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HOW URBANIZATION EFFECT GRAY SQUIRREL BEHAVIOR?

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Urbanization and its effect on the Foraging behavior of Gray Squirrels

James L. Harris III

I would like to thanks, everyone who has allowed is to be at this point today: Chris Meyers and Dr. Nancy Solomon for assisting me with my focus in animal behavior. Diane B. Harris and James L. Harris Jr for believing in me as well.

Outline

- **TimeLine**
    - **Late September- early October**
        - Fall semester research
    - **Late November- mid-December**
        - Fall-Winter data observation
    - **Early February- Mid-February**
        - Winter Research
    - **Mid-February-Late February/ Late February-Early March**
        - Winter-Spring Observation
- **Report**
    - Introduction

- Background Information
  - Basic information on Gray Squirrels and their distant cousins.
    - Gray squirrel vs Fox Squirrel
    - Body Parts and functions
  - Habitat range
  - Seasonal activities
    - Foraging in the spring and Winter times, when their natural food supply is the highest.
    - Winter and Summer time, they are out less frequently
      - Extreme and infrequent temperature change
      - Low food supply
  - Diet
    - Seeds, nuts preferred
    - Insects
    - Eggs
    - Other Squirrels (cannibalism)
  - Social behavior

- Fluid society
    - Male> Female
    - Old> Young
- Mating
    - December-January
    - May-June
    - Males will chase and try to mount the females.
    - Female will accept/reject males
- Aggression
    - Dominant male will chase away subordinate male
    - Tail bent and wagging associated with dominance
    - Dominate warns subordinate male by tail wagging.
    - Females will chase away other females
- Predation
    - Red-tailed hawks
    - Feral/Domestic Cats and dogs

- Gray foxes
- Coyotes
- Tail wagging and squawk call alert group of potential predators.

- Urbanization
  - Squirrels make home in older houses
  - Will consume unnatural and/ or Artificial foods
  - Become less alert to humans and more alert towards domesticated pets such as dogs and cats.
  - More approachable to humans.

- **Methodology**
- **Results**
  - Foraging behavior
    - Fall vs Winter vs Fall-winter vs Winter-spring
    - Town vs Forest Area vs Natural area vs built area vs Mixed campus areas
    -
  - Unnatural Behavior

        - Fall vs Winter vs Fall-winter vs Winter-spring
        - Town vs Forest Area vs Natural area vs built area vs Mixed campus areas
    - Alert
        - Town vs Forest vs Natural vs Built vs Mixed campus.
        - Fall vs Winter vs Fall-winter vs Winter-spring
    - Factors
        - Predator's Present
        - Predator Absent
        - Temperature (Fahrenheit) <50
        - Temperature (Fahrenheit) >50
        - Human density
            - High
            - Med
            - Low
- Discussion

- Explain results
- Was Hypothesis supported or Rejected and why
- Future studies

Abstract

In this experiment, I determined if urbanization affecting the foraging behavior in eastern gray squirrels? Do these behaviors become less or more frequent with the different season? The purpose of this experiment is to see how urban development and urban sprawl is affecting that behavior, not just in terms of foraging but in terms of diet as well. My hypothesis is that location and weather effects the behavior of the focal animal. To answer this question, I observed the squirrels in five areas Town (T) Built Area (BA) Mixed campus area (MCA) Natural Area (NA) and Forested Area (FA). For three days, a week for three weeks. In each area, I observed five squirrels for two to two and a half minutes each and recorded how long (in seconds) they performed certain types of behavior. To ensure this is done randomly, I walked 10- 15 ft. away from the previously observed squirrel and recorded the next squirrel I saw (determining the sex was be attempted, however, due to the specific time this observation were taken place and

the fact that the observed squirrels was neither trapped nor handled, this was impossible). I also wanted to record possible factor that may inhibit one behavior over the other such as the presence of a predator, the current weather condition, temperature, human density and time (although squirrels are the most active a few hours after the sunrise and few hours before the sunsets). There will be figures for the following: There was a table comparing the foraging, alert and unnatural behaviors which contained four observed seasons to see any changes in behavior. The purpose of this was to indicate if season change plays a factor in the change in behavior. This process will be done three days a week for three weeks per season. Any uncontrolled factors such as the presence of the predator or temperature was taken into consideration when observing the data, I will compare the result of the fall season, fall-winter season, winter season and winter-spring season to determine if seasonality plays a factor in the behavioral differences of the gray squirrel or is it based solely on the type of environment they live in. In this experiment, it was discovered that neither area nor seasons greatly alter the behavior of the squirrels in the study also none of the figures were statically significant ($p<0.05$). Many factors could've contributed to these findings such as a large variety in squirrel behavior as well as tree availability seem to help vary the both the duration and frequency of behavior. To avoid, this experiment could have some experimental restriction such as only going down to two areas or enclosing the test subject to determine the behavior of and lower the possible p-value.

Introduction

As the human population began to increase due to advances in modern medicine and technology, they require space to build homes for their ever-growing population. Due to this, many animals will be forced to move out of their natural habitat and food resources. This is the reason why biodiversity near urbanization decreases. However, not all animals die due to urbanization, some not only survive but thrive in the new man-made habitat. Raccoons take full advantages of the new environment even making use of the garbage and waste as potential food and Kit foxes instead of settling into shrubs within their natural habitat, they will utilize urban areas as a potential habitat for nest and homes. (Gehrt D. Stanley et. al 2010). In large cities, pavement ants can be seen eating a large variety of food even outside of urban habitat which consists of insects, grain, and honey. In urban habitats, they can become attracted to processed and artificial food from the high sugar and grease content within our food (Klotz John, et al. 2008). Some animals do much better in urbanization.

The eastern gray squirrel (*Sciurus carolinensis*) is possibly the most well-adapted species to urbanization next to raccoons and opossums (Robiou, 2008). Being able to make their dreyes or nest in almost any location. Many gray squirrels in urban areas could thrive thanks to an abundance of space such as abandoned homes and electric poles to build these dreyes in. Gray squirrels are also able to survive due to the introduction of new food resources provided by humans, allowing the population to thrive even more in

an urban environment than rural areas. (Nilon and Parker, 2008). These resources also gave the squirrels an easier food access causing them to no longer need their natural resources as their main food source. But is this factor strong enough to sway the gray squirrel completely away from their natural resources in an urban environment? In Blair et. al (2012), the researchers observed the biodiversity of mammalian species in a different area within and near Oxford, Ohio. In their experiment, they labeled the areas based on how natural, rural or urbanized these locations were using an urban gradient. What they discovered was that in moderately urbanized areas, gray squirrels were the most abundant but were found in neither extreme natural areas nor extremely urbanized areas. This experiment is relevant to my experiment for two reasons: First, the urban gradient will be used in my research as well as some of the areas for the gradient (this excludes Hueston Woods as this will be replaced with the hiking trail behind Peabody Hall). The second reason is to determine where the gray squirrel roams within a specific part of my study area. There have been other studies where they have used different states such as Nilon and Parker's experiment on squirrel aggression and density in park location (2008). Even though their method for measuring squirrels' density is crucial, my research will remain within Oxford Ohio.

In my experiment, I observed the gray squirrel to determine if urbanization is affecting their behavior? This was answered by observing how often the gray squirrel performs certain behaviors in both an urban and natural environment. My hypothesis is that urbanization does play a role in gray squirrel behavior. My prediction is that in more

urbanized areas, squirrels will spend less time performing foraging behavior and more time on unnatural behavior such as garbage foraging. My second prediction is that gray squirrels will be more likely to perform unnatural behavior during the winter observation more than any other observation. Researching this hypothesis is essential because gray squirrels are one of the main animals to assist the tree in seed dispersal. If the gray squirrels aren't foraging and dispersing the seeds, then the trees are at risk of inbreeding (breeding with someone closely related to that individual) and parent- child competition where the seedling plants grow too close to the parent plant and they end up competing for resources (Steele and Koprowski, 2001).

Background

History and Biology

The eastern gray squirrel is part of the family Scruidae. This family consist of tree squirrels, ground squirrels, flying squirrels and chipmunks. Members of this family can live in a variety of locations from the desert to the rainforest. The eastern gray squirrel lives within the eastern parts of North America and has adapted extremely well to the developing country. Throughout the history of America, the eastern gray squirrel (more specifically tree squirrels) have always lived and thrived in the United States. However, it wasn't until the industrial revolution that the gray squirrel population started to emerge in

cities and suburban areas. This was done to the fact that at this given time, gray squirrels were considered more of a tolerable pest more than other common species, such as many wolves and coyotes. By the early twentieth century, these small rodents were found in almost all rural and urban areas. Gray squirrels share some similarities with other tree squirrels such as the fox squirrels (*Sciurus niger*), however, there are some key characteristics between the two species; gray squirrels are more darkly colored with a white underbelly and smaller than fox squirrels while fox squirrels are much larger and come in either red or orange. Although both species are omnivores, the gray squirrel tends to keep a herbivorous diet consisting more of walnuts and oak acorns. Gray squirrel lives on average one year but there are records of them living to about a decade (Department of natural history, 1995). A gray squirrel can reach sexual maturity by about six to eight months for females and nine to eleven months for adult males. They normally mate from December to January and then again from May to June.

Since gray squirrels live a more herbivorous lifestyle, even if they are found in more urban areas, they will stay in areas that contain deciduous trees (such as walnuts and oaktrees). Even though in urbanized areas, they require these locations as they store the seeds of these trees as a food supplies during the months of winter when they are less active (Steele 2001). This would explain why in Blair and crew's. experiment where they took a census of the mammalian biodiversity in Oxford, Ohio. They only found gray squirrels in the recreational areas and the residential areas. These areas have at least one

deciduous tree present in each area of this type compared to the business district and the apartment complexes, which might not even have these type of trees (2012).

Habitat

As mentioned before, gray squirrels can live in any location, so long as their deciduous tree source is available. However, gray squirrels seems to prefer more dense area and a lot of tree cover more than the fox squirrels which might explain why gray squirrel might thrive better in urban areas than fox squirrels (Steele & Koprowski,2001), although both species can live together in their natural habitat. Squirrels don't just use these trees for a food source, but they also use them as a natural home source.

Tree squirrel uses the tree as a perfect home spot to take care of their young and a place to stay warm during the harsh winter months. Squirrels live in dreys, a small hollow substance made mostly out of dead leaf litter, but can also be made from sticks and dirt.

Diet

Although gray squirrels are mostly herbivorous, they can adapt to an omnivorous food supply when their favorite foods, acorns, and nuts are in scarcity. In general, their diet consists mostly of nuts and acorns, however, they are capable of consuming insects, bird eggs, baby birds and other squirrels (there hasn't been much study on this feeding so one possible explanation may be sexual competition). During the fall, they spend most of their time foraging for seeds, nuts, and acorns. They don't eat all the seeds that they

forage, they will bury or cache their food near specific areas so that it may find it later when the winter comes. As they go to a dormant state, they are less active and conserving their energy. If they feel as though they are being watched by another squirrel who might steal their cache, they will move their food to a secondary cache site to avoid looting by other squirrels.

In Parker and crew's study, the foraging activity of Gray squirrel during the fall and summer season during the years of 2003 and 2004, they discovered that foraging time is spent more in the fall time than it is in the summertime when the mast is starting to diminish (2014). This helped me to create my methods for two reasons. 1) As they didn't perform the experiment/observation during the spring, winter or the months in-between so it would help me determine if this behavior were to change between the fall, winter, spring and in-between seasons of the observation. 2) It had also assisted me in creating a baseline for my own observation. As they observed the squirrel, they made a calculation (in percentage) of the certain behavior of individual squirrels. It appears the gray squirrel is selectively picking their foods with the highest nutritional value (Steele 2001) as they are preparing for the winter and the months where food will be scarce. During those months, they will have to rely on their cache to supplement them through the winter months. However, in the spring, they will also perform this same foraging behavior as their cache will be depleted completely now.

Social Behavior

The gray squirrel lives in a fluid social group, meaning the size of the social group will change as individual will leave the group and create new groups. (One personal group of mine at Shriver consist of Olivia and her children). In this group, males are dominant by females within the area and adults are dominant over the juveniles within the group. In most cases, it consists of an adult dominant male that controls small acres of an area. When another subordinate male comes within contact of the dominant or bull male, the bull will chase the subordinate away from the area. This performance could last from a few seconds to a few minutes depending on how far the subordinate wants to go. This is called a chase, but it isn't the only form of the chase that squirrels perform.

If the gray squirrels that arrives at his territory is male, the male will start to wag his tail, to keep him away (Steele, 2001), if there is a female during mating season however, the male will try to mate with her by chasing her through the field and up and around the trees. Once caught, the female has a choice of either accepting the male or rejecting him by running away. The male will persist but eventually, will give up the chase if he wasn't successful at copulating.

Squirrel Tail Signaling

The gray squirrel's tail is an essential part of its body that is used for many functions of its life: It's used as thermoregulation to either heat-up or cool its body. In the cold, it will slide its tail above its head and back as it is used to warm the squirrel and in the summer, it will cool the squirrel off (Steele & Koprowski 2001). The tail is also used as an alarm for both predator and another squirrel. When a squirrel sees a predator, it will

run towards the nearest tree and viciously flick its tail and makes a cawing noise. These alarms the other squirrels to let them know that there is a predator present. They also use their tail to show an act of dominance.

In a recent study by Pardo and crew, they wanted to see if gray squirrels use their tails as a sign of dominance by determining the aggression of the dominant male based on the position of the subordinate's tail. What they discovered was that the dominant male would become more aggressive with the subordinates when they had their tail bent suggesting that, the position and bending of the tail signify dominance in the gray squirrel fluid population.

Urbanization

As mentioned before, as the human population comes closer and closer to the population of the gray squirrel, both species are forced to live together. However, the gray squirrel's high intelligence, omnivorous diet and strong adaptive traits have allowed them to thrive in this new environment. Likewise, urbanization has contributed to several behavioral changes to the gray squirrels dwelling in these urbanized habitats allowing them to adapt and become completely at home with the human population.

Urbanization and Foraging

The gray squirrels still needs to forage for the lean seasons, however, they seem to be increasing their choice of food as the supply of trees in urban areas are low. To meet their needs before the winter, they have resorted to eating artificial food and food created

or grown by man. In an experiment with Steele, they set corn pieces into a site with squirrels during the fall season and in the winter season. What they discovered by performing this experiment, was that the squirrels would only pick up or consume the corn near the winter months when their food supply was running low (2001). This experiment gave me the idea and concept that the squirrel won't eat artificial food or human-made/ human raised foods during the fall or spring season because their natural foods supplies used as winter reserves would be in high abundance now. However, during the winter (possibly near the end of the winter season) the squirrel will start to consume artificial or manmade food as their natural food ration start to diminish.

Urbanization and Habitat

It doesn't' sound surprising that squirrel can make a home anywhere even in the backyards of humans. Squirrel are capable of nesting in residential areas and have even built their dreys inside abandoned houses. (Balbang 2013) This is a strong advantage for this urban squirrel as they are more likely to avoid predation, raise their young and able to survive the cold than their rural squirrel. Likewise, mother squirrel's raising their young in an urban will have them grow to sexual maturity faster than those in the rural area, mostly likely from the abundance of the food supply in urban areas than within the rural areas as well as predation being low in these areas.

Urbanization and Alert Behavior

Living within a loud, packed environment, it could be concluded that gray squirrel would be habituated to being around people and their machinery. However, this isn't always the case. It seems that squirrels still perform their alert behaviors. In Cooper et al. experiment, they study if squirrels will perform an alert behavior when there is a human approaching, human running, human and dog approaching and human and dog running towards it. What they discovered was that more squirrels in the low human capacity performed an initial response (alert behavior) when the dog was a presence, but there was no change in the with a run response by the observer and the observer with the dog. In the area with high human capacity, however, more squirrel ran with the presence of the dog and the human but allowed a closer approach before sprinting towards a tree. (2008). This experiment helped me to understand that squirrel in areas with high human capacity will be more tolerant with my approach than the squirrel in the areas with little to no human contact. In Bateman and Fleming's finding, they discovered that the squirrel in urban areas in Manhattan could adapt and upgrade their flight response when humans' behavior changes from what they are used to.

James L. Harris III

Materials

- Video camera

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Methods



Five areas types within Oxford , Ohio were picked for the study. They have all been labeled as followed:

- · Forested area:
  - Hiking trail behind Peabody hall,
  - Hiking Trail near Level 27:
  - 75%-100% tree cover, no building
  - No human maintenance on lawns or field
- · Nature area:

- The Nature Theater near Peabody Hall,
- Formal Gardens:
- 50%-75% tree cover
- buildings with little to no human maintenance.

- · Mixed Campus area:
  - The Bishop Woods,
  - Near Upham hall and King's library;
  - 20%-50% tree cover, scattered buildings with moderate amounts of human maintenance.
- · Built area:
  - The Northern Quad (the location of all the sorority dorms),
  - West Quad
  - 10%-25% tree cover, buildings are spaced almost daily human maintenance.
- · Town:
  - Uptown, Oxford, Ohio
  - Shriver Student Center:

- 0%-10% tree cover, buildings are packed together with daily human maintenance.

Once in these areas, I chose 5 random squirrels in each area to record and observed their behavior by video recording for approximately 120 seconds to 150 seconds per squirrel (this same individual won't be deliberately studied every day). I kept at least 10 feet (about 3 meters) away from the focal animal until they are habituated or use to my presence. Each day, I spent approximately 15 to 30 minutes at each study area for three days a week from the weeks of September 20th - October 4th, 2016. To study how theses behavior varies by season, these steps will be repeated between November 22nd - December 12th, January 28th - February 17th and March 15th to April 1st.

Since gray squirrels are diurnal animals, meaning that they spend most of their time awake during the day, each day the experiment will begin between 6:00 a.m. and 8:00 a.m. and end between 4:00 p.m. and 8:00 p.m. (Although these times will vary by daylight savings time). During this period, I will observe the behavior of the squirrels in each area to determine the following:

1. Are the gray squirrels in each specific area performing foraging behavior?
2. · Are the squirrels more likely to perform other behavior besides foraging behavior?
3. Are they are foraging for unnatural food supplies?
4. How much do these behaviors vary by season?

As for the questions mentioned above, I will time how long each individual squirrel is performing each individual behavior, then I will average the duration of time (in seconds) spent and record the time on a table sheet. The behavior that will be observed are:

- **Foraging**



  - Running
  - Halt <3 seconds
  - Sampling food: eating food < 5 seconds





- Sniffing the ground and walking for only a few feet
    - Burying food
    - Occasional Halts

- · **Social behavior**





- Mating

- Chasing mate (regardless if they are successful or not)

- Grooming

- Dominate chasing subordinate

· **Consumption of food**



- Consuming food for >5 seconds

- **Arboreal**



  - Climbing trees
  - Dwelling in trees
  - Observing in the trees

- **Grooming (self)**



- Scratching
- Rubbing tail
- Licking

- **Resting**





- Remaining stationary for >10 seconds
- Laying down
- Falling asleep
- Thermoregulating the body: Tail erected upward or rested on its back

- **Alert**
    - Tail wagging
    - Cawing noises
    - Immediate halt > 3 seconds
    - Sprinting towards a tree
- · **Unnatural behavior**



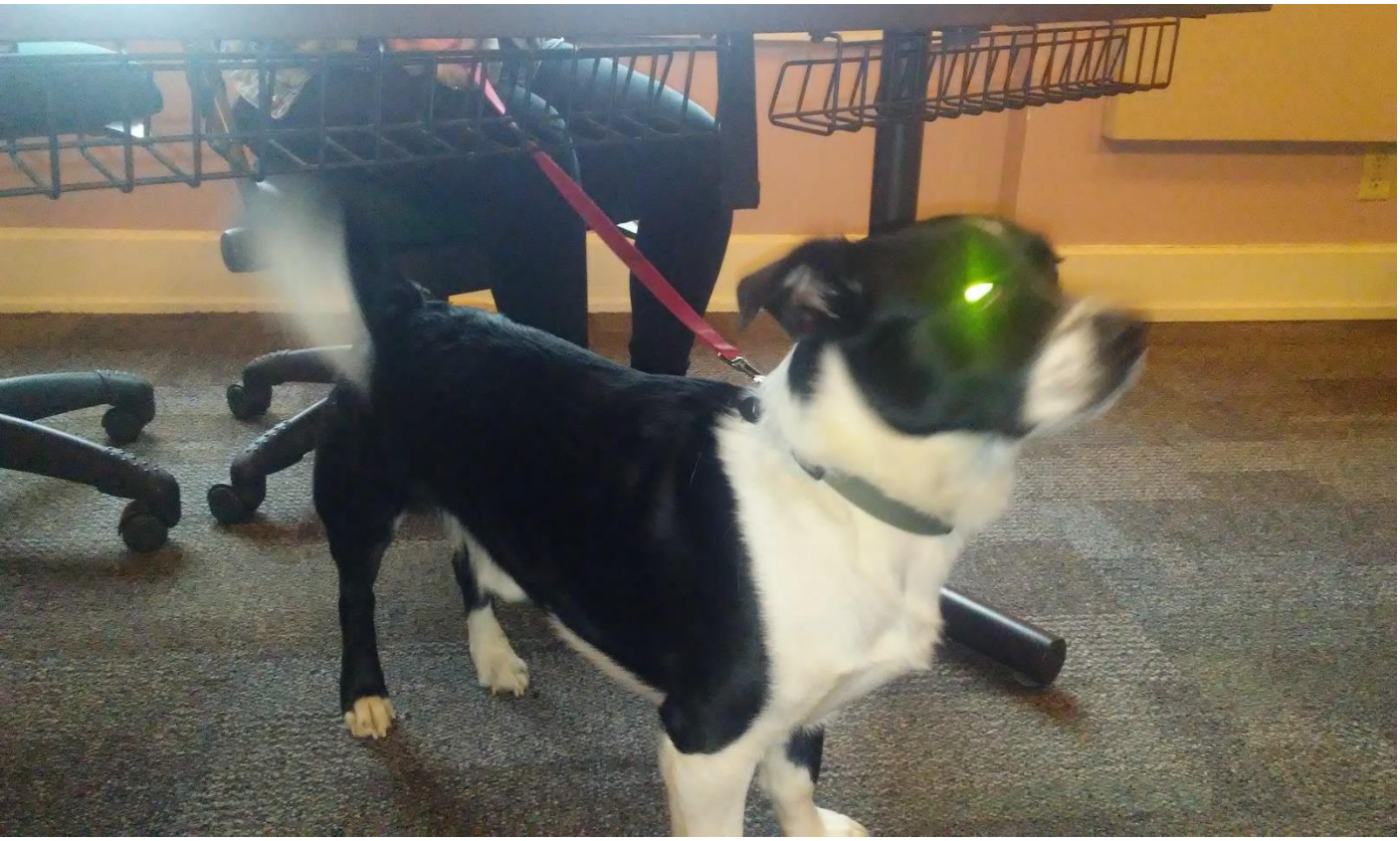
    - Garbage diving
    - Approaching human for food and/or lack of fear
    - Foraging near street without sprinting or performing alert behavior
    - Foraging near construction

- Foraging away from construction

The video recorder ensured that no behavior from an individual focal animal was missed during the duration of the experiment. Since behavior can be affected by various factors such as weather and predators, I also took note of:

- Weather conditions (rain, snow, cloud cover etc...) and temperature
- Predator(s) near observation site or within (red-tailed hawks)
- Any other species near the observation site (crows and other species of bird)
- The current time the squirrel was observed
- The human density at the current point of observation (e.g.: High, Med, low, None)
- Sex: If possible, the squirrel's sex will be marked as either, Male, Female or undeterminable (It may be hard to determine the sex of the young, juvenile and those high in the tree).





These factors were taken into consideration based on how they affected the data. For each area, the squirrels were numbered based on which area they were observed as well as in numerical order (knowing the individual isn't relevant for this experiment as the average time spent between the individual five squirrels performing each form of behavior is only relevant). They will also have the following abbreviations:

- NA= Natural areas,
- FA=Forest area,

- MC=Mixed Campus area,
- BA=Built Campus area,
- T=Town

For example, the first squirrel observed in a Built area will be labeled: BA1 on the observation notes while the third squirrel observed in the Nature area will be labeled: NA3.

Analysis

Near the end of the experiment, the amount of time that all five individuals performed each individual behavior was totaled. Then the average for the entire research time will be taken and recorded on bar graphs Once all the averages have been taken each average for each behavior will be converted to a bar graph.

Of the four different behaviors studied in this experiment, foraging, alert and unnatural were separated into three different bar graphs as well as the season in which they were observed. These bar graphs will compare the average time spent performing each behavior in the different study areas. variables such as the present/absent of predator, weather and human density time will be taken into consideration and will be discussed later.

The One -Way ANOVA was used to determine if my results were either statically significant meaning that my results were consistent or no significant, they were an event that happened by chance. This was determined by my results after One -Way ANOVA, if the results are less than the p-value ($p<0.05$). If yes, then the results of the study are significant, if not, however, then I must void the results as random.

Results

Figure 1 shows that during the time in the fall, the focal animal spent more time foraging in the "T" area than the forest area. MCA and BA area have about the same amount time spent on foraging. It seems foraging during the fall was greater in the more urbanized area. However, not all the error lines overlap indicating a possible variance. This data is statically significant as($p<0.05$). In figure 2 it shows that BA has the greatest amount of time being alert possibly because this area has a higher human density on average than the other areas. However, when we enter the data from Fall-Winter observation, it shows that the T areas had the overall longest duration for the behavior. However, the data is not statically significant ($p>0.05$). In figure 3, the unnatural behavior almost never occurred during the Fall observation but was the highest during the Spring observation for all sights. This data is statically significant ($p<0.05$). the "T" in all seasonal observation has the shortest time spent performing unnatural behavior while

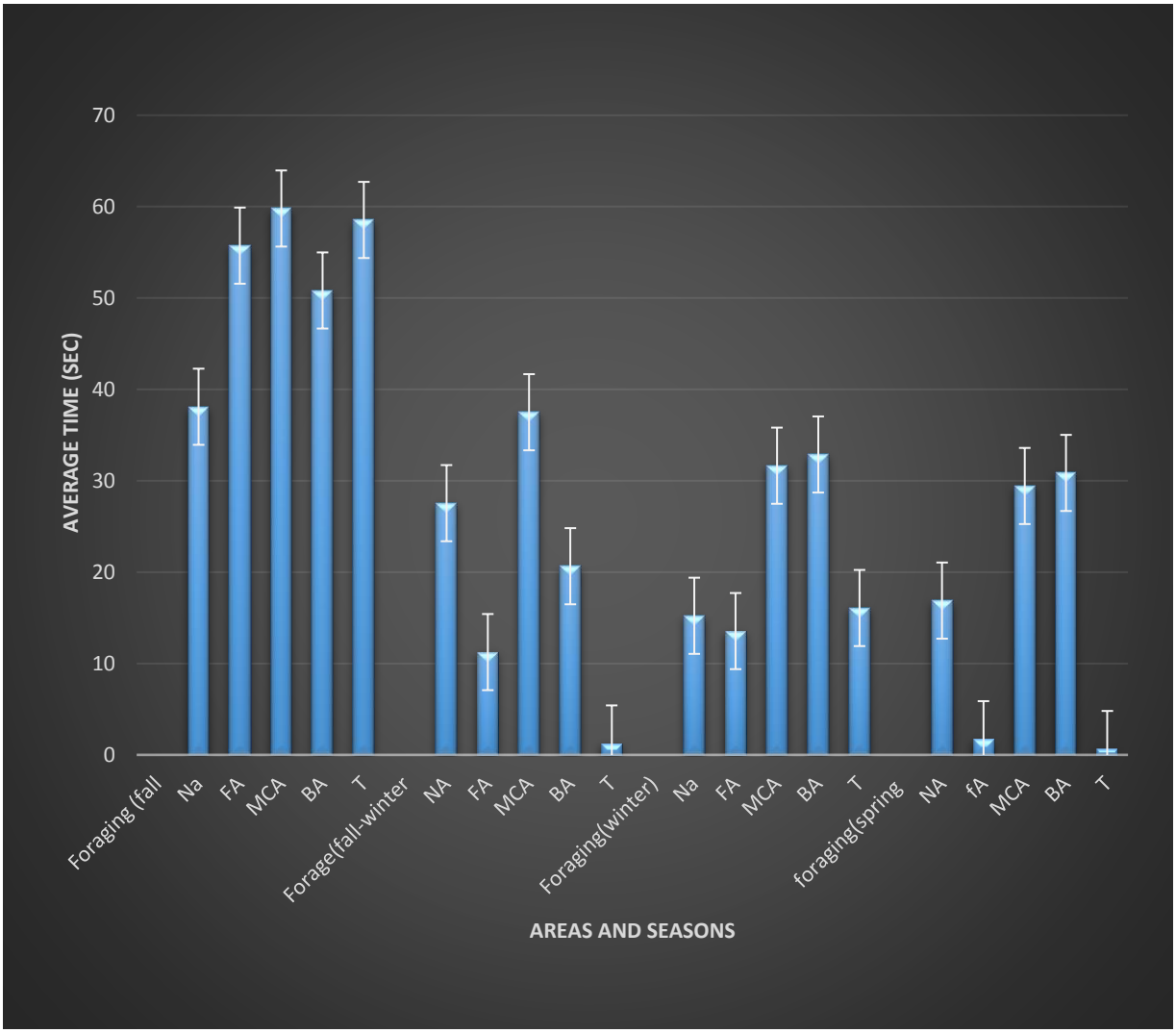


Figure 1: The average time focal animals spent performing foraging behavior within each observation area. DF: 19. N=450 p=4.84281E-06

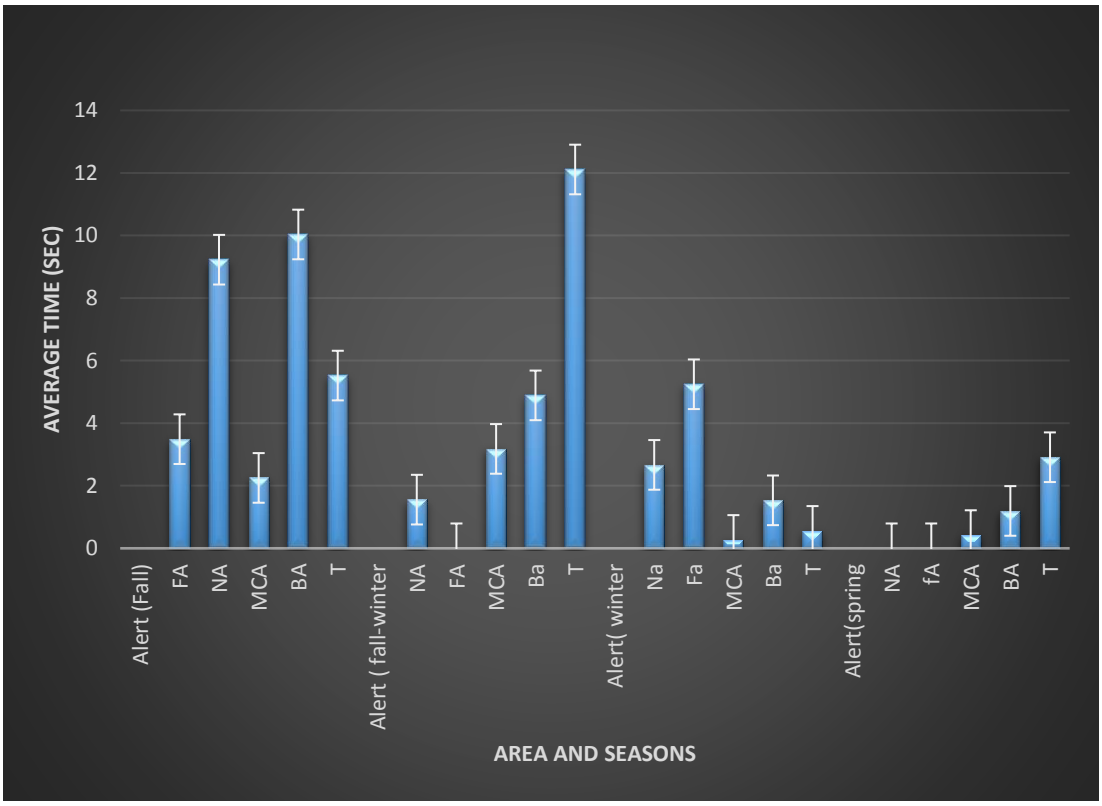


Figure 2: Average time focal animals spent being alert. N=450 DF: 19, p=0.614150751

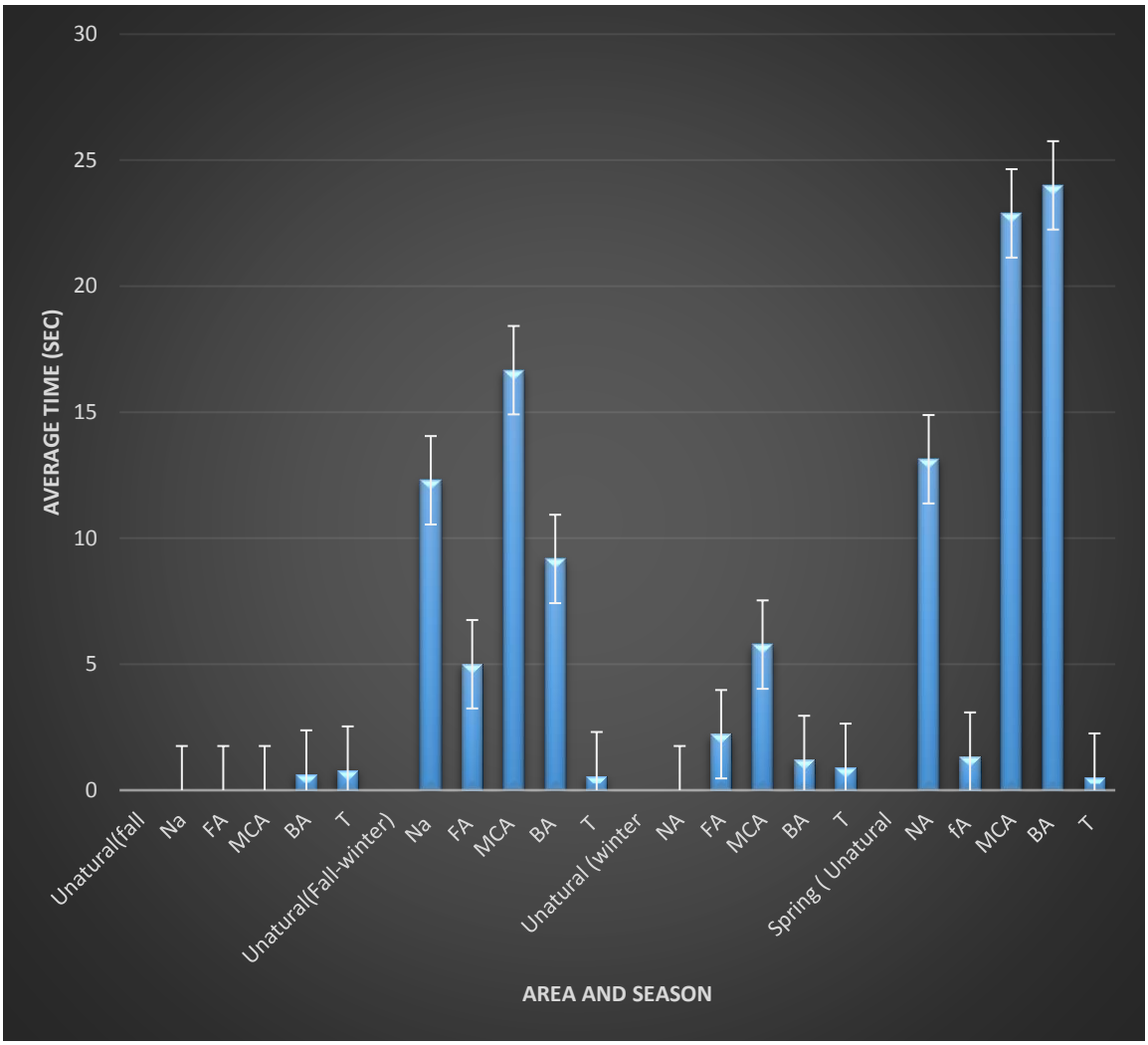


Figure 3: Average Time spent being unnatural. N=450 DF:19, p=5.39812E-07

Discussion

Although the figures showed that there was a difference in the behavior as well as within different seasons, not all the data (figure 2) was statistically significant and failed

to reject the null hypothesis. Some possibility that caused the result was most likely the area in which I studied the squirrels. There were many cases where I have seen my squirrel move from one location to the next (Since the only thing separating one location from another is a street, those that wish could easily cross the street.) In this study, I found that the Mixed Campus area (MCA) was more likely to perform the unnatural behavior. All the observation areas had at least one trash can within their perimeter, however, MCA had four as well as being close to the restaurant. This area has specific times when the human density is extremely high (more specifically, when the class has run out) that is an everyday occurrence for this are, which might've also played a role in the results. Another probability was that due to weather conditions during the fall-winter observation, the sample size was lower than the other observations.

Since the squirrels weren't restricted to where they were and weren't able to roam, many of them might've left one area or it's possible I could've recorded a squirrel that was from the town or built area. To not have such as strong variability, more experimental control on both the focal animals as well as the site itself would be recommended to repeat this experiment without the potential of high variability. ($p<0.05$). Another study that I could do is see how urbanization is affecting the behavior of other animals that are living close to or within urbanization such as raccoons and white-tailed deer. Another possibility is that I could only look at 2 or 3 behaviors and determine if there is a difference between these set behavior. I would also see how this behavior varies by sex since squirrel litters not only have a lower mortality rate but reach

maturity in a shorter amount of time within an urban environment (Roubio,2008) seeing if the female squirrels' behavior change if they were to have a litter. Since gray squirrel generally do better than fox squirrels in an urban environment (Steele,2001) I would like to compare both species' direct and indirect fitness within this environment.

Balbag, Brittany. "Does behavioral flexibility and tolerance to disturbance explain why eastern gray squirrels and eastern fox squirrels have succeeded in invading urban areas?" (2010).

Bateman, P. W., and **P. A. Fleming**. "Does human pedestrian behavior influence risk assessment in a successful mammal urban adapter?" Journal of Zoology 294, no. 2 (2014): 93-98. doi:10.1111/jzo.12156.

Cooper, Christopher A., Allison J. Neff, David P. Poon, and **Geoffrey R. Smith**. "Behavioral responses of eastern gray squirrels in suburban habitats differing in human activity levels." *Northeastern Naturalist* 15, no. 4 (2008): 619-625.

Eastern Gray Squirrel in Ohio. Columbus: Division, 1978. 11+.

Parker, Tommy S., Shinelle K. Gonzales, and **Charles H. Nilon**. 2014. “Seasonal Comparisons of Daily Activity Budgets of Gray Squirrels (Sciurus Carolinensis) in Urban Areas.” Urban Ecosystems 17 (4): 969–78. doi:10.1007/s11252-014-0371-2.

Pardo, Michael A., Scott A. Pardo, and **William M. Shields**. 2014. “Eastern Gray Squirrels (Sciurus Carolinensis) Communicate with the Positions of Their Tails in an Agonistic Context.” American Midland Naturalist 172 (2): 359.

Riem, Jennifer G., Robert B. Blair, Derric N. Pennington, and **Nancy G. Solomon**. "Estimating mammalian species diversity across an urban gradient." The American midland naturalist 168, no. 2 (2012): 315-332.

Robiou, Natalie. "Urban Wildlife and Leopold's Land Ethic: "The squirrels on a college campus convey the same lesson as the redwoods...."." (2008).

Smith, Christopher C., and **David Follmer**. 1972. "Food Preferences of Squirrels." Ecology 53 (1): 82–91. doi:10.2307/1935712.

S**teele, Michael A**., and **John L. Koprowski.** North American Tree Squirrels. Washington: Smithsonian Institution Press, 2001.

Thompson, D. C., and **P. S. Thompson**. 1980. "Food Habits and Caching Behavior of Urban Grey Squirrels." Canadian Journal of Zoology 58 (5): 701–10. doi:10.1139/z80-101.

Thompson, D. C., and **P. S. Thompson**. "Food habits and caching behavior of urban gray squirrels." Canadian Journal of Zoology 58, no. 5 (1980): 701-710.



White-tailed deer doe wondering formal Gardens at Miami University. (Photo was taken by James L. Harris III)



Canadian Geese at an artificial pond near Level 27 Apartments (Photo taken by James L. Harris III).



Pileated Woodpecker searching for food within a tree near king's library (Photo taken by James L. Harris III