasive mammalian predators have been linked to 87 bird, 45 mammal, and 10 reptile species extinctions, representing 58 percent of total extinctions worldwide (Doherty et al 2016). Two of these mammalian predators are domesticated species to which humans are closely tied, cats and dogs. Annually in the United States, domestic cats of all types are responsible for an estimated 1.4–3.7 billion wild bird and 6.9–20.7 billion wild mammal deaths. This is the largest human–influenced source of mortality in wild birds and mammals (Loss et al 2012). In the United States, there are also 117–157 million pet, stray, and feral cats (*Felis catus*) (Dauphine and Cooper 2011). The United States has approximately 70 million pet dogs (*Canis familiaris*) (AVMA 2012). Domestic dogs have been documented depredating small mammals, foxes, mule deer, bobcats, adult white–tailed deer, wild turkeys, and other native species of birds in the United States. These documented encounters include feral, owned, and free–roaming domestic dogs (Young et al 2011).

Domestic Cats. Each of these two species affects wildlife populations in different ways. Domestic cats (hereafter referred to as cats) have been directly linked to the extinctions of 40 bird, 21 mammal, and two reptile species (Doherty et al 2016). Cats are now the most abundant carnivore in all of North America, outcompeting native mesopredators such as striped skunks (*Mephitis mephitis*) and northern raccoons (*Procyon lotor*) (Dauphine and Cooper 2009; Dauphine and Cooper 2011).

Supplemental food from cat–feeding colonies and private land owners allows densities of cats to reach up to 100 times that of native carnivores and does not reduce the number of wildlife killed (Kays and DeWan 2004). Cat colony population size is a function of this food availability, high reproduction rates, and immigration bolstered by continuous abandonment of cats. This combination causes cat densities to reach levels higher than can be supported by prey availability (Hawkins 1998). Cats are explorative. A feral cat has an average home range of 1.5 square miles (Hildreth et al 2010). They are attracted to sensory cues: the sounds, sights, and smells, of native wildlife (Ancillotto et al 2013). Cats are opportunistic hunters, attacking almost any animal smaller than itself, often without the intention of consumption (Dauphine and Cooper 2009). The Endangered Species Act states that it is against the law to "harass, pursue, hurt, shoot, wound, kill, capture or collect" any endangered species. People who abandon cats or allow their pets to hunt potentially endangered species are in violation of this law (Jessup 2004). Cats allowed outdoors unsupervised violates the Migratory Bird Treaty Act since cats hunt and kill species protected by the Act (Lepczyk et al 2010).

Domestic Dogs. Cats are not always the most abundant and threatening invasive predator. Domestic dogs are now the most abundant carnivore in some parts of the world (Young et al 2011). Domestic dogs (hereafter referred to as dogs) have directly impacted 156 threatened or extinct species around the world (Doherty et al 2016). Thanks to strict licensing and ownership laws on dogs in the United States, the stray and feral epidemic seen with cats is not seen with dogs. However, dogs affect native species in a multitude of ways including predation, competition, disturbance, hybridization, and disease transmission (Hughes and MacDonald 2013; Young et al 2011). A survey of land owners in Brazil found that 58 percent of owned dogs preyed on wildlife consisting of 56.8 percent small and medium mammals, 20.3 percent large mammals, and 33.3 percent birds and nests (Martinez et al 2013). Large mammals are infrequently predated by other native carnivores or domestic cats. Similar to cats, dogs receive nutritional management from humans. With consumption of wildlife occurring less than half the time in attacks by pet dogs, it can be assumed that, like cats, dogs are not hunting due to hunger, but for other reasons (Martinez et al 2013). One explanation is in the domestication of dogs to assist with human hunting—consuming the catch would have been selected against (Martinez et al 2013). Dogs also impact native species without an attack occurring. Dogs can inflict unnecessary stress on wildlife and even prevent their occurrence in some areas (Young et al 2011).

Pennsylvania Crises and Laws. The number of cats in the United States has tripled in the past 40 years (Dauphine and Cooper 2009). According to officials at the Lancaster Society for the Prevention of Cruelty to Animals (SPCA), this coincides with a recent increase in cats being thrown out of their homes and into 'the wild' (White 2015). The Humane League of Lancaster County estimated that there are 84,000 feral cats in the county with 5,000 in the city of Lancaster alone (Crable 2012). Part of this increase of feral cats in Pennsylvania comes from the large support for trap–neuter–return (TNR) programs where stray and feral cats are trapped, neutered or spayed, and returned to areas where private citizens feed the cats in a colony ranging from a few to over 40 cats (Crable 2012). The Humane League of Lancaster County reported that until 2008 they euthanized 1,500–2,000 feral cats a year, however, with the start of TNR in 2008, they now release 2,500–3,000 cats into the environment per year (Crable 2012).

Native Prey Species. While interactions between wildlife and domestic cats and dogs are now common, some species are more vulnerable than others. Any native wildlife could be potential prey for dogs, however, cats have a narrower prey selection. Ground dwelling animals are likely easier prey for both cats and dogs (McRuer et al 2016). Birds that forage on the ground are frequent targets (McRuer et al 2016). This includes fledglings of many avian species that spend part of their life on the ground.

Based upon previous research we know which species are likely victims of cat and dog attacks. Previously, eastern cottontails (*Sylvilagus floridanus*) alone made up 40 percent of cat prey by volume (George 1974). Other potential victims in Pennsylvania include other small mammals, eastern screech–owls (*Megascops asio*), and passerines (Gode and Ruth 2010). Unfortunately, many endangered and threatened species in Pennsylvania are potential cat and dog prey including: blackpoll warbler (*Setophaga striata*), dickcissel (*Spiza americana*), Delmarva fox squirrel (*Sciurus niger cinereus*), Indiana bat (*Myotis sodalis*), least shrew (*Cryptotis parva*), Allegheny woodrat (*Neotoma magister*), small footed bat (*Myotis leibii*), northern flying squirrel (*Glaucomys sabrinus*), and West Virginia water shrew (*Sorex palustris punctualatus*) (Pennsylvania Game Commission 2018).

Wildlife Rehabilitation. Wildlife rehabilitation centers across the United States see these species admitted after domestic cat and dog attacks every day. Portland Audubon's Wildlife Care Center reported in 2007 that cats alone caused 40 percent of their patient intakes (Dauphine and Cooper 2009). Receiving injured and orphaned wildlife from across their state, wildlife rehabilitators have a unique, real–time opportunity to see the threats facing native species.

The types of injuries that cat and dog attack patients must overcome is daunting. They can include the following: lacerations, punctures and internal damage, degloving, fractures, spinal and head injuries, hemorrhage, and diseases often causing sepsis (Casey and Goldthwait 2013). Chasing by cats or dogs may cause capture myopathy, miscarriage, and parents to abandon their young even without direct contact (Casey and Goldthwait 2013). Even if the animal has the potential to survive and be transported for treatment, they continue to face challenges. Rescuers often attempt to care for or feed wildlife incorrectly, causing additional trauma. Young animals may go into shock from being left in the cold and stress caused by the experience can be fatal to many prey species (Casey and Goldthwait 2013). *Pasturella multocida* is a major concern for wildlife rehabilitators. These gram–negative bacteria are responsible for 90 percent of all infections from cat wounds in humans and other animals (Frink et al 1994). In wildlife the infection can be deadly within six to twelve hours after a cat bite or scratch (Gode and Ruth 2010).

In Pennsylvania, all wildlife rehabilitation centers are non–profit organizations relying on donations to care for wild animals in need. Raven Ridge Wildlife Center (RRWC) in Lancaster County is one of the newest, busiest rehabilitation centers in the state. Operating solely with the work of volunteers and public donations, every patient puts a large strain on a small budget. RRWC specializes in the care of native wild mammals and rabies vector species but also often cares for waterfowl, passerines, and raptors from across the state. The goal of this study is to identify how Pennsylvania's native wildlife is affected by domestic cats and dogs by looking at patients admitted for rehabilitation to RRWC. Currently very little is known of the differences in admission rates and survival in wildlife rehabilitation between dog– and cat–attacked patients.

Hypotheses. The authors made several predictions regarding the impacts of cats and dogs on patients admitted for rehabilitation.

1. Dog– and cat–attacked patients will have lower survival–to–release rates than patients admitted for other reasons. Previous reports show that 80 percent of cat attacked wildlife admitted for rehabilitation succumb to their injuries (Harris 1998). To the authors' knowledge, no such estimates exist for dog–attacked wildlife in rehabilitation.
2. Patients admitted due to the secondary effects (mother chased away, siblings killed, etc.) of cats will have similar survival rates to those of other patients due to never having come in contact with the diseases and potential injuries from a dog or cat attack.
3. Both dog and cat attacks will be higher during breeding seasons. Breeding season for the majority of native wildlife is between March and August (Gode and Ruth 2010).
4. With reports of up to 1580 cats/km^2 in urban areas in the US, greater intakes of cat– and dog–attacked patients will be from urban areas (Dauphine and Cooper 2011). Greater cat density in urban areas will offset the fact that rural cats are often allowed outdoors for longer periods of time (Ancillotto et al 2013). The human to dog ratio is likewise higher in urban areas therefore the same trend in dog attack patients is expected (Hughes and MacDonald 2013).

Methods

All data were collected from Raven Ridge Wildlife Center (RRWC) in Washington Boro, PA using intake sheets completed by rescuers who found injured or orphaned wildlife. Upon admission to the wildlife rehabilitation center case number, species, reason for admission, date of admission, rescuer information, and address of rescue were recorded. The final disposition of the animal (euthanized, deceased, transferred, or released) was also recorded. Some patients' final dispositions were unknown due to transfer from RRWC to other wildlife rehabilitators. Patients transferred to other rehabilitators were removed from survival analyses. Records were collected from 1 July 2015 to 30 June 2016. Intake records were entered into Wildlife Rehabilitation MD (WRMD.org), a free online medical database designed specifically for wildlife rehabilitators to collect, manage and analyze data.

All patients admitted for known or suspected cat or dog attacks were treated with antibiotics and, in many cases, pain medication. Only patients known to be attacked by a cat or dog (through rescuer observation) were used in analyses. Therapies differed between species and injury severity. In some cases, the decision was made by the wildlife rehabilitator

to euthanize an animal upon admission. Probability of release and humane rehabilitation decisions were made using standards set forth by the National Wildlife Rehabilitators Association (NWRA) (Miller 2000).

All patients were categorized by intake type as cat attack, dog attack (attacks and nest disturbances), impact (with buildings, vehicles, lawn mowers, etc.), removal (purposeful taking of the animal including wildlife kidnapping and 'pest' control), orphans, entrapment (stuck in buildings, drains, on glue traps, etc.), secondary cat effects (mother chased away, siblings killed, etc.), injuries and illnesses of unknown origin (suspected rabies, squirrel pox, spinal traumas, fractures, etc.) other (imprinted animals, surrendered 'pets', etc.), and unknown causes of rescue. Only patients with known disposition were included in the analyses. Differences in survival by intake type and months that cat attack and dog attack patients were admitted were analyzed using chi–square contingency analysis. Months were combined in pairs to avoid zeros for statistical analysis. Cat attack intake survival was compared directly with other intakes and with dog attacks using Fisher exact tests. Analyses were completed using GraphPad Prism 6.0 and P–values less than 0.05 were considered statistically significant.

Locations of rescue for dog attack, cat attack and secondary cat effect wildlife were compiled in Excel and used in a geographic information system (GIS) address locator (ESRI 2011, ArcGIS Desktop). Some locations could not be determined due to limited information (given voluntarily) by the rescuer of the patient. Some duplicate locations exist due to multiple attacks occurring on one or more occasions. Maps were created using base layers from the Pennsylvania Spatial Data Access (PASDA). Topologically Integrated Geographic Encoding and Referencing (TIGER) geodatabases and information from the 2010 United States census provided urban area classifications. Urban areas were defined as locations that had population levels of 50,000 or more individuals. Information from PASDA also provided probable and confirmed breeding locations for all birds in the state, including endangered and threatened species. Only species that had the possibility of being prey to both cats and dogs as defined by previous literature were examined.

Results

Patient Survival. Over the course of the year–long study, RRWC admitted 1,668 patients. Of these patients, 6.12 percent were admitted as cat–attacked patients (CAP, 102 total). An additional 25 patients, for a total percentage of 7.61 percent, were admitted as secondary (cat) effect patients (SEP). 102 animals, 6.12 percent, were admitted as dog–attack patients (DAP). Disposition was known for 96 CAP, all 25 SEP, and 91 DAP. Comparing all intake types, survival rate differed significantly across all groups for all species admitted (Figure 1; χ^2_9=118.3, P<0.0001). Entrapped patients had the highest survival rate (72.7percent) and patients admitted for other illnesses and injuries of unknown origin had the lowest survival rate (17.1 percent). CAP had a survival rate lower than DAP with only 18.8 percent surviving while 30.2 percent of DAP survived. SEP had a survival rate of 40.0 percent, similar to all other intake types. Survival of CAP varied significantly in comparison to all other possible prey species admitted for any other reason (1008) (P=0.0005). Species similar to those attacked by cats survived to release 36.1 percent of the time, twice as often as CAP (Odds Ratio=2.449).

Impacted Species. CAP consisted of ten avian species (22 patients) and six mammalian species (80 patients), including one rabies vector species (RVS) (Table 1). None of the 22 avian CAP survived. 24 percent of all mammal CAP survived. The most numerous species, the eastern cottontail, with 62 CAP, had a lower–than–average survival rate of 17.74 percent. Eastern cottontails that were DAP had a survival rate (35.62 percent) twice as high as eastern cottontails that were CAP (P=0.0501). Survival rate of eastern cottontails admitted for any reason was 34.94 percent.

Species of DAP were less diverse. Nine DAP were admitted from four avian species and 93 DAP were admitted from six mammalian species, including two RVS. CAP and DAP had several species in common: American robin (*Turdus migratorius*), eastern cottontail, eastern gray squirrel (*Sciurus carolinenis*), and Virginia opossum (*Didelphis viginiana*). Similar to CAP, 0 percent of DAP that were avian species survived. Mammalian survival rate for DAP was 33.33 percent. For DAP, eastern gray squirrels had a lower than average survival rate with only one of the nine admitted surviving to release (11.11 percent). When comparing eastern gray squirrels, the survival rate was four times higher in CAP (44.44 percent) than DAP. Eastern gray squirrels had a survival rate of 45.69 percent across all intakes.

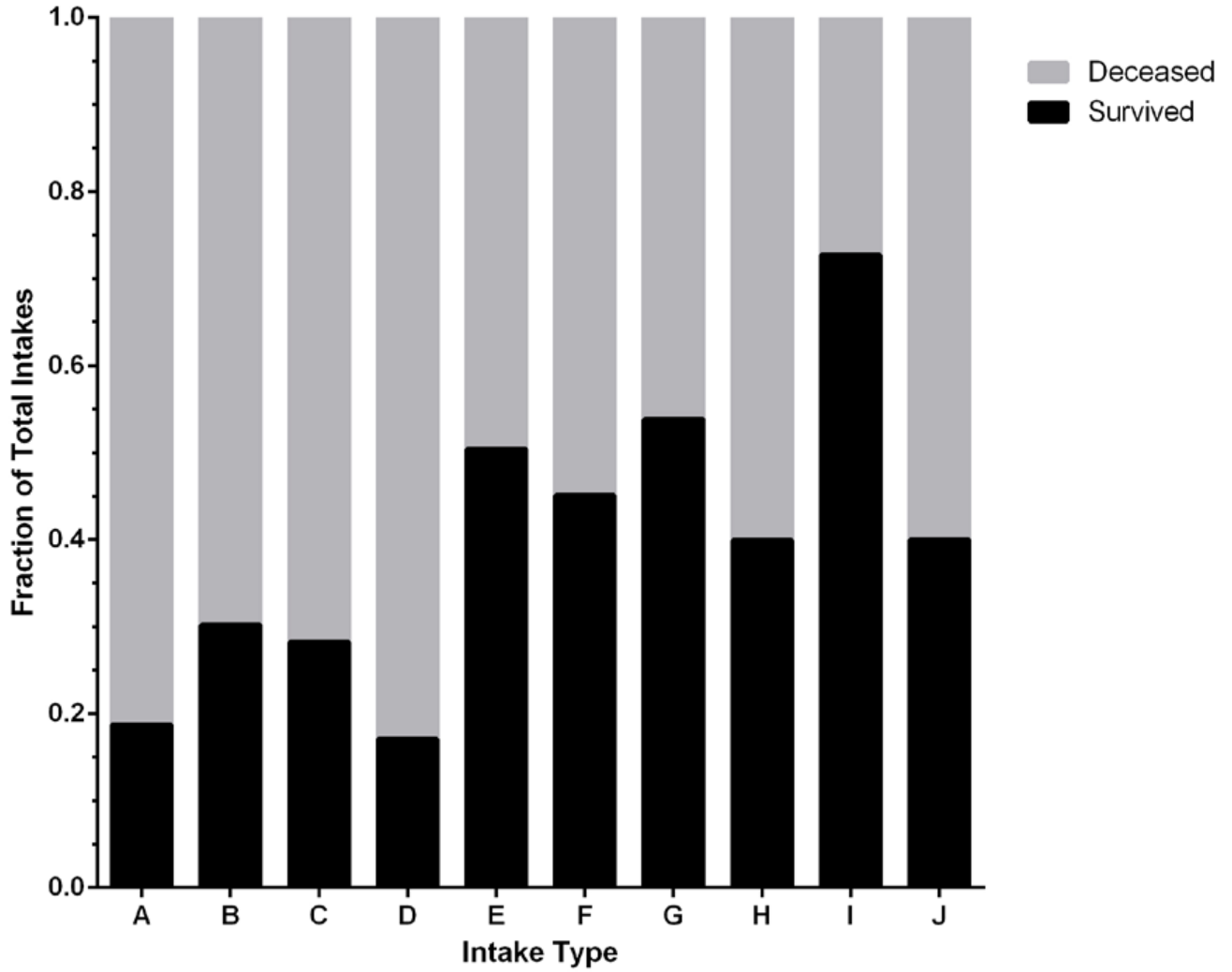

Figure 1. Fraction of total intakes that survived to be released for all different intake types from 1 July 2015 through 30 June 2016 at Raven Ridge Wildlife Center in Washington Boro, PA. A–cat attacks (n=96), B–dog attacks (n=91), C–impact/collisions (n=163), D–other injuries and illnesses (n=205), E–removal/kidnapping (n=232), F–orphans (n=286), G–other (n=39), H–unknown (n=223), I–entrapment (n=55), and J–secondary cat effects (n=25). Patients who had an unknown survival were not analyzed. Survival depended significantly on the group (χ^2_9=118.3, P<0.0001) using a χ^2 contingency analysis.

Intake Season. The percentage of CAP and SEP admitted varied significantly among each two–month interval (Figure 2; χ^2_5=116.7, P<0.0001). Most CAP were admitted between May and June (40.94 percent). From March through August, 91.33 percent of CAP and SEP were admitted in only half of the study time. DAP also varied significantly with each interval (χ^2_5=67.65, P<0.0001). Similar to CAP, the month interval with the highest intake was May and June (34.31percent). In the same March through August six–month interval, 89.21 percent of DAP were admitted. Across all intake types, 36.87 percent of patients were admitted in May or June and 84.2 percent of all patients were admitted from March through August.

Rescue Location. Of the 127 CAP and SEP patients admitted, exact addresses were determined for 105. Admissions came from Adams, Berks, Chester, Cumberland, Dauphin, Franklin, Lancaster, Perry, and York counties in Pennsylvania. Rescue locations were up to 65 miles away from the wildlife rehabilitation center while others came from within the same township as RRWC. 64.76 percent of intakes came from within Lancaster County. An additional 18.10 percent of CAP and SEP came from within York County. Of the 105 patients, 77.14 percent came from urban areas. In addition, 12 intakes came from within one mile of an urban area (suburban). Rural areas further than one mile from urban locations accounted for 11.43 percent of all CAP and SEP. 97 of the 102

Table 1. Species Admitted as CAP and DAP with Survival.

	CAP	DAP	CAP % Survival*	DAP % Survival*
Avian Species	23	9	0	0
American Robin	4	1	0	0
Blue Jay	—	1	—	0
Carolina Wren	—	6	—	0
Common Grackle	2	—	0	—
Common Starling	1	—	0	—
Eastern Screech-owl	1	—	—	—
Gray Catbird	3	—	0	—
House Finch	1	—	0	—
House Sparrow	3	—	0	—
Mourning Dove	4	—	0	—
Northern Cardinal	2	—	0	—
Red-eyed Vireo	1	—	0	—
Wood Duck	—	1	—	0
Mammalian Species	80	93	24	33.33
Big Brown Bat	3	-	33.33	—
Eastern Cottontail	62	78	17.74	35.62
Eastern Chipmunk	3	—	0	—
Eastern Gray Squirrel	9	9	44.44	11.11
Red Fox	—	1	—	—
Virginia Opossum	1	3	—	33.33
Southern Flying Squirrel	2	—	100	—
Striped Skunk	—	1	—	0
Woodchuck	—	1	—	100
* Only patients with known survival are included				

DAP had exact addresses of attack known. Admissions came from Chester, Cumberland, Dauphin, Lancaster, Lebanon, and York counties. 56 percent of DAP admissions came from within Lancaster County and 30 percent from York County. Only 3.1 percent of DAP came from rural areas, and an additional 5.15 percent from suburban areas, with 91.75 percent of DAP from urban areas.

Four endangered bird species were found to have probable or confirmed breeding locations near cat and dog attack locations from a survey with the Pennsylvania Game Commission: loggerhead shrike (*Lanius ludovicianus*), sedge wren (*Cistothorus platensis*), dickcissel (*Spiza americana*), and upland sandpiper (*Bartramia longicauda*). One of the sedge wren and dickcissel breeding locations is within one mile of known cat attack locations. The same two locations are also within five miles of dog attack locations.

Discussion

The goal of this study was to evaluate how Pennsylvania's wildlife is being affected by domestic cats and dogs by studying those animals admitted for wildlife rehabilitation. Several species of wild animals in south central Pennsylvania are impacted in various ways by both domestic species.

Patient Survival. As hypothesized, patients attacked by cats or dogs had a lower survival rate than most other patients. The authors found survival rates of CAP lower than those of other wildlife rehabilitation centers. An eleven–year study at the Wildlife Center of Virginia (WCV) concluded an average release rate of 24.2 percent between small mammals and birds with 14.8 percent of mammals and 13.7 percent of birds being admitted as CAP (McRuer et al 2016). Although our recorded survival rate is lower than previously reported rates from other centers, RRWC had fewer patients admitted due to cat attacks and therefore a smaller sample size. When comparing CAP survival rate to all other potential prey species admitted for other reasons, the significant impact of cat attacks on patient survival, a rate half that of other prey species, is evident.

DAP were admitted with the same frequency as CAP which was surprising due to the high population of outdoor and at–large cats. This similarity is likely due to the nature of rehabilitation in that people are required to find the animals in order for them to be admitted. Dogs are often within eyesight of their owners who are able to accurately report that a dog attack occurred and quickly bring wild patients in for treatment. DAP had a higher survival rate than CAP. This may be for a variety of reasons, including the previously mentioned visibility of dogs by their owners. Cat owners often report their pets bringing animals home and even finding them the next morning. It is often unknown how long an animal has been injured and may have already become infected. SEP had a very

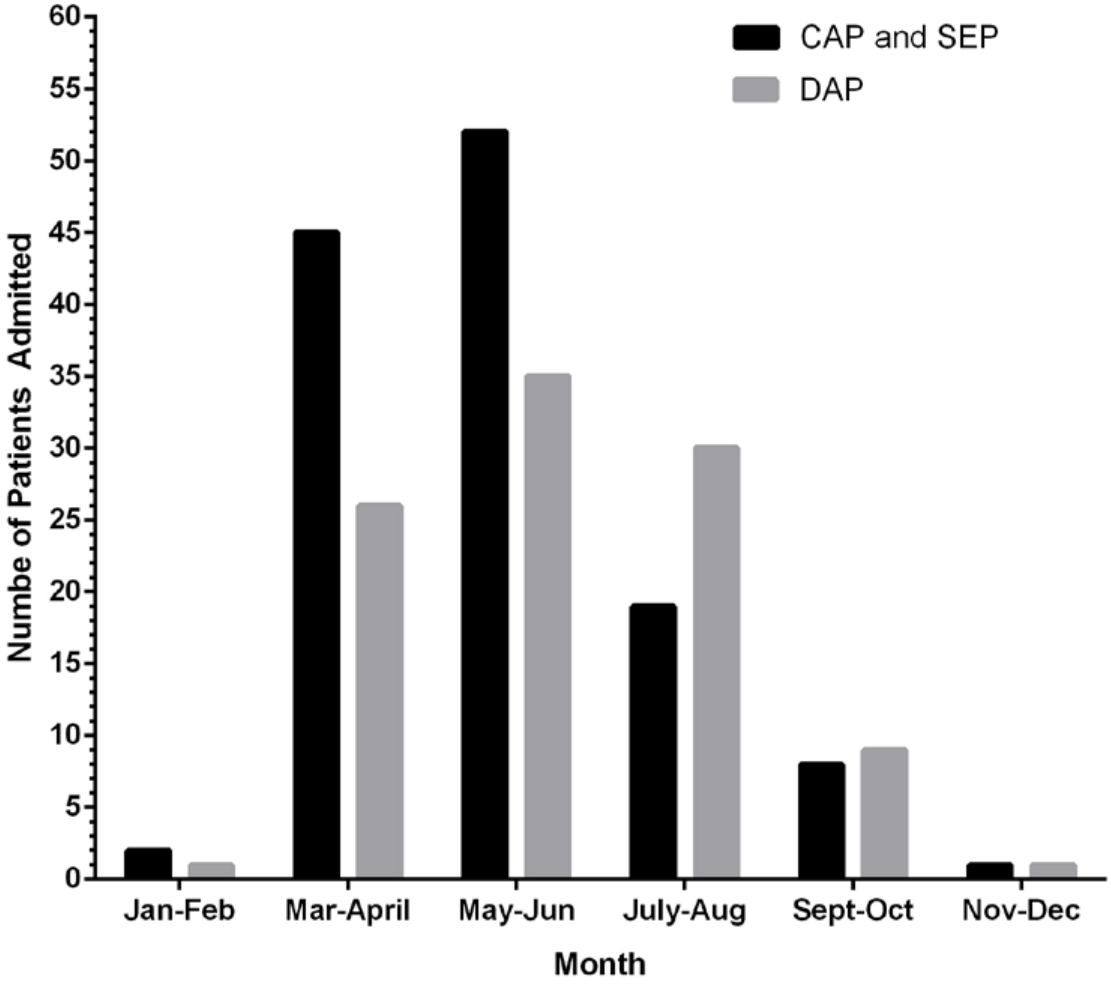

Figure 2. Number of cat attacks and secondary effect patients (n=127) and dog attacked patients (n=102) for each two–month period for 1 July 2015 through 30 June 2016 at Raven Ridge Wildlife Center in Washington Boro, PA. Months were combined to avoid zeros. Amount of cat related intakes (χ^2_5=116.7, P<0.0001) and dog related intakes (χ^2_5=67.65, P<0.0001) depended significantly with a χ^2 contingency analysis on each two–month interval.

similar survival rate to that for all other intakes. This was expected since these patients were not exposed to the cat's physical damage or pathogens.

Impacted Species. The patient species from RRWC were less diverse than the eleven–year study at WCV where 21 mammal and 62 avian species were admitted as CAP (McRuer et al 2016). Some similarities in frequency of intake within species was observed. At the WCV, mourning doves *(Zenaida macroura)* and American robins accounted for half of their CAP intakes (McRuer et al 2016). These two species were also the most common at RRWC, accounting for nearly 35 percent of avian CAP intakes. However, there were some differences in the RRWC mammal intakes. Eastern cottontails accounted for 77.5 percent of all mammal CAP intakes at RRWC. Eastern cottontails were the second most common CAP at WCV at 26.1 percent (McRuer et al 2016). Knowing the relative abundance of these native species in the two areas may explain the differences in CAP since cats are opportunistic predators.

Eastern cottontails, which were the only species with a comparable sample size for cat and dog intake types, had a survival rate more than twice as high when admitted as a DAP than a CAP. When admitted for any other reason, eastern cottontails had a similar survival rate as DAP. Based on additional information provided by rescuers, dogs often attack eastern cottontail nests and are quickly caught by their owners. Deceased infants are not often brought by the rescuer to rehabilitation and the remaining members of the nest may only suffer superficial wounds and saliva contact if the dog is stopped quickly enough. Cat–attacked eastern cottontails often sustain internal injuries from puncture wounds by the cats' teeth and

are brought into rehabilitation even though their prognosis may be bleak. Another similarity observed between CAP and DAP is 100 percent mortality rate of avian species, however, the sample size was much lower than admitted mammals.

During the year–long study, five interactions were recorded between cats or dogs and rabies vector species (RVS), which included woodchucks, raccoons, skunks, foxes, coyotes, and bats in Pennsylvania. Three CAP were big brown bats (*Eptesicus fuscus*). In addition, one woodchuck (*Marmota monax*) and red fox (*Vulpes vulpes*) were DAP. These interactions put the dog and cat at risk of being exposed to rabies. 75 percent of rabies cases in PA in 2012 were from raccoons, skunks, and cats that all congregate near cat colony feeding operations, continuing to put themselves and humans at risk (Robinson 2016). Rescuers have the right to demand RRWC euthanize a RVS and have it tested for rabies if they feel that their pet or family were exposed to rabies at any time during the attack and rescue.

Intake Season. Most CAP and DAP were admitted during breeding season, which supported the hypothesis and complemented previous research. WCV admitted 88 percent of mammal and 85 percent of bird CAP from April through September (McRuer et al 2016). George (1974) found 79.7 percent of prey in southern Illinois was captured by cats in March through August.

Overlapping breeding seasons for many species may indicate that cats and dogs have more accessible prey during these months. Video surveys of cats found that 56 percent of their prey weighed less than 5g and an additional 45 percent of prey was between 6g to100g (Loyd et al 2013). These weights coincide with the small weights of many newborn or juvenile mammals and birds as well as many adult rodents and birds. WCV found that 74 percent of their mammal CAP were juveniles or neonates (McRuer et al 2016). Many mammal species, including eastern cottontails, nest directly on the ground and adults spend little time with their young, leaving them vulnerable prey for cats and dogs. Conversely for avian species, WCV found that 42.7 percent were adults and 37.2 percent were juveniles (McRuer et al 2016), potentially due to the inaccessibility of nestlings high in trees. Adults often come to the ground to forage and fledglings of many species spend a large amount of time on the ground, making them easy targets. Adults are more active and there are more juveniles during this time of year which makes more prey available. There is little competition from native predators for adult birds (Dauphine and Cooper 2009).

Rescue Location. Nearly all CAP and DAP at RRWC came from urban or suburban areas as hypothesized. In Virginia, the number of different species interacting with cats is similar in rural and urban areas while small birds were more likely to come in contact with cats in rural areas. No differences in interaction locations were seen in mammals (McRuer et al 2016). As natural areas decrease, urban areas increase in importance to biodiversity and potential habitat for many species (Loyd et al 2013). We expected the majority of rescues to occur in these locations for several reasons. In urban areas, cats are the most abundant carnivore (Ancillotto et al 2013). More landowners with pets means a greater density of cats and dogs with greater total predatory effect within urban areas (Lepczyk et al 2003). Feral cats rely on greater densities of humans as their primary food source. Urban areas have a reported 3.43 cats/ha while 1.19 cats/ha are reported in rural areas, with very similar predation rates per cat in both areas (Lepczyk et al 2003). Additionally, rehabilitators rely on the public to find injured wildlife and bring it in for rehabilitation. In rural areas with fewer people there may be injured wildlife, but it may not be found and brought in for treatment. We found that several cat and dog related incidents were located within close proximity to important bird breeding areas. With many of the breeding areas located within rural areas, discovery of cat–attacked birds in these areas is unlikely.

Limitations. Studying the effects of dogs and cats on wildlife by looking at animals admitted to wildlife rehabilitation centers has some limitations. Wildlife rehabilitators do not receive a complete count of wildlife affected by cats or dogs. With only half of captured wildlife escaping cat attacks alive, wildlife rehabilitators would see at most 50 percent of those animals effected (Kays and DeWan 2004). A previous study recorded that 49 percent of cat prey is left at the capture site, 28 percent is eaten, and only 23 percent is brought home (Loyd et al 2013). Relying on the public to bring wildlife to a rehabilitation center means that wildlife left at a capture site may not be found and eaten prey is not taken into consideration in wildlife rehabilitation.

Rescuers tend to have a bias against nonnative and 'nuisance' wildlife (McRuer et al 2016). Although many observational studies of cat attacks suggest that mouse–like animals are a large part of prey captured, these species were not admitted at all during the course of this study. RRWC also did not have any reptiles or amphibians admitted as CAP or DAP. Rescuers may be reluctant to seek help for uncharismatic species.

Our study also fails to capture the impacts of feral cats on wildlife. Although not directly measured in this study, most rescuers reported that attacks were caused by pet cats. Feral cats do not interact with humans as often and therefore rescuers and rehabilitators rarely see these victims. Studies, such as ours, focusing on patients at wildlife rehabilitation centers allow for an overview of species, potential hotspots, and impacts of cats and dogs on wildlife after events. These studies are not meant to collect the total number of incidences between pets and wildlife.

Education and Implications. In addition to rehabilitation and release of wildlife, education of the public is an important goal for most wildlife rehabilitation centers. Education helps to prevent thousands of kidnappings and conflicts between people and Pennsylvania wildlife each year. This research can inform wildlife biologists and educators to help mediate the impacts of cats and dogs on wildlife. If pet owners restricted the time of year in which their pet is allowed outdoors unsupervised, many wildlife conflicts could be prevented. Owners should be extra vigilant during the spring and summer as their yard may be home to newborn eastern cottontails or fledgling birds. When possible, cats should be kept indoors or in enclosed patios and dogs on leashes so that humans have the control to prevent these conflicts. Rehabilitators and educators should also suggest restricting time of day. Birds are most active in the early morning, two hours before dawn (Hodge 1996). The same is true for nursing eastern cottontails tending their nests which could potentially draw the unwanted attention of cats and dogs (Gode and Ruth 2010).

Beyond limiting situations where domestic species can interact with wildlife species, native predators also play an important role. Native predator (e.g., coyotes) abundance decreases cat abundance and increases bird diversity (Crooks and Soulé 1999). Rehabilitators should educate the public on the importance of these secondary and tertiary predators and the benefits they can provide by excluding cats. Education can help eliminate some of the public misperceptions and fear of native beneficial animals.

Future Research and Recommendations. Quantitative studies of abundance and locations of feral cats in Pennsylvania would be extremely beneficial. Currently the scope of the problem is not completely clear which makes decision making challenging for resource managers and conservation biologists. Interactions between native carnivores, dogs, and cats also needs to be explored in Pennsylvania. With the high transmission rate of disease between the species, investigating modes of transmission, what species are at risk, and if TNR feeding stations are indicators of risk to wildlife would be valuable for the state. In addition, the possibility of exclusion of cats with the support of native tertiary or secondary predators should be explored.

With the large scale of this problem, the authors' recommendations are to start in areas of high conservation concern. If biologists are able to exclude domestic animals from areas with important native species, we will likely see an increase in abundance as well as diversity in those areas. Previous research indicates that eradication and exclusion of cats is possible in island scenarios which could be applied to conservation hotspots (Robinson and Copson 2014). Additionally, long–term studies after the eradication of other invasive mammalian predators (like the Norway rat) show that native breeding populations of birds can increase by over 20 percent each year after removal (Le Corre et al 2015).

Conclusion

An analysis of intakes from RRWC over the course of one year shows clear evidence of negative impacts of domestic cats and dogs on native wildlife. The hypothesis addressed in this study reveals some of the ways native wildlife are affected. 1) CAP and DAP had lower survival rates than other patients even with intervention by wildlife rehabilitation professionals. Public education to prevent these attacks should be prioritized over increasing rehabilitation interventions. 2) SEP had survival rates similar to RRWC patients admitted for reasons other than cat or dog attacks. This indicates that it is direct injuries from cat and dog attacks that contribute to low survival rate, not the stress of capture and rehabilitation. However, it should be noted that these patients, including orphans, may have lower survival rates in the wild without wildlife rehabilitation intervention. 3) An increase in the number of CAP and DAP seen during breeding seasons correlates to the increase in juvenile animal abundance and increased activity by adult wildlife. Particularly for Pennsylvania's threatened and endangered species, this time is critical for wildlife populations and increased prevention measures should be taken by cat and dog owners. 4) A higher number of CAP and DAP admitted from urban areas correlates with higher numbers of their human caretakers. More research is needed to reveal the full scope on the effects of domestic dogs and cats on native wildlife individuals and populations.

Prevention must be a priority. With low survival rates, even with medical intervention, the best chance for the victims of dog and cat attack is to prevent it from happening. Using an estimate of $33 per patient (Heckly 1998), domestic dogs and cats cost RRWC $7,557.00 in one year. By educating just one person that their cat should not roam outdoors many wildlife attacks can be prevented, potentially reducing the negative population impact for threatened and endangered species. It is imperative that wildlife rehabilitators, educators, and biologists educate members of the public about the true costs of allowing domestic cats and dogs outdoors unsupervised.

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