Spring 2015

The Effects of Urbanization on Fear in Wildlife

Sarah Spier
University of Nebraska-Lincoln

Joseph J. Fontaine
University of Nebraska-Lincoln, jfontaine2@unl.edu

Disclaimer: The following thesis was produced in the Environmental Studies Program as a student senior capstone project.

The Effects of Urbanization on Fear in Wildlife

By:
Sarah Spier and Joseph J. Fontaine

AN UNDERGRADUATE THESIS

Presented to the faculty of:
The Environmental Studies Program at the University of Nebraska-Lincoln
In Partial Fulfillment of Requirements
For the Degree of Bachelor of Science

Major: Environmental Studies and Fisheries and Wildlife

Under the Supervision of TJ Fontaine

Lincoln, Nebraska

May, 2015

Abstract

Through this study we sought out to determine if Fox Squirrels in Lincoln, Nebraska exhibited a change in response to aerial versus terrestrial predators in urban areas. We addressed the possible consequences that human disturbance has on daily stimuli, predator behaviors, and, in turn, prey behaviors. Specifically, the experiment exposed Fox Squirrels to the vocalizations and visual models of an aerial predator, terrestrial predator, and a control species. Squirrels did not show a significant change in behavior between predator types. However, fox squirrels displayed correct anti-predator behaviors by only responding to the predators and not the control. The time it took to respond, length of response, and flee distance were not distinguishable by predator type.

Introduction:

Urbanization, the expansion of urban areas onto rural land, is an issue faced by wildlife managers, city planners, and environmentalists. Currently, over five percent of United States land area is made up of urbanized land, and by 2030, it is predicted that sixty percent of the human population will live in urban areas (Lowry et al, 2012; McKinney 2002). Urban expansion is responsible for some of the most significant local extinction rates as it has the ability to greatly alter habitat as land continues to be transformed by anthropogenic structures, roadways, energy use, and activity.

Habitat alteration generally forces animal populations to move outside of the urban landscape and find habitat better suited for their needs, but some animals are capable of adaptation and remain in urban areas (Lowry et al, 2012). For the animals that reside in urban areas, human disturbance has the potential to alter many aspects of animal behavior due to the changes imposed on habitat (Theobald et al, 2004; Frid et al, 2002). Indeed, the method in which animals forage, interact with humans, reproduce, and even reaction to predators can be altered when species are exposed to high human disturbance (Marvier et al, 2004; Lowry et al, 2012; Salsbury, 2004; Frid et al, 2002).

Given the ever increasing urbanization rate coupled with the changes that urbanization can induce, it is becoming increasingly necessary to understand how urban environments alter animal behaviors, particularly as it pertains to important trade-offs which influence survival. Behavior modifications may occur that can vary from a slight alterations in diet to wholesale changes in natural history (Lowry et, al., 2012; Bowers & Breland 1996; Shultz & Finlayson, 2010) sometimes resulting in the development of completely new behaviors that rural populations do not express in order to thrive in rapidly changing human environments (Lowry et, al., 2012). For

example, urbanization clearly alters predator communities as many larger predatory species are excluded from urban environments (Koproski, 2005; Crooks & Soule, 1999; Roth, 2003), while many other predator species occur at higher densities (Crooks and Soule, 1999). Humans companion animals and household pets can also act as totally novel predator communities for native fauna (Chace & Walsh, 2006; Pickett et. al., 2008). Given the importance of predators in shaping prey behavior (Shultz & Finlayson, 2010; Solomon, 1949), it is not unreasonable to expect urban prey populations to behave very differently than their rural counterparts.

Moreover, human interaction itself has the ability to alter the anti-predator response of animals by affecting what prey species recognize as a risk (Etter et al, 2002). High encounter rates with people and subsequently habituation to the human environment has led many urban species to not respond to anthropogenic disturbance unless the disturbance is especially large or loud, or the threat is imminent (Frid et al., 2002).

A reduction in risk aversion presumably has fitness benefits in an urban environment as individuals that correctly fail to respond to a non-threat (i.e., a person walking by) waste less time and energy displaying unnecessary behaviors (i.e., fleeing). However, a lack of responsiveness by prey may have consequences if prey are incapable of differentiating between non-threating perceived predators and real predators. Prey species clearly have evolved the capacity to differentiate among predator types (i.e., aerial versus terrestrial or ambush versus stalk-and-chase; Caro, 2005; Sherman, 1985) as specific anti-predator responses are often necessary to avoid different modes of predation (Caro, 2005; Sherman, 1985). Fleeing up a tree, for example, may be an appropriate anti-predator response to a terrestrial predator, but may put an individual at greater risk to aerial depredation.

Through this study I intend to address the implications of the urban lifestyle by measuring a suite of behavioral reactions to predation risk in urban areas. If there are behavioral changes, the costs of the urban environment may have significant fitness consequences if urban animals are less responsive to specific types of predators. Through exposure to the urban environment, prey can become less aware of signs of predation such as calls, or predator movements, and they may choose to expend less energy avoiding predation in order to conserve it for other activities.

There are many differences in the behavior of wildlife between urban and rural areas, and it is increasingly apparent that anti-predator responses are included in these changes. However, further understanding surrounding responses to different types of predators is needed. In urban areas, predation occurs at both the terrestrial or aerial level. Terrestrial predators hunt from the ground and tend to use techniques such as hiding, chasing, and pouncing, while aerial predators take prey from the sky using techniques including scanning while soaring, watching prey from a tree, and dive-bombing prey from the sky. Humans tend to have a disproportionate affect in the terrestrial level of urban environments, therefore it is not surprising that aerial predators tend to be more adaptable to urban environments (Roth, 2003; Chace & Walsh, 2006) Terrestrial predators tend to be less abundant and more strongly affected by fragmentation, leading to a rise of mesopredators—predators at lower trophic levels with a diet that allows more habitat flexibility (Crooks & Soule, 1999).

Another environmental factor introduced by humans is pets. Pets such as domestic cats are wide spread in urban environments and often interact with wildlife (Chace & Walsh, 2006; Pickett et, al., 2008). The presence of pets may cause prey to be more responsive to terrestrial predators due to the frequency of attacks made by pets. Alternatively, prey species may be less responsive to the presence of pets because pets are often restrained. For example, if a prey species is exposed to dogs that are always on leashes, they may begin to perceive dogs as less of a threat (Pickett et, al., 2008).

Given the multitude of changes in the predator community, as well as the potential for habituation to reduce anti-predator responses the extent to which prey will alter their behaviors, particularly in response to different predator types is difficult to ascertain. However, assuming that the response of prey to people is indicative of a larger suite of anti-predator responses, I predicted that the effects of human activity on prey animals is causing them to become less responsive to terrestrial predators than aerial predators due to the many disturbances that occur without negative effects on the prey. Additionally, mammalian predators are negatively affected by fragmentation, reducing the threat imposed by actual predators, and allowing the density of prey populations to increase in fragmented areas (Koprowski, 2005).

Here I explored how urbanization alters anti-predator responses and the subsequent trade-offs between safety from predators and access to food resources. Specifically, I exposed fox squirrels (*Sciurus niger)* to models of two predator types: aerial (Red-tailed Hawk, *Buteo jamaicensis*) and terrestrial (Coyote, *Canis letrans*), and observed the subsequent anti-predator responses to ask the question: Does the urban environment cause a change in response to aerial versus terrestrial predators?

Methods:

Predator Model and Study Species

Fox squirrels are an ideal species for exploring the impacts of urbanization on anti-predator responses. As a common species in urban areas, fox squirrels are comfortable with the disturbances of an anthropogenic setting (McCleery et, al., 2009). In squirrels, urban populations have a lower giving-up density when foraging, which is the lower limit of food density in which they will dismiss efforts to forage (Bowers et al., 1996). This means they spend more energy obtaining food, and potentially less energy expended toward anti-predator behaviors. Urban fox squirrels allow humans to come within closer proximity than rural squirrels will allow (McCleery, 2009). The choice in response and boldness fox squirrels have toward humans indicates that at least to some degree they have lost some of their innate anti-predator response.

To represent predator species at the aerial and terrestrial level, I chose to use a model red-tailed hawk and a model coyote as the predator representatives. The Red-tailed Hawk's diet consists of birds, reptiles, and small mammals, including fox squirrels. Most raptors prefer to hunt in open areas, but their large home range size allows them to venture into urban areas as well (Roth, 2003; Chace & Walsh, 2006). Red-tailed hawks are relatively insensitive to urbanization and are known to do well in developed environments. Nesting is even favored in developed areas as urban environments provide sufficient amounts of food and artificial nest sites are very suitable for hawks (Chace & Walsh, 2006). Coyotes, while found in urban areas, tend to remain less

active in well-developed areas. In fact, in many urban areas Coyote species are less prominent, giving way to heightened success of mesopredators (Crooks & Soule, 1999).

Treatment:

The treatment chosen for this study was done on free-ranging Fox Squirrels in urban areas such as parks, yards, and the University of Nebraska campus in Lincoln, Nebraska, USA. The squirrels were presented with either type of predator model or a control, and their responses were recorded. One to three days before implementation, simple feeding stations were created by laying down piles of corn at least 100 meters apart. Once the points of interest were established and feeding by squirrels was verified, testing began. The experimental procedure involved exposing feeding squirrels to a perceived predation event to test whether squirrels in urban environments expressed alternative anti-predator responses to each predator type.

For the aerial predation test, the red-tailed hawk model was placed on top of a post with a speaker below. For the terrestrial experiment a coyote model was placed on the ground with a speaker hidden near it, and the control model turkey was placed similarly. The model and the call were covered by a camouflage tarp with the observers sitting in a blind 3-5 meters behind the predator to allow the observer to pull off the camouflage cover. Once in place the observer allowed the subject squirrel to return to normal foraging activity. Once normal activity was observed, the following behaviors were recorded: vicinity to cover, freezes, scanning, alert calls, fleeing, lying down, intraspecific reactions, and attempts to hide. The different reaction behaviors were recorded at three different stages in the experiment.

The first stage preceded exposure to any model to measure baseline activity. The second stage occurred once the model and call were initiated. At this point, the time it took for the squirrel to react to stimuli and the type of reaction that occurs will be recorded. Finally, after the reaction had ceased and squirrels return to normal behavior (behaviors expressed prior to treatment), the model was retrieved and the trial ended. The experiment was repeated at different urban settings and during various times of the year to assess the overall impacts of urbanization on squirrel behavior.

Results:

Time until Response

Of the 35 trials conducted, 17 produced a response. Of the turkey trials, 0 out of 8 squirrels responded to the visual model and vocalizations; 7 out of 14 Coyote trials and 10 out of the 13 hawk trials had a response. In order to quantify a lack of response, a five minute cap was put on observation. The 18 trials that did not lead to a response were quantified at a five minute (300 second) response time.

There was no significant evidence of a difference between hawk and coyote response. However, the hawk and coyote responses were significantly different from the turkey. The responses to the coyote were very binomial with an instant response if the distance to the model predator was less than twenty meters. The coyote only hindered one response over the twenty meter mark. The hawk model produced a variety of response times that were under one minute unless there was no response.

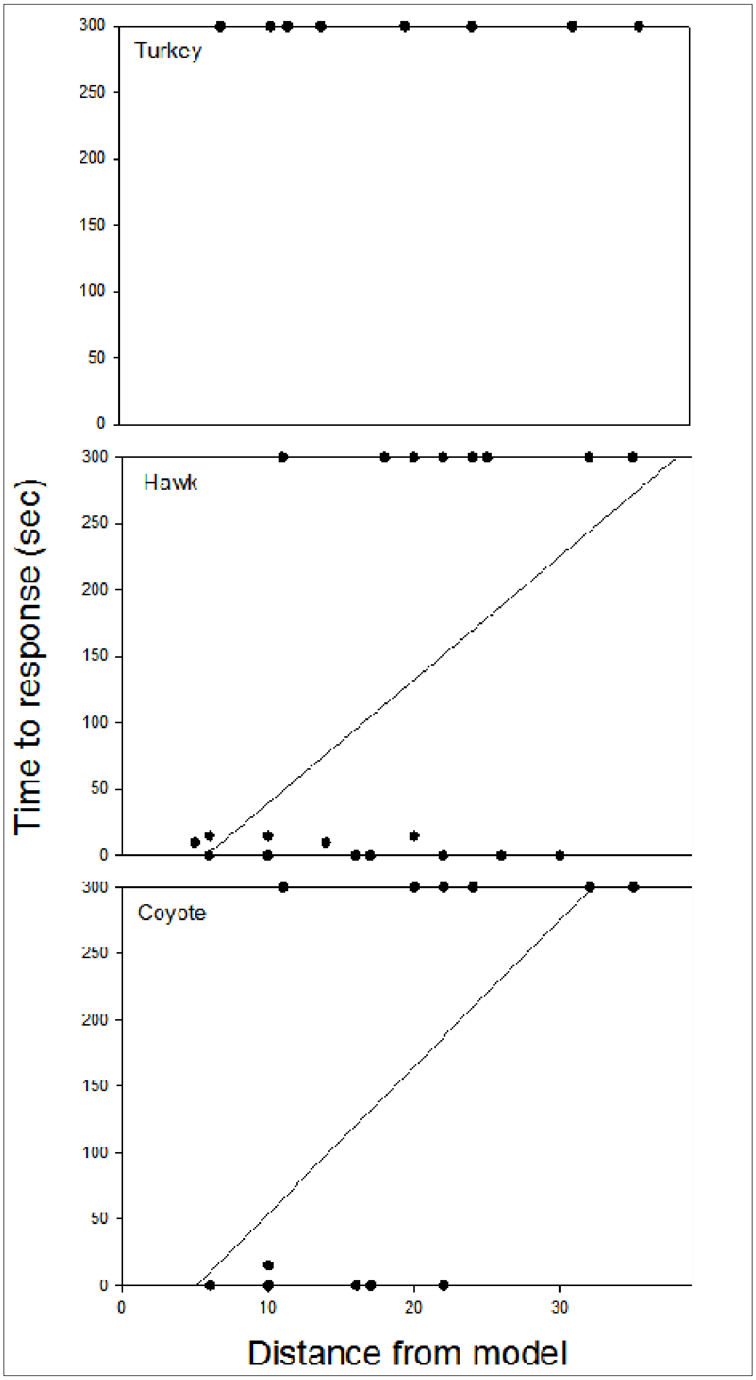

Figure 1: correlation of time until response to distance predator model was from individual.

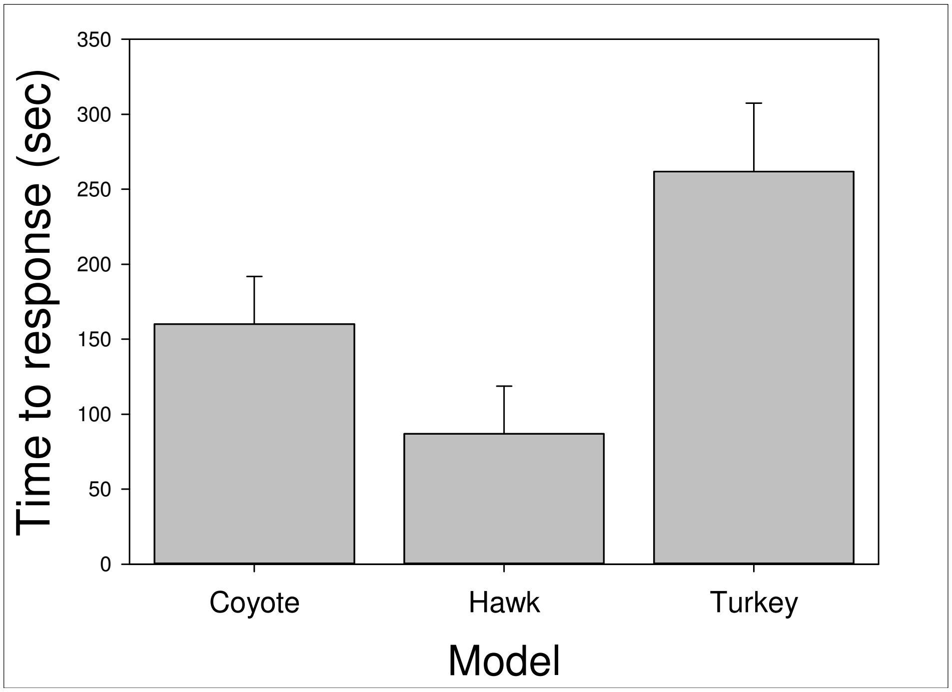

Figure 2: The data analysis concluded no significant difference between the Hawk and Coyote models. However, there was a significant difference between the Hawk and Turkey and the Coyote and Turkey.

Tests of Between-Subjects Effects for Time Until Response

Dependent Variable: Time Until Response

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	379622.803[a]	4	94905.701	7.339	.000
Intercept	74.468	1	74.468	.006	.940
Distance from Predator	122045.129	1	122045.129	9.438	.004
Distance from Cover	10798.532	1	10798.532	.835	.368
Model	125973.254	2	62986.627	4.871	.015
Error	387931.483	30	12931.049		
Total	1620875.000	35			
Corrected Total	767554.286	34			

a. R Squared = .495 (Adjusted R Squared = .427)

Flee Distance

The turkey model was not included in flee distance results as it did not generate a response. The flee distance was not significantly different for the two predator models (hawk and coyote). Therefore, there was no effect of the model. However, distance from the model did have an effect. If the predator was closer, the squirrel would flee further; if the predator was at a greater distance from the squirrel, its flee distance would not be as far.

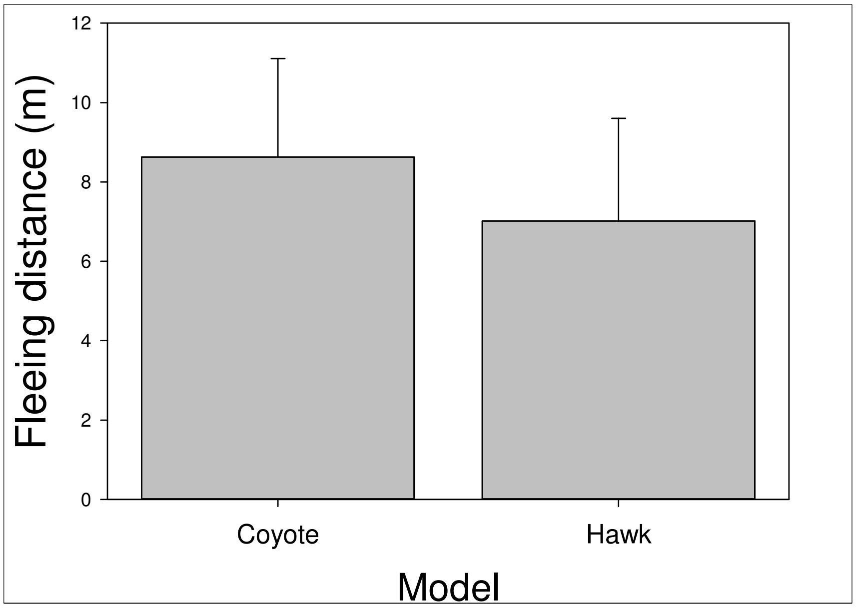

Figure 3: non-significant difference in flee distance for hawk and coyote

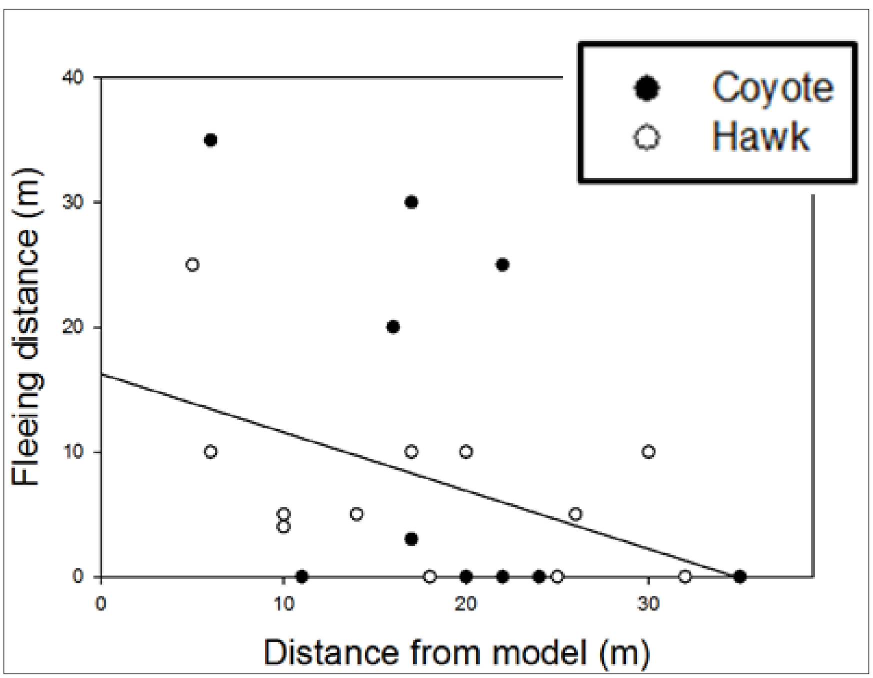

Figure 4: Flee distance decreased as the distance from the predator increased. Squirrels would flee further if the model was closer.

Tests of Between-Subjects Effects for Flee Distance					
Dependent Variable: Distance of Flee (m)					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	733.418[a]	3	244.473	2.881	.058
Intercept	1405.877	1	1405.877	16.565	.000
Distance from Predator	654.063	1	654.063	7.707	.011
Distance from Cover	277.569	1	277.569	3.271	.084
Model	16.767	1	16.767	.198	.661
Error	1951.990	23	84.869		
Total	4350.000	27			
Corrected Total	2685.407	26			
a. R Squared = .273 (Adjusted R Squared = .178)					

Time to Normal Behavior (Length of Response)

The time until normal behavior measured the time it took for the squirrel to return the behaviors preformed during pre-treatment. The turkey was not included, as it did not generate a response. The responses to the coyote and hawk were not significantly different. There was a relationship between the length of the response and the distance to cover. The greater the distance was to cover, the longer the response would be.

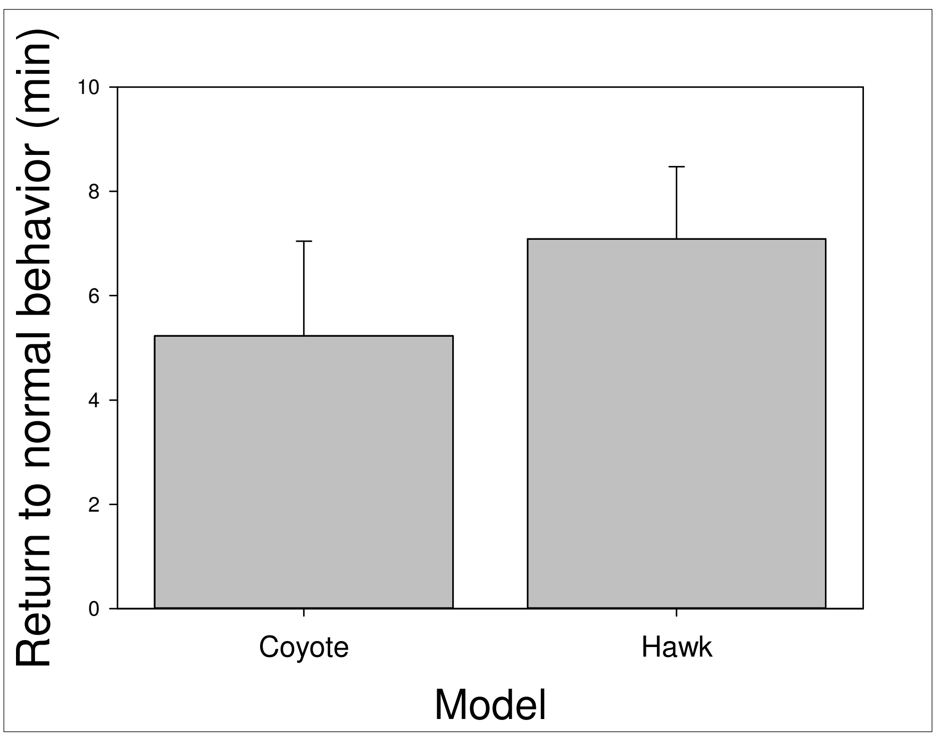

Figure 5: Time to return to normal behavior was not significantly different for the hawk and coyote models.

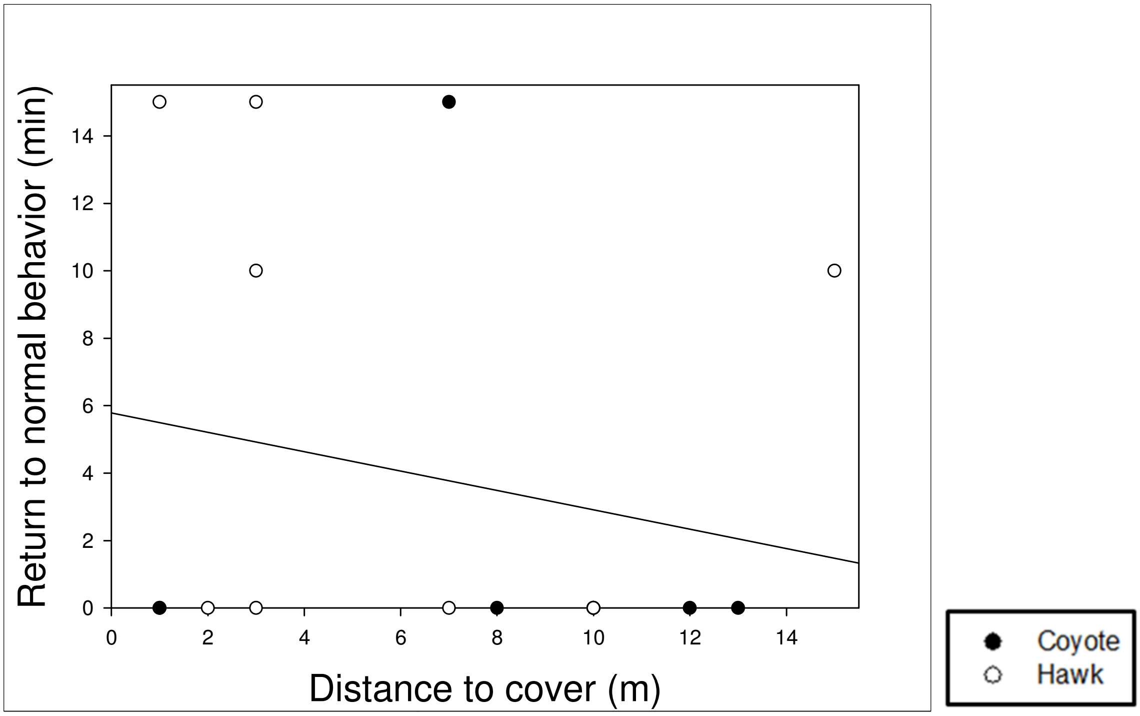

Figure 6: A greater distance to cover increased the time it took for squirrels to return to normal behavior.

Tests of Between-Subjects Effects					
Dependent Variable: Time to Normal Behavior (min)					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	91.399[a]	3	30.466	1.670	.226
Intercept	202.878	1	202.878	11.118	.006
Distance from Predator	13.703	1	13.703	.751	.403
Distance from Cover	91.378	1	91.378	5.008	.045
Model	11.346	1	11.346	.622	.446
Error	218.972	12	18.248		
Total	963.813	16			
Corrected Total	310.371	15			
a. R Squared = .294 (Adjusted R Squared = .118)					

Discussion:

The data does not support any significant change in overall anti-predator response between the two predator types. However, there was a difference in response between the predator models (red-tailed hawk and coyote) and the control model (turkey) (See figures 1 and 2). The turkey model never evoked a response, while the squirrels responded strongly to the coyote and red-tailed hawk. This implies that squirrels are retaining their ability to correctly respond to stimuli by performing antipredator behaviors in response to predator models, and avoiding energy expenditure by not responding to non-threatening species.

Time to Response:
Squirrels responded to the red-tailed hawk and coyote, but not the turkey (See figures 1 and 2), indicating that antipredator response continues to persist in urban populations. However, while there was a significant overall effect of predator type, there were not significant differences in response time among the two predator models. Due to the lack of significant change in response between the two predator types, I was unable to provide any clear evidence that predator type affects the time it takes for squirrels to respond to threat stimuli.

Flee Distance:
There was no significant difference in response between aerial and terrestrial models for flee distance as well (See figure 3). Due to the fact that the turkey never inhibited a response, the turkey model data was not included for comparison. Similar to the pattern we found with response time, the distance a squirrel ran after the model was presented was significantly affected by the proximity to the potential predator (See figure 4), suggesting that there is a certain buffer zone in which squirrels sense they are safe from the predation threat.

Time to Normal Behavior (Length of Response):
Once again there was no effect of the model on the length of the response (See figure 5), and the turkey was not included in data analysis due to lack of response. One interesting find was that the time it took for the squirrels to return to normal behavior did reflect their distance from cover prior to the onset of the treatment (See figure 6). If squirrels were a relatively short distance from cover, they would return to their initial area and behavior relatively quickly. Alternatively, if the squirrels had to travel a further distance to reach cover, their anti-predator response would be prolonged.

Previous research has found a relationship between flight initiation distance (the distance from a predator that causes a prey species to initially flee) and distance to cover exists in grey squirrels (Dill and Houtman, 1989). In other words, if a squirrel's distance from cover is increased, the vicinity in which a predation threat can be displayed without flee will decrease. Additionally, our data suggests that squirrels are also responding for an increasing amount of time reflecting an increasing distance to cover.

Conclusion:

Through this study I was unable to find significant evidence of any major difference in response to aerial versus terrestrial predators. However, some small trends were observed and a larger data set may confirm some ways in which responses are being altered. It is known that other species in the family *Sciuridae*, the family fox squirrels fall under, recognize the difference between terrestrial and aerial predators in rural areas, which hinders different responses to each predator type (Sherman, 1985), but variation in time to response and extent of response was not significant in this study. It may be valuable for a study to be conducted that looks at the specific qualitative behaviors performed in response to a predator, which may generate results showing significant differences that are not being shown in a quantitative study. An increase in trials may reveal significance in some quantitative trends as well.

References:

Bowers M.A., Breland B. (1996) Foraging of gray squirrels on an urban-rural gradient: use of the GUD to assess anthropogenic impact. Ecol Appl 6:1135–1142.

Caro, T. (2005). Conspecific Warning Signals. In Antipredator defenses in birds and mammals (pp. 205-211). Chicago, Illinois: University of Chicago Press.

Chace, J., & Walsh, J. (2006). Urban Effects On Native Avifauna: A Review. Landscape and Urban Planning, 74(1), 46-69

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

Dill, L., & Houtman, R. (1989). The influence of distance to refuge on flight initiation distance in the gray squirrel. Canadian Journal of Zoology, 67(1), 233-235.

Etter, D. R., Hollis, K. M., Van Deelen, T. R., Ludwig, D. R., Chelsvig, J. E., Anchor, C. L., et al. (2002). Survival and Movements of White-Tailed Deer in Suburban Chicago, Illinois. The Journal of Wildlife Management, 66(2), 500-510.

Frid, A. & Dill, L. M. (2002). Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6, 1–16

Koprowski, John L. "The response of tree squirrels to fragmentation: a review and synthesis." Animal Conservation 8.4 (2005): 369-376. Print.

Lowry, H., Lill, A., & Wong, B. B. (2012). Behavioural responses of wildlife to urban environments. Biological Reviews, 88, 537-549.

Marvier, M., Kareiva, P., & Neubert, M. G. (2004). Habitat Destruction, Fragmentation, and Disturbance Promote Invasion by Habitat Generalists in a Multispecies Metapopulation. Risk Analysis, 24(4), 869-878.

McCleery, R. A. (2009). Changes in fox squirrel anti-predator behaviors across the urban–rural gradient. Landscape Ecology, 24, 483–493.

McCleery R. A., Lopez RR, Silvy N.J., Gallant D.L. (2008) Fox squirrel survival in urban and rural environments. J Wildl Manag 72:133–137.

McKinney, M. (2002). Urbanization, Biodiversity, And Conservation. BioScience, 52(10), 883-883.

Pickett, S., Cadenasso, M., Grove, J., Nilon, C., Pouyat, R., Zipperer, W., & Costanza, R. (2008). Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas. In Urban Ecology (pp. 99-122). Springer.

Roth II, T. (2003). Hunting Behavior and Diet of Cooper's Hawk: An Urban View of the Small-Bird-In-Winter Paradigm. The Condor, 117(1), 474-483. Retrieved March 18, 2015.

Rutz C. 2006. Home range size, habitat use, activity patterns and hunting behaviour of urban-breeding Northern Goshawks Accipiter gentilis. Ardea 94(2): 185–202.

Salsbury, C. M., Dolan, R. W., & Pentzer, E. B. (2004). The Distribution of Fox Squirrel (Sciurus niger) Leaf Nests within Forest Fragments in Central Indiana. American

Solomon, M. (1949). The Natural Control of Animal Populations. The Journal of Animal Ecology, 18(1).

Sherman, P. (1985). Alarm Calls Of Belding's Ground Squirrels To Aerial Predators: Nepotism Or Self-preservation? Behavioral Ecology and Sociobiology, 17(4), 313-323.

Shultz, S., & Finlayson, L. (2010). Large body and small brain and group sizes are associated with predator preferences for mammalian prey. Behavioral Ecology, 21(5), 1073-1079.

Theobald, David M., Miller James R., and Hobbs N. Thompson. "Estimating the cumulative effects of development on wildlife habitat." Landscape and Urban Planning 39 (1997): 25-36. Print.