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Investigation of the anthropogenic factors influencing Eastern fox squirrel, Sciurus niger, distribution and abundance in urban residential areas

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Abstract

In this rapidly developing world, the relationship between humans and wildlife is becoming more strained. Despite the challenges, some animals respond better than others to the additional pressures present in urban environments, and squirrels are a prime example (McKinney, 2002). Several studies have focused on the distribution and abundance of tree squirrels in urban landscapes, but more information is needed to understand the connections between anthropogenic factors and population density (Shochat *et al.*, 2006). Previous research that examined leaf nest densities within residential neighborhoods found a positive correlation between property value and nest density (Salsbury *et al.*, unpublished data). The biological explanation of this relationship was unclear, so a follow-up study was necessary to further investigate this connection. The potential anthropogenic effects on Eastern fox squirrel (*Sciurus niger*) distribution and abundance in urban residential areas was investigated using a combination of leaf nest surveys, observations of squirrel activity, and a citizen scientist questionnaire. The results indicated that the reported relationship between leaf nest density and property value was likely a correlation without causation. There were also inconsistencies in the relationship between squirrel activity and leaf nest density, and the squirrels appeared to be changing their nest locations relatively frequently. Therefore, there are likely other anthropogenic and environmental factors that have a stronger influence on squirrel activity and leaf nest density.

Introduction

Urbanization has had a tremendous impact on wildlife distribution and habitats (Shochat *et al*., 2006). It is estimated that within less than 30 years, more than 50% of all humans will be concentrated in urban areas, and roughly 80% of the US population lives in urban areas (population densities greater than 186 people/km^2) (Francis and Chadwick, 2012). Often issues arise for wildlife in urban areas because humans are occupying and altering more land, which limits the amount of suitable habitat available. In addition, urbanization can affect the behavior, morphology, population dynamics, and community structure of wildlife, so species must adapt to these changing conditions in order to be successful (Shochat *et al*., 2006).

Several species that were historically more closely associated with rural and wilderness areas have transitioned to using habitat available in urban areas (Ditchkoff *et al.,* 2006). In particular, small mammals, birds, reptiles and some amphibians have been known to use urban habitat that is highly fragmented. Species, such as coyotes (*Canis latrans*) and white-tailed deer (*Odocoileus virginianus*) that have not been closely associated with human activity have entered urban and suburban areas (Ditchkoff *et al.*, 2006; Gehrt, 2007). When species occupy urban habitats, they are subject to novel environmental pressures that were not present in their former rural or wilderness habitats. Oftentimes, these urban stresses influence behavior and life-history strategies in a way that helps them avoid or lessen the negative impacts of their urban environment. Specific modifications include changes in movement, diet, reproduction, density, and disease exposure, all of which may ultimately influence survival. One example involves raccoons (*Procyon lotor*) in urban areas that tend to be distributed in clumps gathered around anthropogenic feeding sites, such as parks and garbage dumps (Prange *et al.*, 2004). These higher concentrations of anthropogenic food sources in urban areas result in smaller home ranges and greater population densities compared to more natural settings where nonterritorial, solitary raccoons congregate only when food is concentrated into separate patches (Prange *et al.*, 2004).

Nonetheless, urban ecosystems can be quite diverse because they include species that were present prior to urbanization, colonizing species, and nonnatives (Francis and Chadwick, 2012). Urban species are typically generalists that can utilize a diverse array of resources found in urban landscapes. Specialists may also be present in urban landscapes, but they often have smaller populations (Francis and Chadwick, 2012). Synurbic species have higher urban population densities than their rural counterparts and positively respond to urban environments, as measured by increased survival, reproduction, and population growth (Francis and Chadwick, 2012). In some cases, urban wildlife populations can respond to anthropogenic stresses through microevolution within several generations (Ditchkoff *et al.*, 2006).

Tree squirrels are among those animals that can be described as “urban adapters,” and they make excellent research subjects because they are common mammals that are relatively easy to observe (Steele *et al.*, 2001). They are considered generalists because they capitalize on open areas near forests, and they often utilize the extra anthropogenic food sources (McCleery, 2009). Several studies have focused on the distribution and abundance of tree squirrels in urban landscapes. For example, a comparison between Eastern fox (*Sciurus niger*) and gray squirrel (*S. carolinensis*) distributions in an urban environment found that Eastern fox squirrels prefer elms and maples and are found in areas of lower human population density compared to grey squirrels (Van der Merwe *et al*., 2005). In addition, results of another study suggested that urban squirrel populations can even be a source for suburban and rural populations (McCleery, 2009). Over a span of two years, McCleery (2009) found that urban fox squirrels had high reproductive productivity as evidenced by large average litter sizes and a larger proportion of reproductive females compared to rural populations (McCleery, 2009). Reproductive success can be related to habitat suitability, so the high reproductive rate of these urban fox squirrels is indicative of the quality habitat present in urban environments. In fact, fox squirrels easily navigate urban landscapes, as their movements are not limited by common features such as concrete surfaces and buildings that other species might avoid (McCleery, 2009).

Although habitat quality is an important factor for squirrel populations, the relationship between habitat suitability and squirrel abundance can change in urban landscapes (Parker and Nilon, 2008). A study on gray squirrels assessed tree canopy cover and food availability and found that anthropogenic foods accounted for 35% of the urban gray squirrel diet, and one of their models indicated that natural food sources alone were too low to support such a high population (Parker and Nilon, 2008). This indicates that either urban squirrel populations were not as heavily constrained by bottom-up effects or anthropogenic food sources helped to support such a large population (Parker and Nilon, 2008).

Additional studies are still needed to fully understand the connections between anthropogenic factors and population density for many species living in urban landscapes (Shochat *et al*., 2006). While tree squirrels in urban areas have received some attention, it is still unclear how humans impact squirrel density and distribution. For example, a previous study examined leaf nest densities within residential neighborhoods and found a positive correlation between property value and leaf nest density (Salsbury *et al.*, unpublished data). The biological explanation of this relationship was unclear, so my study is a follow-up to investigate this connection. I hypothesize that anthropogenic factors associated with socioeconomic status may influence Eastern fox squirrel distribution and abundance in urban residential areas. Specifically, I predict that homeowners of higher socioeconomic status are more likely to have bird feeders on their properties. Likewise, the number of pets present across the properties may vary, explaining the association of leaf nests with property value, although it is unclear how pet abundance, pet type, or both may vary with property value.

In order to estimate tree squirrel abundance, I conducted leaf nest surveys and observations of squirrel activity along transects in residential areas that varied greatly with regard to property value. In addition, I distributed a citizen scientist questionnaire to the transect residents to help gauge the influence of various anthropogenic factors. Ultimately, this study will provide insight into the potential effects of anthropogenic factors on urban tree squirrel populations, which in turn, may have broader implications for other urban species.

Methods

Study Site

This study was conducted in the Butler-Tarkington and Meridian Kessler neighborhoods near Butler University about 8.85 kilometers from the center of downtown Indianapolis, Marion County, Indiana. The area was primarily comprised of older single-family homes on vegetatively mature lots with an average tree (diameter at breast height ≥ 10 cm) density of 25.67 trees/ha (s.d. ± 6.872) (Salsbury *et al.*, unpublished data). Five transects each approximately 2.85 km in length were examined. The transects extended between 38th Street and 54th Street along Boulevard Place, North Capitol Avenue, Illinois Street, Washington Boulevard, and Central Avenue. It is important to note that there is an apparent socioeconomic gradient along each transect. Generally, higher property values were found at the northern ends of the transects, while lower property values were found along the southern ends of the transects (Figure 1). Each of the five transects were divided into ten block units comprised of a relatively equal number of property parcels, although the parcels were not necessarily of equal size. The creation of block units enabled me to make comparisons of roughly equal numbers of parcels across transects.

Leaf Nest Surveys

I estimated squirrel abundance by counting the number of active leaf nests along each transect. Previous studies have used leaf nests to estimate the relative abundance of squirrels (Don, 1985; Wauters and Dhondt, 1988). The number of active leaf nests was recorded along each of the transects. When viewed with binoculars from ground level, a leaf nest was considered active if it did not show any sunlight through the nest (Salsbury *et al*., 2004). Each of these five transects were monitored in a previous study (Salsbury *et al*., unpublished data), which enabled me to compare data across years. In the most recent survey, all active leaf nests in each property parcel along both sides of the transects were recorded, and it was also noted if a nest was found in a tree with at least one other leaf nest. Leaf nest surveys were conducted between February and early April of 2015, and another round of leaf nest surveys was conducted in December of 2015 and January of 2016, before the trees' leaves blocked the view of leaf nests.

The number of potential leaf nest trees in each property parcel along one side of each transect was recorded in a previous study (Salsbury *et al*., unpublished data). A tree was counted as a potential nest tree if it had a diameter at breast height (dbh) greater than or equal to 10 cm, a height of at least 6-9 m, and its limbs appeared to be able to support a leaf nest. I did not record the number of trees in each parcel in the present study because I assumed that the number of mature trees had not changed significantly from the previous tree survey conducted in 2009.

Observations of Squirrel Activity

I observed squirrel activity as another method to gauge relative squirrel abundance and distribution, as private property in residential areas prevented direct capture of squirrels. I observed squirrel activity along each of the five transects at least five times per week, weather permitting, from May through July of 2015. Squirrels are typically most active from 7-11AM and 3-7PM (Steele *et al.*, 2001), so observations of squirrel activity were conducted during these two time periods.

I followed a standard observation protocol, which was based on the methodology used in a study designed to monitor tree squirrel activity in Chicago neighborhoods (Van der Merwe *et al.*, 2005). I biked along each of the transects and scanned both sides of the transect for squirrel activity. I moved steadily along each transect at a pace of approximately 0.24 km/min. When a squirrel was sighted, I stopped cycling and marked its approximate location from the side of the street nearest the squirrel using a GPS unit (Garmin etrex 20). I also made note of the date, time, weather conditions, and any unusual occurrences in the environment at each sighting. Once back at the laboratory, I entered the GPS locations into Google Earth for later analysis.

It must be noted that it was possible that individual squirrels were recorded more than once during each observation along a transect because the squirrels were unmarked. Nonetheless, I tried to minimize this by biking at a steady pace along each transect, and I helped decrease observer bias by conducting all of the observations of squirrel activity myself. It is certainly likely that the same individuals were observed between different days, but I judged this to be acceptable because the observations of squirrel activity were meant to provide relative activity levels by time and location rather than estimates of absolute population density. Although only data on living *S. niger* individuals were used for analysis purposes, I did note the location of dead squirrels and Eastern gray squirrels, *S. carolinensis,* along each transect.

Citizen Scientist Questionnaire

In order to better understand potential relationships between squirrel activity and anthropogenic factors along the five transects, I developed a citizen scientist questionnaire that was completed by transect residents, and I received IRB approval for involving human subjects in this portion of my study (Approved on June 18, 2015). The questions focused on the type and quantity of pets in the household, availability of supplemental food for wildlife, presence of seed producing ornamental plants, and the number of bird feeders on the property (Appendix A). The questionnaire was available in an online format, and the LimeService Survey program was used for administering the questionnaire and collecting the results.

I created a handout that provided some general background information on my study and invited residents along the transects to complete my online questionnaire. I received approval from the Butler-Tarkington and Meridian Kessler neighborhood associations to deliver a physical copy of the handout to the residents along the transects. This handout directed the residents to an online link to complete the questionnaire, and it also included an email address that they could use to contact me directly (Appendix B). Handouts were delivered twice to each house along both sides of the street of each transect to maximize participation. To generate interest and answer general questions about my study, I created an electronic flyer with more information (Appendix C). If they wanted more specific details, residents were directed to my electronic flyer via links distributed by neighborhood associations.

Data Analysis

I investigated the association between leaf nest abundance and property value using a correlation analysis (Minitab 17 statistical software, 2016). I also calculated the partial correlation coefficients for the number of leaf nests and property value along each transect after removing the effect of nest trees.

Each of the five transects was divided into ten block units so that each block unit contained approximately the same number of property parcels. However, the property parcels in each block unit varied in size along and across the transects. The results from the leaf nest survey conducted in 2015-2016 were compared with a former study conducted in 2009 (Salsbury *et al.*, unpublished data) by conducting a correlation analysis comparing average nest densities in each block unit. Average nest densities per block unit were calculated by dividing the total number of nests by the number of parcels in each block unit.

The data from the questionnaire were compiled, and the total number of each of the anthropogenic factors was found for each of the ten block units along every transect. My objective was to conduct correlations between leaf nest density and a number of anthropogenic factors including pet abundance, supplemental food presence, average property value, quantity of bird feeders, and the presence of ornamental plants.

Squirrel activity sightings were grouped by block unit for each transect and were analyzed by conducting correlations between leaf nest density, number of potential nest trees, and property value.

Results

Leaf Nest Surveys

The number of leaf nests was positively correlated with the number of trees for all of the transects combined and each of the individual transects based on the spring 2015 survey data (Table 1). I assumed that the number of trees and property values did not change from the 2009 study, in which the number of trees was significantly positively correlated with property value along each transect (Salsbury *et al.*, unpublished data). When comparing leaf nests to property value without the effect of trees (partial correlation coefficients) for the 2015 survey data, there were significant positive partial correlations for Boulevard, Central, and all of the transects combined (Table 1).

There were statistically significant positive correlations between leaf nests and number of trees for the 2015-2016 survey data for all of the transects except along the Central transect (Table 1). There was also a significant positive correlation between leaf nests and number of trees when all of the transects were combined (Table 1). The partial correlation coefficients comparing leaf nests versus property value without the effect of trees showed that the number of leaf nests was positively correlated to property value for Capitol, Illinois, and all of the transects combined (Table 1).

When I compared the number of leaf nests per block unit along each of the transects for the 2009 versus the 2015-2016 leaf nest data, the number of nests was significantly positively correlated between the years for the Illinois and Washington transects (Table 2).

Of the 281 total nests observed in 2015 and 2015-2016 on one side of the transects, 86 leaf nests were found in trees with at least one other nest, and multiple nests per tree occurred about 30.6 percent of the time (Appendix D). There were 22 leaf nests found in a tree with at least one other leaf nest on Boulevard, two nests along Capitol, 15 nests for Illinois, 14 nests on Washington, and ten nests along Central for the 2015-2016 survey.

Squirrel Activity

Squirrel activity surveys were conducted from May 19, 2015 through July 2, 2015, and a total of 29 observational surveys were conducted along each transect (Appendix E). The Washington transect had the largest total number of squirrel sightings with 113, followed by Capitol with 98, Central with 84, Illinois with 48, and Boulevard with 24.

No relationship between squirrel activity and property value was found across any of the individual transects (Table 3). When the number of total nests was compared to squirrel activity across the individual transects, there were significant positive relationships for the Boulevard, Capitol, and Washington transects (Table 3). No significant correlations were found for the relationships between squirrel activity and the total number of trees by block unit along any of the transects (Table 3). The total number of squirrel sightings did not differ among the transects (ANOVA: $F_{4,45} = 1.49$, $p = 0.221$).

Questionnaire Data

A total of 121 questionnaires were completed and returned by residents (citizen scientists) that live along the transects resulting in an estimated response rate of 10%. A questionnaire was considered complete if every question was answered and an address was provided by the citizen scientist. Unfortunately, the number of completed questionnaires received from each block unit along each transect was too low to support statistical analyses (Table 4). No residents responded from many block units in spite of my repeated efforts to encourage citizen participation.

It is interesting to note that there did not appear to be a generally consistent trend in the distribution of bird feeders or number of pets between the transects or along the socioeconomic gradient of each individual transect (Figure 2). For example, the Boulevard transect did not report many bird feeders overall, but for block units five through eight, there were about the same number of pets as bird feeders (Figure 2A). Along the Capitol transect, there was a general increase in the number of bird feeders and total pets within block units six through nine (Figure 2B). However, this trend was not consistent across the other transects.

Along the Illinois transect, the number of bird feeders and pets was relatively low, about one to two of each variable, and consistent over the length of the transect, except for a brief spike in the number of bird feeders at block units five and six (Figure 2C). Along the Washington transect, the number of bird feeders and total number of pets was higher towards the southern end of the transect and noticeably decreased towards the northern end of the transect (Figure 2D). The Central transect had relatively low and consistent numbers of bird feeders and pets over much of the transect except for a sharp jump of both variables in the middle of the transect between block units four and seven

(Figure 2E). In general, there were some trends along several block units of individual transects, but there did not appear to be any consistent trends between all of the transects overall. Any trends, therefore, should be considered with caution as they are based on a small number of completed questionnaires.

Discussion

A previous study on the number of active leaf nests of Eastern fox squirrels in relation to number of available nest trees and property values of parcels in an urban-suburban neighborhood set the precedent for this study (Salsbury *et al.*, unpublished data). A positive relationship was found between property value and leaf nest density, but the causal nature of that relationship was unknown (Salsbury *et al.*, unpublished data). In the present study, leaf nest and squirrel activity surveys were conducted to reassess and explore the strength of potential relationships between leaf nests, number of trees, property value, and squirrel activity. A citizen scientist questionnaire was incorporated to help understand the potential effects of anthropogenic factors on squirrel abundance and distribution and to help elucidate the earlier positive property value-leaf nest density relationship.

There were statistically significant positive correlations between leaf nests and number of trees for all of the transects combined and each of the individual transects based on the spring 2015 leaf nest survey data. Similar results were observed for the 2015-2016 leaf nest survey data, as there were statistically significant positive correlations between leaf nests and number of trees for all of the transects combined and all of the individual transects except for the Central transect. With the exception of the Central transect, these results are in agreement with those from a previous study in 2009 along the same transects where the number of leaf nests was positively correlated with the number of potential nest trees (Salsbury *et al*., unpublished data). These results are understandable in light of previous studies that show that tree squirrel abundance is highly contingent upon the trees present (McComb, 1984; McPherson and Nilon, 1987; Salsbury *et al.*, 2004; Williamson, 1983).

The lack of a relationship between leaf nests and number of trees along the Central transect is perplexing. I assumed that the number of trees would not have changed significantly between the 2015 and the 2015-2016 surveys, so it was unexpected that the relationship between leaf nest density and number of trees would have changed within such a short timespan on the Central transect. This indicates that along the transect, fox squirrels had changed the location of their active leaf nests in a significant way within a year that was unrelated to the number of trees. It is possible that there might not have been enough variation between the number of trees and number of leaf nests along the length of the Central transect, which would have made it difficult for a meaningful relationship to be observed.

Perhaps there were other aspects of the trees that were more influential than just the number of available nest trees. For example, previous studies have found that tree species and size have a more substantial impact on tree squirrel distribution and abundance than the number of available trees (McComb, 1984; McPherson and Nilon, 1987; Salsbury *et al.*, 2004; Williamson, 1983). Specifically, in a study on habitat use of fox squirrels in urban environments, McCleery *et al.* (2007) found that the number of trees present was not a relevant predictor of squirrel activity, but rather the size, species, and canopy cover of the trees were more influential. It is possible that squirrels responded to tree size and type more along the Central transect but is difficult to determine as I was unable to measure tree size and type due to the limitations to access private property along each transect.

A potential causal explanation for the previously observed relationship between leaf nest density and property value may be that properties of higher value have more trees and it is in fact the number of trees that really influences the density of nests. This positive relationship between leaf nest density and property value was observed in the 2009 study (Salsbury *et al*., unpublished data). Because I did not recount the number of trees during my 2015 or 2015-2016 survey, I expected this relationship to remain as I assumed that the number of trees and property values did not change greatly between 2009 and my surveys. The 2009 study found significant positive correlations between the number of trees and property value along all transects individually, except the Central transect (Salsbury *et al*., unpublished data). This indicates that higher property value is closely associated with more nesting trees. When comparing the average number of potential nest trees along the transects, it varied almost seven fold between the ten block units for each transect (Salsbury *et al*., unpublished data), which could partly help explain why trees were closely related to property value, which also varied greatly along each transect.

The initial study in 2009 found that property value was the most influential factor along three of the five transects, and property value by itself explained a significant portion of the variation in nest density along many of the transects (Salsbury *et al.*, unpublished data). When comparing 2015 leaf nests to property value without the effect of trees, there were statistically significant positive partial correlations for Boulevard, Central, and all of the transects combined. For the 2015-2016 survey when comparing leaf nests versus property value without the effect of trees, there were statistically significant positive partial correlations for Capitol, Illinois, and all of the transects combined. There was not a statistically significant relationship for the Washington transect either year, which could be due in part to the fact that property value along the transect is relatively consistent. Specifically, the average property value for each of the block units of the Washington transect was around $250,000, except for a higher average property value in block unit three at nearly $270,000.

It was unexpected that the two surveys conducted within a year of each other would have yielded such opposite results. Because the relationship between leaf nests and property value is inconsistent between the two surveys, it suggests that the relationship between leaf nests and property value has no consistent underlying causal explanation; it is in fact a correlation without causation. Instead, the relationship between number of trees and nests is stronger than property value and nest density. Nonetheless, the number of trees was assumed to be relatively consistent from year to year and yet the nest distribution changed between the surveys. Thus, there are likely other factors influencing nest placement along the transects observed.

The number of leaf nests per block unit along each of the transects in 2009 was statistically similar to those observed in the 2015-2016 leaf nest survey for the Illinois and Washington transects only. This indicates that squirrels statistically change the locations of their leaf nests over the years, and the nests are not consistently located in the same block units along most of the transects. A similar comparison could not be made between the 2009 and 2015 data because I did not do a complete survey of each transect in 2015. Although it is unclear why the number of nests was only consistent along the Illinois and Washington transects, I have personally observed that these two transects have large property parcels that extend far back from the streets with many mature trees.

This could have influenced the results as the large parcels had many trees that could have provided more consistent opportunities for the construction of leaf nests. There are no previous studies to my knowledge that examine site fidelity with regard to nest placement in tree squirrels. The lack of site fidelity with regard to nest placement in urban areas is especially interesting given that it seems likely that squirrels may have limited nesting sites in urban areas. The inconsistencies in leaf nest placement, especially in urban areas, could be an important future direction for study.

Multiple nests in one tree were only found eight percent of the time in a previous study conducted in suburban and urban woodlots (Salsbury, 2008), whereas in urban residential areas, leaf nests were in trees with at least one nest 42 percent of the time (Salsbury *et al.*, unpublished data). I found that over the course of the 2015 and 2015-2016 leaf nest surveys combined, multiple leaf nests occurred approximately 30.6 percent of the time, which is more consistent with the results from the Salsbury *et al.* (unpublished data) study conducted in urban residential areas. This could be a result of a smaller pool of potential nest trees in urban residential areas. Thus, Eastern fox squirrels might resort to building their nests in trees that are already occupied by at least one nest (Salsbury *et al.*, unpublished data). Nonetheless, it is still an unusual finding considering that Eastern fox squirrels are typically asocial (Steele and Koprowski, 2001), and most interactions are aggressive (Koprowski, 1996; Steele and Koprowski, 2001). Therefore, it is reasonable to speculate that being forced to nest in the same tree as other conspecifics might have strong implications on the social behavior of residential fox squirrels.

Squirrel activity data were only collected in the summer months of 2015; thus, these data were correlated with leaf nest locations from the 2015 season only. After comparing the number of total nests versus squirrel activity across the individual transects, there were significant relationships for the Boulevard, Capitol, and Washington transects. These results support the idea that leaf nest density is a reliable indicator of squirrel activity (Don, 1985; Wauters and Dhondt, 1988) at least along some of the residential transects. The lack of a relationship for all transects might suggest that squirrel movement patterns are very large in residential areas, and squirrels from nests that were not counted in the survey impacted the relationship.

In addition, previous studies have found that tree squirrel coexistence is influenced by trade-offs between predator vulnerability and foraging efficiency (Van der Merwe *et al.*, 2005); therefore, other environmental factors such as cover and quality of both anthropogenic and natural food sources could be influencing squirrel activity. Specifically, Eastern fox squirrels preferred live oaks and trees with a larger diameter and canopy cover as opposed to introduced pines and conifers (Van der Merwe *et al.*, 2005). Although tree species was not recorded and used for analysis in my study, it could be an important factor to incorporate in the future as another potential influence on squirrel activity. Furthermore, Parker and Nilon (2008) found that there is no relationship between habitat suitability and mean squirrel abundance. In fact, there are variables other than habitat suitability that impact squirrel density, which could help explain why the relationship between leaf nest density and squirrel activity was not consistent across all of the transects (Parker and Nilon, 2008).

No relationship between squirrel activity and property value was found across any of the individual transects. This is most likely because property value is not the most significant predictor of leaf nest density or squirrel activity. Instead, the relationship between number of trees and leaf nests is likely more powerful.

When comparing the total number of squirrel sightings across all transects, there was not a significant difference. This means that there was no difference among the transects with regard to squirrel activity, which is odd because there were some transects that appeared to have a lot more activity than others, but the variation might have been too great to see any significant difference. Merrick and Koprowski (2017) found that common features of urban wildlife populations, such as higher population densities and smaller home range sizes, could lead to changes in social interactions, which could have influenced squirrel activity along the transects.

Because the total questionnaire response rate was low, only general trends from the responses can be discussed. In particular, there were not large enough sample sizes from each of the block units to compare them within or between transects. Initially, I expected the number of bird feeders to be positively associated with squirrel activity, number of leaf nests, and property value and would therefore increase towards the northern ends of the transects. I was not sure how the number of pets might vary, if at all, along the socioeconomic gradient of the transects, but I was hoping that the results would shed some light on this anthropogenic factor.

Several studies have found that tree squirrels utilize bird feeders as supplemental food sources (Alder, 1988; Sexton, 1990), so I thought that this could be an influential anthropogenic factor. Tree squirrel population densities have also been found to track food availability (Gurnel, 1983; Weigl *et al.*, 1989), so areas with supplemental food available would have been likely to attract squirrels. The number of pets was also thought to be another important anthropogenic factor and influence squirrel activity because dogs and cats can prey on urban wildlife (Adams *et al.*, 2006). Cat density in particular was negatively correlated with gray squirrel distribution and abundance because they tried to avoid areas of high cat density in an attempt to minimize predation (Van der Merwe *et al.*, 2005).

It is interesting to note that there did not appear to be a generally consistent trend in the distribution of bird feeders or number of pets between the transects. In fact along the Washington transect, the trend was opposite of what I expected because the number of bird feeders actually decreased towards the northern end of the transect, but for most of the transects, the number of bird feeders and pets was generally consistent along the transects with a spike in numbers at some point along the length. Although there were some minor patterns along several block units of individual transects, they did not hold up across all of the transects. In general, the trends were unexpected and variable across the transects; this is likely due to the low number of responses and could have been disrupted by a few responses that had unexpectedly high numbers that skewed the relationships. Again, I cannot fully interpret these trends because there were so many block units with few, if any, completed questionnaires.

The results of this study contradicted some of the findings from the most recent study conducted in the same urban-residential area (Salsbury *et al.*, unpublished data), indicating that the previous relationship between property value and leaf nests was likely a correlation without causation. Instead, there are likely more powerful indicators of leaf nest density, such as the number of potential nest trees. Further, I found inconsistencies in leaf nest distribution, which suggests that something other than potential nest trees available may be influencing the distribution and abundance of leaf nests because my results indicate that property value is important along some of the transects even when the effect of trees is removed. The lack of consistency with regard to nest placement between years suggests as well that some factors other than availability of nest trees and property value are important, as I assumed that these did not change among years. This lack of site fidelity with regard to nest placement is a unique finding of this study.

Although my research and other studies indicate that factors other than the number of potential nest trees are related to leaf nest density, I could only speculate, so moving forward, it is important to consider other factors such as tree species and behavioral changes in an urban environment. Because my questionnaire return rate was so low, the results could not provide information about the potential influences of anthropogenic factors on Eastern fox squirrel distribution and abundance, but bird feeders and outdoor pets could still be important variables to consider in future studies. Overall, my findings emphasize the need for more research to be conducted to better understand what factors influence leaf nest placement and densities in urban environments, how leaf nest densities are related to Eastern fox squirrel abundance in urban environments, and the specific influences of anthropogenic factors on urban Eastern fox squirrel populations.

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Table 1. Comparisons between leaf nests and number of trees, leaf nests and property value, and number of trees and property value for each of the five transects and all of the transects combined. Leaf nest surveys were conducted in winter and early spring of 2015 and 2015-2016 along the Boulevard, Capitol, Illinois, Washington, and Central transects. Statistical significance was determined at $\alpha \leq 0.05$. Pearson correlation coefficients were calculated for the comparisons of leaf nests versus number of trees and number of trees versus property value, while Pearson partial correlation coefficients were calculated for the leaf nest versus property value comparison with the effect of trees removed.

Transect	Year	Sample Size (n)	Total Transect	Leaf Nests vs. Trees	Leaf Nests vs. Property Value	Trees vs. Property Value
Boulevard	2015	110	r	0.396	0.244	0.557
			p-value	< 0.001	0.010	< 0.001
	2015-2016	131	r	0.238	0.058	0.524
			p-value	0.006	0.511	< 0.001
Capitol	2015	116	r	0.309	0.172	0.329
			p-value	0.001	0.064	< 0.001
	2015-2016	137	r	0.172	0.171	0.317
			p-value	0.044	0.046	< 0.001
Illinois	2015	72	r	0.517	-0.005	0.713
			p-value	< 0.001	0.968	< 0.001
	2015-2016	87	r	0.426	0.269	0.672
			p-value	< 0.001	0.012	< 0.001
Washington	2015	89	r	0.211	0.203	0.620
			p-value	0.047	0.056	< 0.001
	2015-2016	111	r	0.263	0.119	0.583
			p-value	0.005	0.214	< 0.001
Central	2015	115	r	0.225	0.279	0.265
			p-value	0.016	0.003	0.004
	2015-2016	138	r	0.085	0.162	0.150
			p-value	0.321	0.057	0.078
All Transects Combined	2015	501	r	0.346	0.184	0.616
			p-value	< 0.001	< 0.001	< 0.001
	2015-2016	604	r	0.258	0.105	0.559
			p-value	< 0.001	0.010	< 0.001

Table 2. Comparison of leaf nests per block unit along each of the five transects between the 2009 leaf nest survey and the winter 2015-2016 leaf nest survey. Each of the five transects were divided into ten block units containing relatively the same number of parcels. The r-values indicate Pearson correlation coefficients, and statistical significance was determined at $\alpha \leq 0.05$.

Transect	r	p-value
Boulevard	0.043	0.905
Capitol	0.215	0.550
Illinois	0.962	< 0.001
Washington	0.791	0.006
Central	0.211	0.558

Table 3. Pearson correlation coefficients for potential relationships between squirrel activity and property value, squirrel activity and number of total leaf nests, and squirrel activity and number of total trees per block unit for each of the five transects individually. Squirrel activity surveys were conducted during the summer of 2015. Statistical significance was determined at $\alpha \leq 0.05$.

Transect	Sample Size (n)	Total Transect	Squirrel Activity vs. Property Value	Squirrel Activity vs. Total Nests	Squirrel Activity vs. Total Trees
Boulevard	24	r	0.401	0.692	0.453
		p-value	0.251	0.027	0.221
Capitol	98	r	0.279	0.766	0.221
		p-value	0.434	0.010	0.568
Illinois	48	r	0.032	0.159	-0.197
		p-value	0.930	0.661	0.611
Washington	113	r	0.325	0.803	0.306
		p-value	0.360	0.005	0.423
Central	84	r	-0.534	0.567	-0.030
		p-value	0.112	0.087	0.939

Table 4. The total number of completed citizen scientist questionnaires received for each of the ten block units and each of the individual transects. A questionnaire was considered complete if all of the questions were answered and the citizen scientist provided their address.

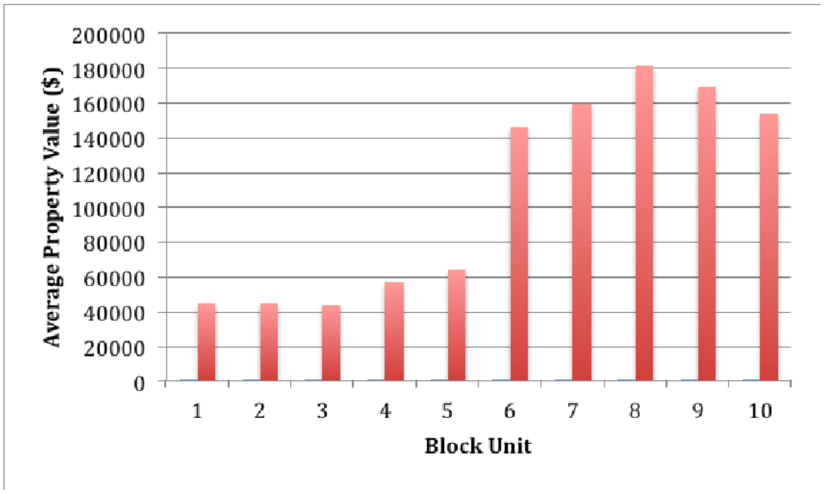
Block Unit	Boulevard	Capitol	Illinois	Washington	Central
1	1	2	1	2	4
2	0	0	0	4	1
3	0	0	2	6	1
4	1	0	3	4	5
5	1	2	6	2	6
6	2	4	6	1	4
7	7	4	1	2	3
8	4	4	5	3	4
9	2	6	2	0	2
10	0	0	0	0	1
Total	**18**	**22**	**26**	**24**	**31**

Figure Legends

Figure 1 (A-E). Average property value per block unit for five urban residential transects which include Boulevard (A), Capitol (B), Illinois (C), Washington (D), and Central (E). Each transect was broken down into ten block units with approximately the same number of property parcels.

Figure 2 (A-E). Total number of bird feeders and pets for each of the ten block units along the five transects that include Boulevard (A), Capitol (B), Illinois (C), Washington (D), and Central (E). The total number of bird feeders (in red) and pets (in green) were self-reported by citizen scientists that live along the transects, and the total number of pets included both dogs and cats and both indoor and outdoor individuals.

Figure 1 A-C.



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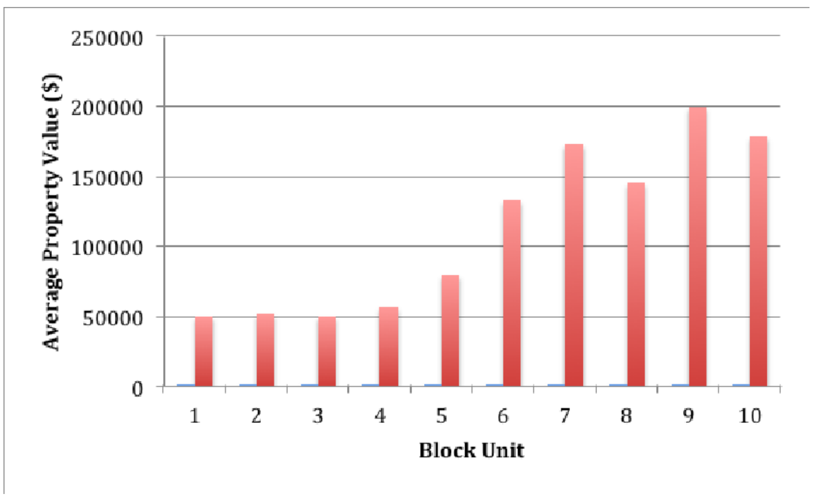

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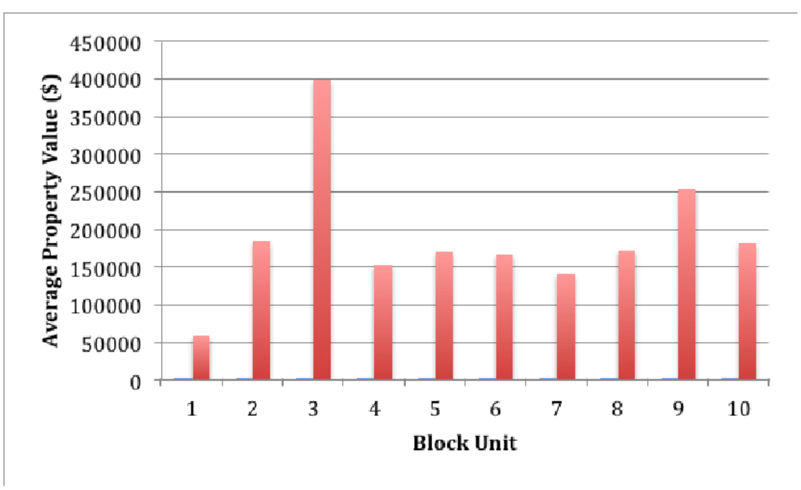

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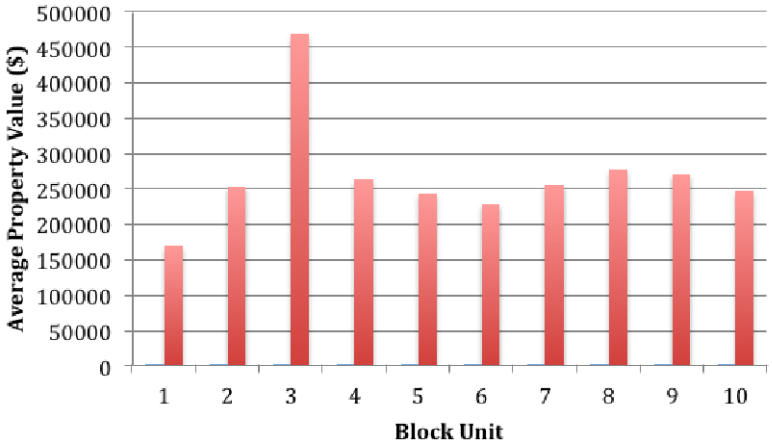
Figure 1 D-E.



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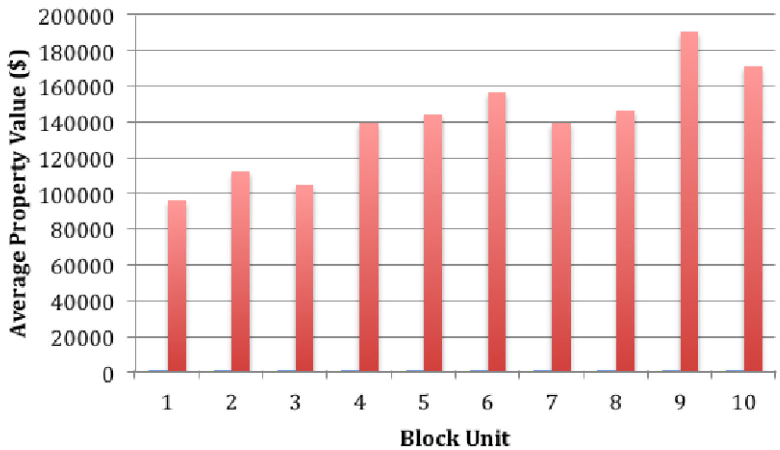

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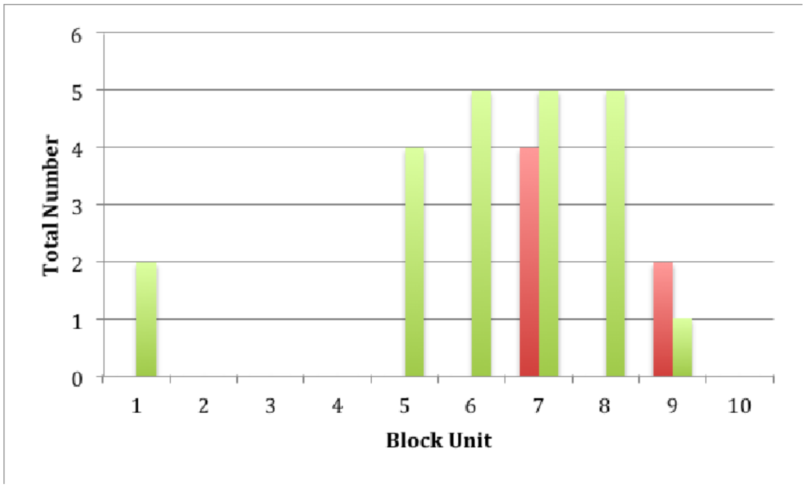
Figure 2 A-C.



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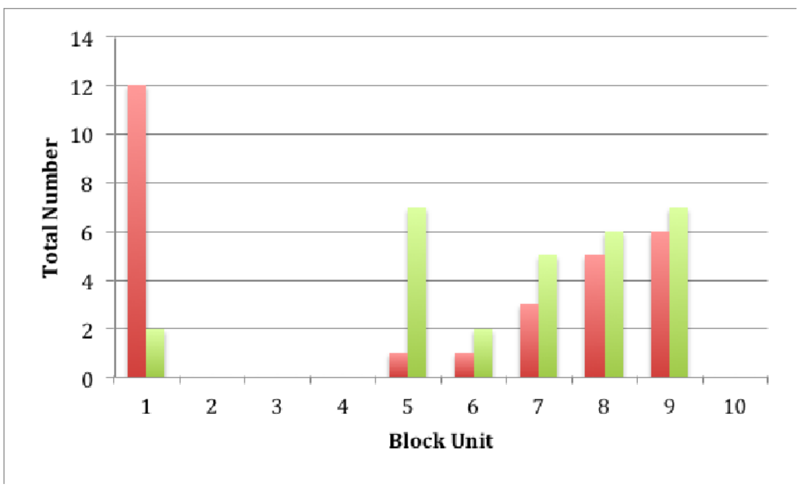

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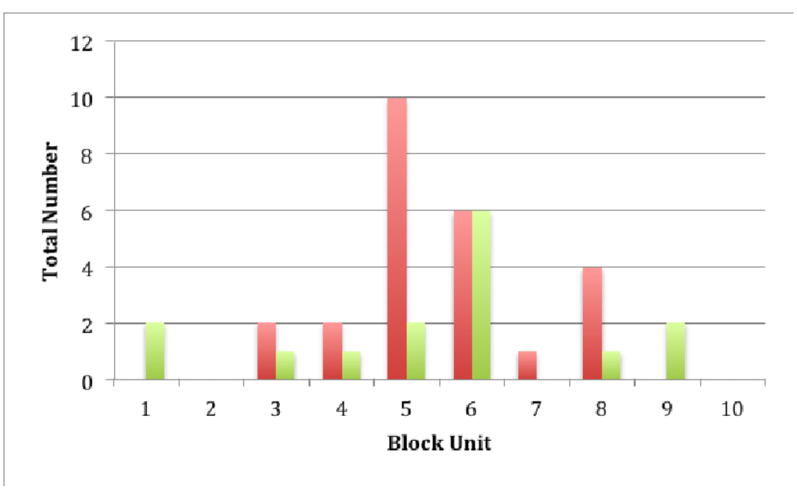
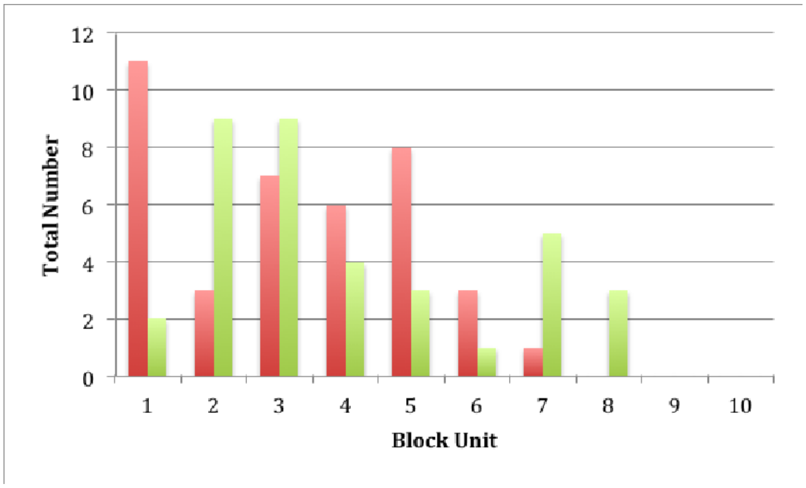


C.

Figure 2 D-E.



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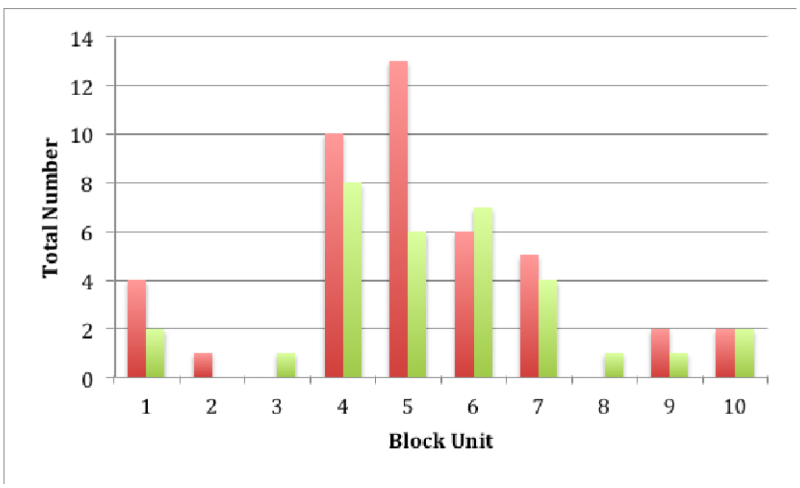

E.

Appendix A. Copy of the citizen scientist questionnaire that was accessible to transect residents via the online LimeService Survey platform during the summer of 2015.

Urban Tree Squirrels and Human Activities Survey

My name is Gabrielle, and I am a junior Biology major at Butler University. This summer, I am conducting research on tree squirrels in the Indianapolis community. In order to determine how human activities affect the abundance and distribution of tree squirrels in an urban environment, I would like your help as a Citizen Scientist to answer a few questions in this anonymous survey. This survey is voluntary, and you are free to withdraw at any time or decline to answer specific questions. You must be 18 years or older to submit this survey, and by completing this survey, you agree that your responses can be used as data in future studies or publications. If you have any questions, feel free to email me at urbansquirrelstudy@gmail.com.

Pets

1. Do you have a dog? Yes ____ No _____

   If so, how many? _____

   Is your dog primarily indoor or outdoor?
   Indoor ____ Outdoor ____ Both ________

   When your dog is outdoors, is it free to roam your yard, or is it restrained (on a leash, in a pen, etc.)?
   Free ____ Restrained ____ Both ______

2. Do you have a cat? Yes _____ No _____

   If so, how many? ______

   Is your cat primarily indoor or outdoor?
   Indoor ____ Outdoor ____ Both _______

Supplemental Food Sources

3. Do you have a bird feeder in your yard? Yes ____ No ___

   If so, how many? ______

For the time of year when food is provided, how often is the bird feeder filled, on average?
4 times per month or more ______ About 2 times per month _____
Monthly____ Every few months ____

Is food provided year-round or for only part of the year?
Year-round ____ Only part of the year _____

If food is only provided for part of the year, select each month that you typically provide food:
January _____
February _____
March _____
April _____
May _____
June _____
July _____
August _____
September _____
October _____
November _____
December _____

4. Do you provide food for wildlife other than birds? Yes ____ No ____

If so, describe the type(s) of food you provide: ___________

5. Do you have chickens in your yard? Yes _____ No _______

What type of feed do you give to your chickens? ________

Landscaping

6. Does your yard contain oak trees? Yes ____ No ___ Unsure ____

Use these pictures of oak leaves as references.

7. Does your yard contain walnut trees? Yes ___ No ___ Unsure ___

Use this picture of walnut leaves as a reference.

8. Approximately how much money do you spend annually on yard care?
Less than $100 ______ Between $100 and $300 ____
Between $300 and $500 _____ More than $500 ______

Tree Squirrel Sightings

9. Rank tree squirrel activity on your property during spring and summer months: Multiple times per day _____ Once per day _____
About 2-3 times per week ____ Every other week _____
No sightings ____

10. Please provide your street address. This information is necessary to match your responses with our observations of squirrel abundance. Although we have no intention or means of associating this address with your identity, it is possible that other people could make this connection if they were to see the results of this research. Providing your address may potentially compromise your anonymity, though this risk is remote.

Please provide your street address: ______________________________________

This upcoming section of questions is an important component of our research because it ensures that the data we collect are diverse and representative of the neighborhood. Your answers are encouraged but optional.

11. How long (in years) have you lived in your neighborhood? ___________

12. How many people live in your household? ________

How many are children (under age 18)? _________

13. Do you own your residence? Yes _____ No _____

14. Annual household income (before taxes):

Less than $10,000 ____
$10,000-$19,999 ____
$20,000-$29,999 ____
$30,000-$39,999 ____
$40,000-$49,999 ____
$50,000-$59,999 ____
$60,000-$79,999 ____
$80,000-$99,999 ____
$100,000 and above ____

Thank you very much for your time and participation!

Appendix B. Handout (front and back) that was distributed two different times to each residence along each of the five transects during the summer of 2015. It provided a link for citizen scientists to access the online questionnaire.

Front

Back

Urban Squirrel Survey

Hi, my name is Gabrielle, and I'm a Biology major at Butler University. In order to complete my research project this summer, **I need your help!**

My research is focused on how human activities impact urban squirrel populations, so I would greatly appreciate it if you took a few moments to fill out my **survey**! It should take 5 minutes or less.

Here is the link to my survey:

http://urbansquirrelstudy.limequery.com/index.php/927669/lang-en

Thank you very much for your time and participation! If you have any questions, feel free to check out this **article** for more information or email me any time at **urbansquirrelstudy@gmail.com.**

Appendix C.

Online flyer that was available to transect residents via Facebook and neighborhood associations if they wanted access to more background information about this study.

Page 1

Butler Summer Institute: How Human Activities Affect Urban Squirrel Population Distribution and Abundance

Urban Squirrel Study

Thank you so much for all of your interest and participation in my study; I could not complete my research without all of your help! Here is a link for my survey: http://urbansquirrelstudy.limequery.com/index.php/927669/lang-en

Feel free to email me at urbansquirrelstudy@gmail.com.

Fun Squirrel Facts!

Squirrels ....

*can rotate their feet 180°

*run as fast as 16.7mph

*have red-green color vision

*have body temperatures as high as 105° F

Facts courtesy of *North American Tree Squirrels*

My Journey to Squirrel Research

My name is Gabrielle, and I am a junior Biology major at Butler University. This summer, I am doing undergraduate research through Butler Summer Institute, under the direction of my faculty mentor, Dr. Carmen Salsbury. I have always had a passion for animals and conservation, so this research project really means a lot to me. Even when I was young, I was the kid that took stray cats under my wing and relocated insects off my driveway so that they wouldn't get crushed by cars. I love being outside in nature, and after Butler, I hope to go to graduate school to pursue a career in conservation or zoology.

Why Squirrels? Squirrels have adapted remarkably well to the rapidly changing conditions of an urban environment, and they are an iconic, easily observed animal to study. As we learn more about urban squirrel populations, we can apply that new information to other urban species and hopefully help urban animal populations survive and thrive in the future.

Appendix C

Page 2

How My Urban Squirrel Study Began

Although an urban landscape is definitely not a squirrel's natural environment, squirrels have managed to make Indianapolis their home.

I'm sure that you have probably seen squirrels running around Indy because they are very visible animals, often scurrying about and chattering with each other.

In a previous study, Dr. Salsbury found that certain areas of the neighborhoods had a higher squirrel presence than others, and this relationship could not be simply explained by the number of trees in the area. There had to be something more to this observation! With this study in mind, Dr. Salsbury suggested that future studies focus on the effects of human activities on squirrel populations.

This is the focus of my research. For my study, I bike five street routes, which include Boulevard, Capital, Central, Washington, and Illinois from 52nd St. to 38th St., counting the number of squirrel leaf nests and then marking the presence of squirrels. In order to be consistent, I bike the routes in both the mornings and late afternoons, when squirrels are typically most active.

Your Role as a Citizen Scientist

However, I still needed to find out how human activities were affecting squirrel distribution.

This is where your help would be very much appreciated! In order to help determine how human activities affect urban squirrel populations, I would love it if you could take a few moments and fill out my survey. It consists of a few questions about activities that could potentially affect where squirrels live, such as pets, landscaping, and bird feeders. Once these data are gathered, I can see if there is a relationship between certain human activities and the distribution of squirrels in these areas. If you have any questions, feel free to send me an email, and let me know if you would like to receive an email with the final results of my research.

2

Appendix D. Data from the leaf nests surveys conducted along each of the five transects in the 2015 and 2015-2016 seasons. The total number of nests in each parcel was tallied, and multiple nests in a tree were recorded, if applicable. Parcels with no leaf nests were excluded from these tables. The "2" column is for trees that held two leaf nests, the “3” column recorded trees that held three leaf nests, and the “4” column recorded trees that held four leaf nests.

2015

Boulevard				Capitol			Illinois				Washington					Central			
nests	1	2	3	nests	1	2	nests	1	2	3	nests	1	2	3	4	nests	1	2	3
1	1	0	0	1	1	0	1	1	0	0	1	1	0	0	0	1	1	0	0
2	2	0	0	1	1	0	1	1	0	0	1	1	0	0	0	1	1	0	0
1	1	0	0	1	1	0	1	1	0	0	3	1	1	0	0	1	1	0	0
2	0	1	0	1	1	0	1	1	0	0	2	2	0	0	0	1	1	0	0
2	0	1	0	1	1	0	3	3	0	0	1	1	0	0	0	1	1	0	0
2	2	0	0	1	1	0	1	1	0	0	1	1	0	0	0	1	1	0	0
3	0	0	1	1	1	0	1	1	0	0	8	1	0	1	1	1	1	0	0
1	1	0	0	1	1	0	1	1	0	0	3	3	0	0	0	1	1	0	0
2	2	0	0	1	1	0	3	3	0	0	4	2	1	0	0	1	1	0	0
3	1	1	0	2	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0
2	0	1	0	1	1	0	1	1	0	0	4	0	0	0	1	3	1	1	0
4	1	0	1	3	3	0	4	1	0	1	1	1	0	0	0	1	1	0	0
2	2	0	0	1	1	0	1	1	0	0	1	1	0	0	0	1	1	0	0
1	1	0	0	1	1	0	3	0	0	1	1	1	0	0	0	3	0	0	1
1	1	0	0	1	1	0	1	1	0	0	1	1	0	0	0	1	1	0	0
1	1	0	0	1	1	0	2	0	1	0	1	1	0	0	0	2	0	1	0
2	2	0	0	1	1	0					2	0	1	0	0	1	1	0	0
1	1	0	0	1	1	0					5	1	0	0	1				
1	1	0	0	1	1	0					1	1	0	0	0				
1	1	0	0								3	1	1	0	0				
1	1	0	0								1	1	0	0	0				
1	1	0	0								1	1	0	0	0				
2	2	0	0								2	0	1	0	0				
1	1	0	0								1	1	0	0	0				
1	1	0	0								1	1	0	0	0				
											1	1	0	0	0				
											1	1	0	0	0				
											1	1	0	0	0				
											3	1	1	0	0				
											2	0	1	0	0				

Appendix D.

2015-2016

Boulevard				Capitol			Illinois			Washington			Central		
nests	1	2	3	nests	1	2	nests	1	2	nests	1	2	nests	1	2
1	1	0	0	1	1	0	1	1	0	1	1	0	1	1	0
3	1	1	0	1	1	0	1	1	0	2	0	1	1	1	0
2	2	0	0	1	1	0	1	1	0	1	1	0	1	1	0
1	1	0	0	1	1	0	2	2	0	2	2	0	2	0	1
1	1	0	0	3	1	1	5	3	1	4	2	1	1	1	0
2	2	0	0	1	1	0	2	2	0	1	1	0	2	0	1
3	0	0	1	1	1	0	1	1	0	2	0	1	2	0	1
1	1	0	0	2	2	0	2	2	0	1	1	0	1	1	0
3	0	0	1	1	1	0	1	1	0	1	1	0	1	1	0
6	3	0	1	1	1	0	2	2	0	1	1	0	1	1	0
1	1	0	0	1	1	0	1	1	0	1	1	0			
1	1	0	0				1	1	0	1	1	0			
1	1	0	0				1	1	0	1	1	0			
1	1	0	0				1	1	0	1	1	0			
2	2	0	0				1	1	0	1	1	0			
1	1	0	0				1	1	0	2	2	0			
1	1	0	0				1	1	0						
2	0	1	0												
1	1	0	0												
1	1	0	0												

Appendix E. Data from the squirrel activity surveys conducted from May 19, 2015 through July 2, 2015 along the Boulevard (BV), Capitol (CP), Illinois (IL), Washington (WA), and Central (CN) transects. The numbers one through ten in the column furthest to the left designate the ten block units for each of the transects, with one being the southernmost end of the transect and ten being the northernmost block unit. The dates of the squirrel activity surveys are provided in the top row.

BV	5/19	5/20	5/21	5/22	5/26	5/27	5/28	5/29	6/1	6/2	6/3	6/4	6/5	6/8	6/9	6/10	6/11	6/12	6/15	6/16	6/18	6/22	6/23	6/24	6/25	6/26	6/30	7/1	7/2
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	3	2	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
8	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix E

CP	5/19	5/20	5/21	5/22	5/26	5/27	5/28	5/29	6/1	6/2	6/3	6/4	6/5	6/8	6/9	6/10	6/11	6/12	6/15	6/16	6/18	6/22	6/23	6/24	6/25	6/26	6/30	7/1	7/2
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	2	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
6	1	0	0	6	1	3	0	2	0	14	3	2	6	0	1	1	4	0	3	0	0	2	4	0	0	2	2	0	1
7	1	0	4	0	0	1	0	3	0	0	0	0	0	1	2	0	1	3	0	0	0	0	0	1	0	0	0	0	0
8	0	0	0	2	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
9	0	0	1	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix E

IL	5/19	5/20	5/21	5/22	5/26	5/27	5/28	5/29	6/1	6/2	6/3	6/4	6/5	6/8	6/9	6/10	6/11	6/12	6/15	6/16	6/18	6/22	6/23	6/24	6/25	6/26	6/30	7/1	7/2
1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	1	0
3	0	0	0	0	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4	0	0	0	0	0	4	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	1	1	1	0	1	0	1	0	1	0	1	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0
6	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
7	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	2	0	3	0	1	1	0	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix E

WA	5/19	5/20	5/21	5/22	5/26	5/27	5/28	5/29	6/1	6/2	6/3	6/4	6/5	6/8	6/9	6/10	6/11	6/12	6/15	6/16	6/18	6/22	6/23	6/24	6/25	6/26	6/30	7/1	7/2
1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	1	3	0	0	1	0	0	0	0	0
2	0	1	2	0	3	0	1	2	0	0	1	0	0	0	1	3	1	0	0	0	2	1	0	2	0	0	0	0	0
3	0	2	1	1	1	0	1	1	0	1	0	1	2	0	1	1	0	0	1	1	0	0	0	0	1	2	0	0	0
4	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1	2	0	1	0	0	1	0	0	0	0	0	1	0	0
5	0	1	3	2	5	3	1	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
7	0	1	1	0	1	2	0	2	0	0	0	0	2	1	0	0	0	0	5	0	0	0	0	0	0	0	1	1	0
8	0	0	0	0	0	0	0	8	1	1	0	0	0	0	2	0	1	0	0	0	1	2	0	2	0	0	1	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix E

CN	5/19	5/20	5/21	5/22	5/26	5/27	5/28	5/29	6/1	6/2	6/3	6/4	6/5	6/8	6/9	6/10	6/11	6/12	6/15	6/16	6/18	6/22	6/23	6/24	6/25	6/26	6/30	7/1	7/2
1	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	2	1	0	0	0	2	0	0	1	2	1	0	0	0	0	1	0	0	0	0	0	0	0
3	0	0	0	0	1	0	1	2	0	0	0	1	0	0	0	1	2	0	1	5	0	0	0	0	1	0	1	0	0
4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6	1	0	0	0	1	0	1	2	0	1	0
5	0	0	0	0	0	0	1	1	0	1	0	3	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
6	0	0	0	0	0	0	2	3	0	0	0	1	1	0	0	0	0	0	0	1	1	1	3	0	0	0	0	1	3
7	0	0	0	0	1	0	0	1	0	0	0	3	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
8	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0