# The relationship between white-tailed deer, ground cover, and proximity to residences

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**Abstract**

Overpopulation of white-tailed deer (*Odocoileus virginianus*) in North America has led to vast effects on vegetation growth and diversity, as well detrimental human-wildlife interactions, such as automobile accidents. The goal of our study was to determine how deer density, activity, and vegetative cover varied across an urban nature preserve in relation to roads, neighborhoods, and a field station. We used camera traps to estimate deer population density and activity across Wild Basin Wilderness Preserve in Austin, Texas. We gathered this information by calculating the angle of detection along with data on average velocity and group size in the preserve. To estimate plant species diversity we established vegetation plots around the camera traps and identified plant species and average height. We found a significant positive correlation between deer activity and vegetation height (rho = 0.84, p = 0.036) and a near significant negative correlation between deer density and residential areas (rho = -0.828, p = 0.058). These results suggest that with an increase in grass height there is more deer activity and with a decrease in proximity to residential areas there is a decrease in deer density. The findings are vital for understanding spatial variation in the movement and distribution of white-tailed deer, which can influence the plant communities through grazing effects. Our results can be used to improve management practices, particularly in urban landscapes where deer density is high. As many urban areas are currently increasing the protection of green space within the city, is critical for both the well being of ecosystems and human society to understand how the dominant large mammalian herbivore in North America can be effectively managed in these systems.

**Overview**

Human population growth and development leads to increased interactions between humans and wildlife. These interactions in turn change the way organisms interact with each other and their environment (Chace et al, 2006). These interactions are studied for their effects on the human population and the study of anthropogenic effects on the ecosystems. For example, in China there are an increasing number of conflicts between local herders and the Tibetan brown bear (Worthy & Foggin, 2008). These interactions were said to have increased due to the depletion of the Tibetan brown bear's main food source, the pika which was depleted by human removal of the species with the pretense that the pika was overgrazing large areas of the Tibetan plateau. Another important human-wildlife interaction that is highly studied is the spread of zoonotic diseases. Many efforts are being made to inform the public on the impact of zoonotic diseases for both humans and wildlife (Decker et al., 2010). These interactions can be problematic for both sides. Human life can be detrimentally affected by wildlife attacks or epidemics of zoonotic diseases. In return, wildlife can be affected by culling and hunts organized in retaliation to the effects on human life. An example of human-wildlife interactions affecting both sides is the Ebola outbreak. Ebola has affected both primate populations and human populations. In 2006, approximately 5,000 gorillas were killed by the epidemic. This outbreak also decimated a great number of villages in the Congo (Bermejo et al., 2006).

The overpopulation of white-tailed deer throughout the U.S. has led to vast effects on the vegetation growth and diversity, as well as an increase in human-wildlife interactions such as automobile accidents (Blackwell et al, 2014 & Côte et al, 2004). White-tailed deer can reproduce rapidly in favorable environments and can inhabit a wide range of habitats (Rooney et al, 2002). Over the past several decades the white-tailed deer population has been increasing, yet their habitat has been steadily decreasing. Many management approaches have aimed to maintain lower populations of deer through different techniques, such as culling and bow hunts (McShea, 2012), however, increased deer densities leads to increased human-wildlife conflict particularly as their habitat becomes smaller. The white-tailed deer act as keystone herbivores that can alter

ecological communities in either a positive or negative way (Waller et al, 1997). White-tailed deer can cause structural changes in the forests as they eat leaf buds, saplings, grasses, fruits, and flowers, which in turn affect the ability of plants to survive (Embleton, 1993). The deer feed on the understory forbs and shrubs seedlings preventing plants from growing and reproducing. However, low densities of deer may be favorable for vegetation growth and diversity (Trdan et al, 2008).

White-tailed deer have a varied diet; they consume leaves, twigs, nuts, fruits, grass, some fungi, and lichens in order to gain nutritional substance (Tilghman, 1989). Previous studies on foraging pressures have concentrated on species composition and grazing effects using enclosure experiments (Augustine & Frelich, 1998). These experiments show that grazing by deer could have substantial effects on vegetation composition and structure leading to long-term effects in the fitness of many plant species initiating a trophic cascade. A culmination of interactions can be seen in the white-tailed deer populations when there is an overabundance of deer leading to severe impacts on understory vegetation and inhibition of forest renewal (McShea et al. 1993). Through this deer can reduce biomass and diversity, which then limits food availability for other herbivores (Webb et al.1956; McShea et al. 1993; Tierson et al. 1996).

Deer will graze in areas that supply them with the greatest amount of nutrients, which is typically around agriculturally developed areas. Many deer also wander to residential areas in order to supplement their diets and can cause the spread of exotic species from gardens to suburban areas (Williams, Ward, & Ramakrishnan, 2008). Therefore, it is important to study white-tailed deer and their effects on vegetation in urban preserves where human-wildlife interactions are frequent. Understanding vegetation usage by white-tailed deer may allow for increased prevention of negative human-wildlife interactions like sever car accidents. Therefore, the goals of our study were twofold: (1) determine how deer density, activity, and available plant forage vary across an urban preserve, and (2) identify possible variables that could affect deer density such as proximity of area to creek, humans and predator activity.

## Methodology

*Study species*

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The white-tailed deer (*Odocoileus virginianus*) is a medium sized deer that is currently the most abundant and recognizable deer species in North America as they can be found anywhere between southern Canada to South America (Cummings, J. 2010). The white-tailed deer belongs to the family Cervidae, which appeared around thirty five million years ago. Over time the Cervidae family deer in North America split into the genus *Odocoileus*. Mule deer and white-tailed deer fall under the genus *Odocoileus* by being native to the Americas and having similar features. They inhabit a large range of habitats from fields and meadows during the summer to dense forest cover during the winter months (Cummings, J. 2010). White-tailed deer in the United States range in size from 27 to 75 inches in height. The bucks (males) are much larger in body weight and size than the does (females). Individuals that live near agriculturally developed areas generally have a higher body weight and size, as the food has better quality nutrients when compared to other non-agriculturally developed regions. (Orth et al, 2002).

Higher deer densities can have detrimental effects on vegetation, which can translate to other trophic levels (McShea, 2012). Browsing and grazing by the white-tailed deer causes most of the damage when the density of the population is large while a small deer density would show no visible long-term effects (Embleton, 1993). The carrying capacity of the land is only able to sustain a number of organisms in a given area. Long term browsing pressure can limit the regrowth of forest plants and herbaceous plants that give rise to indirect effects on the physical landscape (Rooney et al, 2002). White-tailed deer are opportunistic foragers who are able to eat a large variety of plants; nevertheless, they do show preference towards certain food items. For example they seem to prefer acorns, sugar maple leaves and alfalfa growing in the habitat (Embleton, 1993).

*Study Site*

We examined the white-tailed deer population at the Wild Basin Wilderness Preserve, which is a 227 acre urban preserve. The Basin is part of the Balcones

Canyonland Preserve (BCP) located in Travis County, Texas. The BCP is home to many endangered species and is managed jointly by the county and the city of Austin ("The Balcones Canyonlands Preserve," 2014). We specifically looked at the density of deer through the preserve as well as the average grass height and species richness at each of our locations. This is particularly important due to the damaging effects deer can have on vegetation diversity and fitness (Rooney, 2002). This location provides a space where the deer can interact with the environment while also having some human interactions through highways, residential areas, and trails. In addition, there will be little competition from other ungulates or larger herbivores. Austin is a growing city and people continue to move to this area for jobs and school. This could increase interactions between the human population and wildlife. Increased urbanization also leads to pressures on the fauna and flora of the area, and may have positive or negative effects on populations.

*Deer Density*

We chose to use the techniques described by Rowcliffe (2013) for our density measurements because it is a newer technique that is less invasive. This technique utilizes camera traps and is shown to be as effective as more invasive techniques, such as mark recapturing and spotlight surveys. By calculating the trapping rate or, the number of encounters between the camera and the organism of interest, we could estimate with high accuracy the approximate density of deer in the area. This method is particularly interesting because, unlike mark re-capture techniques, it is minimally invasive and there is no need for individual identification. The cameras were set up along a grid system that was generated using ArcGIS by the Wild Basin Creative Research Center to begin long-term data collection.

Before we could use this technique we had to measure the parameters needed for the density calculations: the detection distance $r$, the detection arc $\theta$, the velocity of the deer, and the average group size. Detection distance $r$, is the distance perpendicular to the camera at which the infrared sensors become active. Measuring the parallel distance that is detected by the camera derives the detection arc θ. We determined these values by placing the camera in set up mode and walking perpendicular and parallel to the camera and measuring these distances using a measuring tape. This process was done to each

individual camera. The velocity of the deer as described by Rowcliffe, is measured by estimating the average day range of the deer. The average group size is determined by walking transects and recording the number of individuals seen in a group. However, we were able to base our knowledge on average group size through literary review and have found the average number of individuals to be 1 deer per every 12 acres to maximize fitness (Lagory, 1986). Once we have calculated the approximate deer densities at each location on the grid, we created an activity map through ArcGIS. Our group also measured deer activity, which is a calculation of individuals per unit of time, in contrast to deer density, a measure of individuals per area. Each deer seen at the camera trap location was calculated and averaged per week to find activity levels for the 6 Grid Cam locations.

*Vegetation*

The vegetation plots were set around the camera traps points. We used the tree that had the camera trap as the center and used a circular area with a 10 meter diameter as our plot. In order to get information on the species richness and average grass height we used a falling plate meter (Figure 1), which measures the height of the forage using a weighted plate to find the forage availability. After measuring the height of vegetation we used a species identification book to document the individual plant species and species richness of the overall vegetation seen. A falling plate meter was made from 0.22-inch piece of cardboard cut to a 12x12 inch square. The plate also requires a yardstick, drill, and string to obtain an average forage height. The plate was slowly lowered on to the vegetation in the plot and the height was recorded (Lemus, Parish, & Parish, 2008). We also took note of the species of grasses within the plot and the number of times those species were seen within the falling plate measurement.

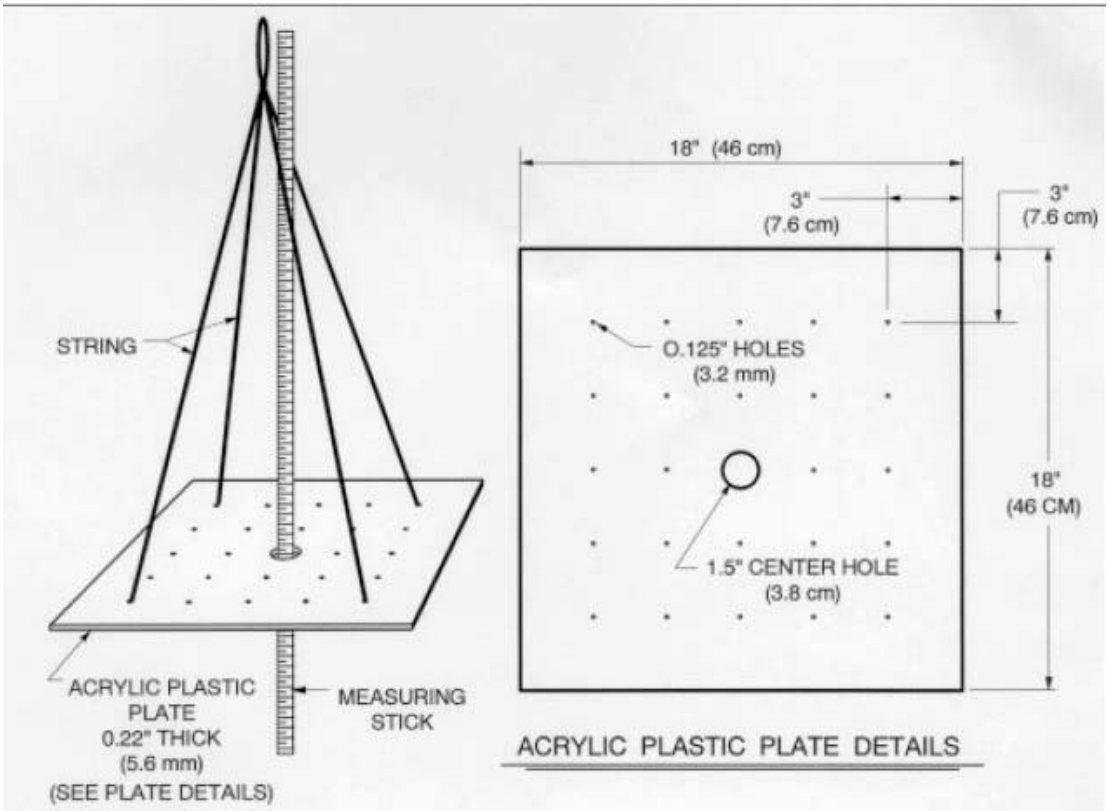


Figure 1: Falling plate meter schematics (Rayburm and Lozier, 2003)

We collected 10 points at each site and this was done on 3 separate occasions for a total of 30 points within a plot. The points were designated through a random number generator.

*Statistics*

We gathered data from ArcGIS such as elevation of each point, distance of each point to trails, roads, residential areas, and creeks, and percent canopy cover. We used R, to look at relationships between these variables. We made pairwise comparisons between all of our variables. We used Spearman's correlations to look more in depth at our more important relationships. We also used ArcGIS to create visual representations of activity levels and deer density.

## Results

*White-tailed Deer Density*

With the use of the formula developed by Rowcliffe, we estimated the average deer density at Wild Basin to be 0.1456 deer/acre, which is similar to the previous estimate of 0.1128 deer/acre derived from the spotlight surveys. Figure 2 shows the density at each point studied, the size of the point signifies the relative density at each point. Larger points, such as point eleven, shows higher deer densities, while smaller points such as point 2 indicates a lower deer density. These results show that the greatest densities are in areas that are closer to human activity such as residential areas.

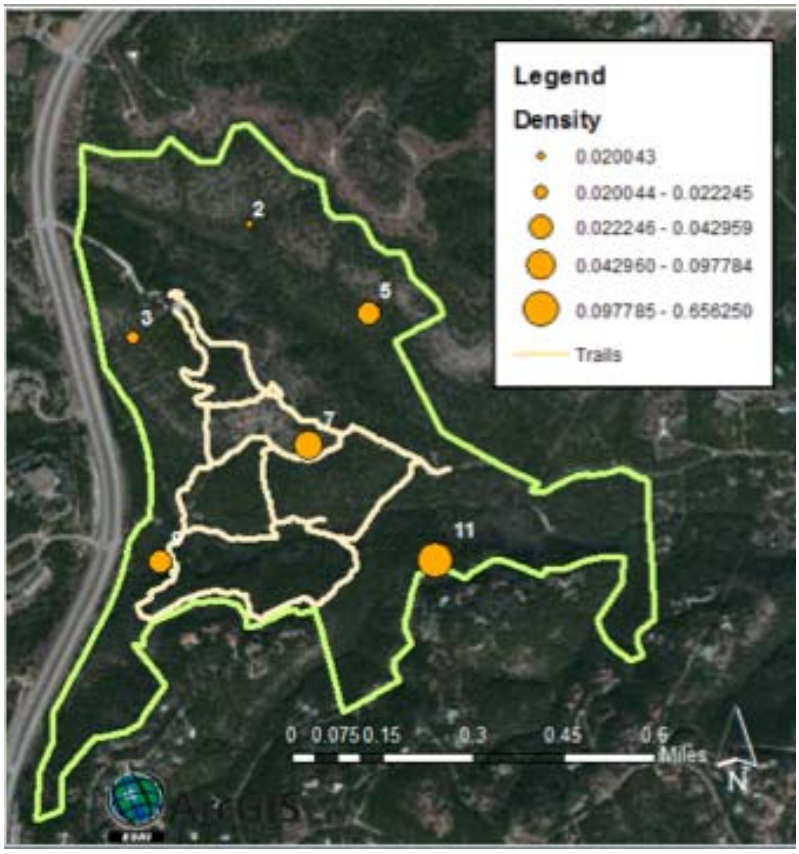


Figure 2. White-tailed deer grid camera locations and density estimation. The density was estimated using the formula developed by Rowcliffe, which takes into account trapping rates, angle of detection, velocity, and average group size of the species being studied. The estimation for average density is 0.1128-deer/acre ± 0.251749782. Some points had

higher density (Grid Cam 11), while other points had lower density (Grid Cam 2).

*Vegetative Ground Coverage by Grid Cam Locations*

Eight different species of grasses were seen when conducting vegetation measurements with the Falling Plate, as well as rocks and plant litter. The species seen were Curly Mesquite (*Hilaria belangeri*), Hairy grama (*Bouteloua hirsuta*), Moss (*Bryophyta*), Poverty Oatgrass (*Danthonia spicata*), St. Augustine (*Stenotaphrum secundatum*), Texas Prairie Dawn (*Hymenoxys texana*), Texas Snakeweed (*Gutierrezia texana*), Texas Wintergrass (*Nassella leucotricha*). The Camera Trap locations showing the highest variation of species richness are Grid Cam 5, Grid Cam 7 and Grid Cam 11 (Figure 3).

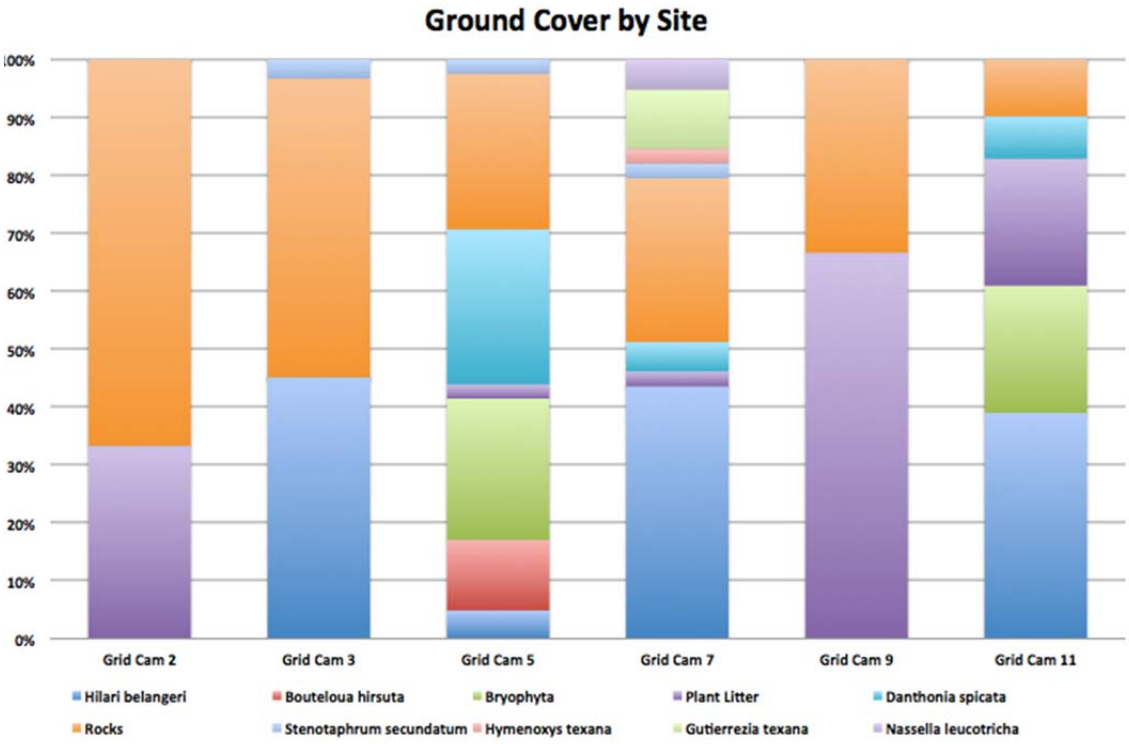


Figure 3. Vegetative ground coverage based on Grid Cam locations. There were a total of 8 species of grasses seen within the plots that we studied. Some locations had no grass coverage, such as Grid Cam 2, where rocks and plant litter covered most of the ground. Grid Cam 5, Grid Cam 7 and Grid Cam 11 showed the most species richness out of the six plots.

*Deer Activity and Vegetation*

Using R, we ran a Spearman's Correlation and found that areas with higher vegetation levels also showed an increase in white-tailed deer activity (Figure 4; rho=0.84066; p=0.03606). Grid Cam 11 exhibits the highest deer sightings per week and was also one of the locations with the highest average grass heights. Areas that had low deer activity also had no grass coverage. These locations were Grid Cam 2 and Grid Cam 9, which were comprised of rocks and plant litter.

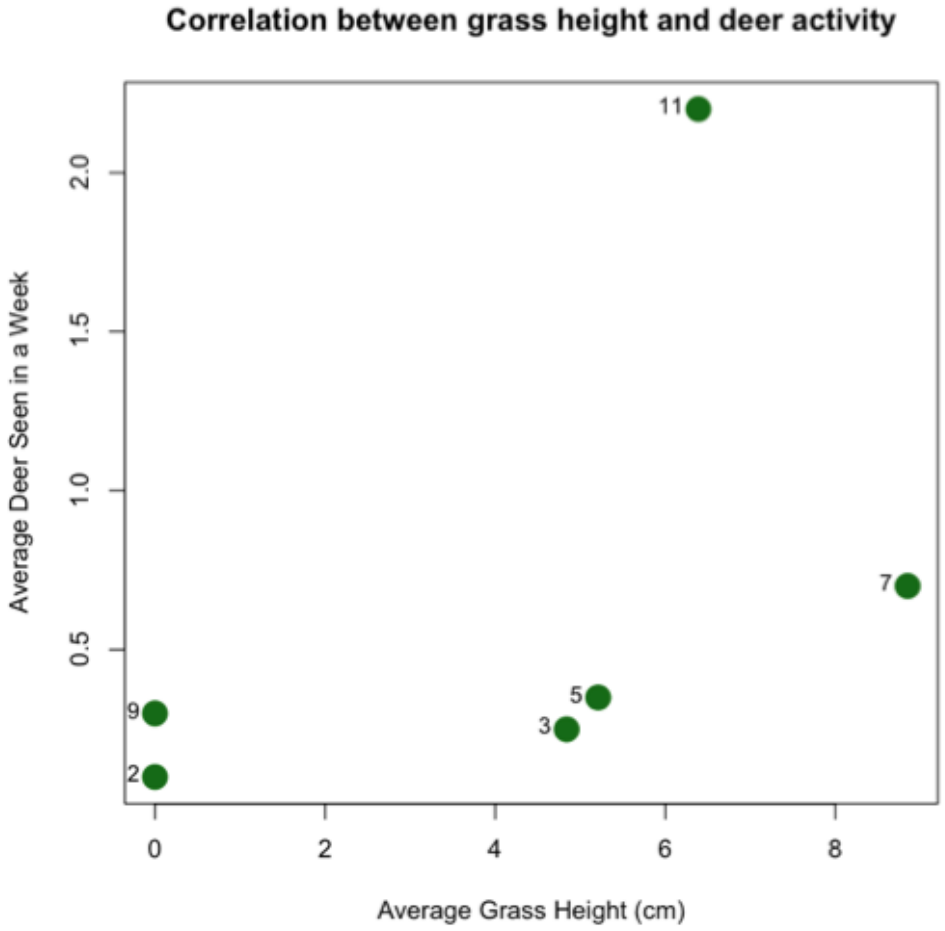


Figure 4. Correlations between grass height and deer activity based on Grid Cam locations. Locations that had increased deer activity also show increased grass height. A

Spearman's correlation shows a significant relationship between these two variables (rho= 0.84066, p-value=0.03606)

*Deer and Distance to Residential Areas*

Another relationship that we explored was average deer activity per week and distance of grid camera to nearest residential homes. Our results show that deer activity was highest at points that were closest to residential areas. Grid Cam 11, showed the highest deer activity and closest point to residential homes. The points that were further away from residential areas showed lower deer activity. We used a Spearman's correlation to look at this relationship, and we found that there is a near significant negative correlation between distance to residential areas and deer activity (rho= -0.8286, p-value=0.05833). As seen in figure 5, points that are further from the residential areas show lower deer activity.

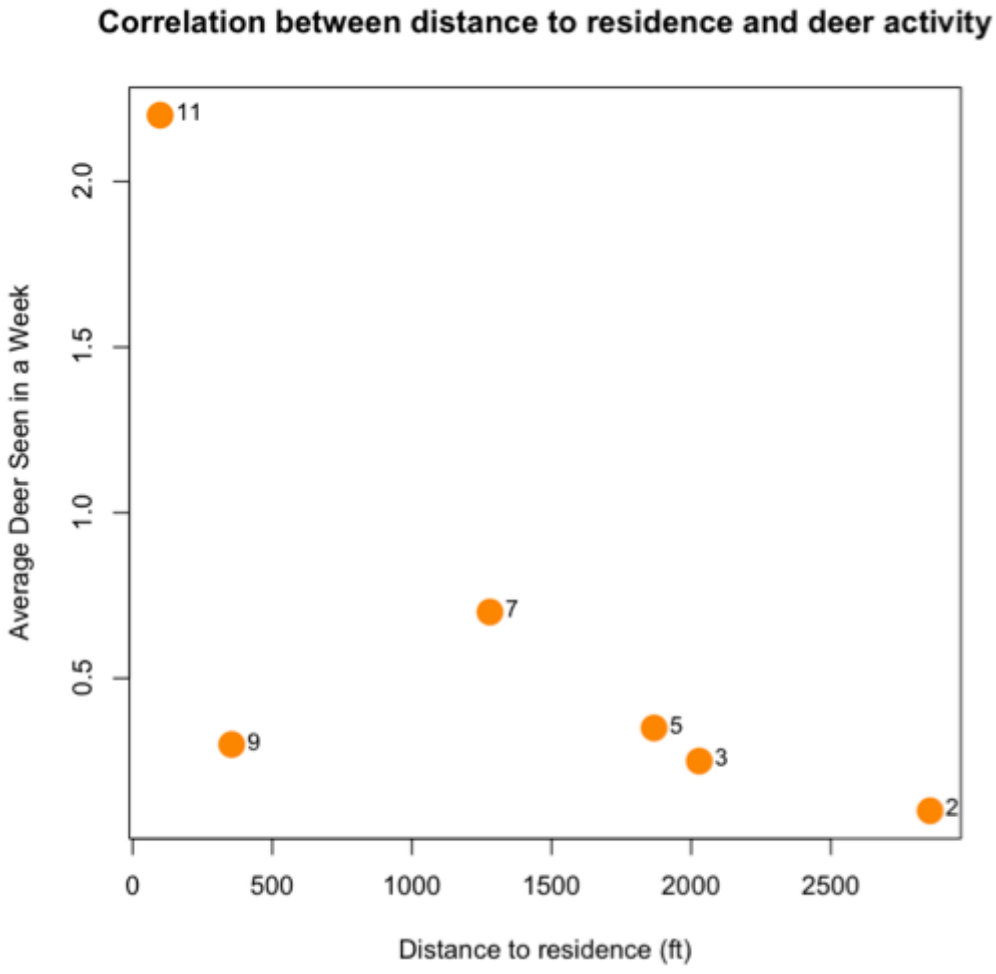

Figure 5. Correlation between distance to residential area and deer activity at Grid Cam locations. Distance to residence (in feet) was calculated using ArcGIS. Points that were closer to residential areas showed higher deer activity. Using a Spearman's correlation we found that there is a near significant negative relationship between average deer seen per week and distance to nearest residence (rho=-0.8286, p-value=0.05833).

*Carnivore Activity*

The two major carnivores in this area are coyotes and bobcats. We looked at relationships between deer activity and carnivore activity. There was no significant relationship between carnivore activity and deer activity (Bobcat: rho= 0.0294, p-value=0.9559; Coyote: rho=0.2571, p-value= 0.6583). However, there was a relationship between coyote activity and bobcat activity. We ran a Spearman's correlations between the bobcat and the coyote activity and found that these carnivores seem to be using similar areas (rho= 0.971, p-value=0.001). Using ArcGIS, we were able to visualize the activity levels of these carnivores (figure 6a and 6b).

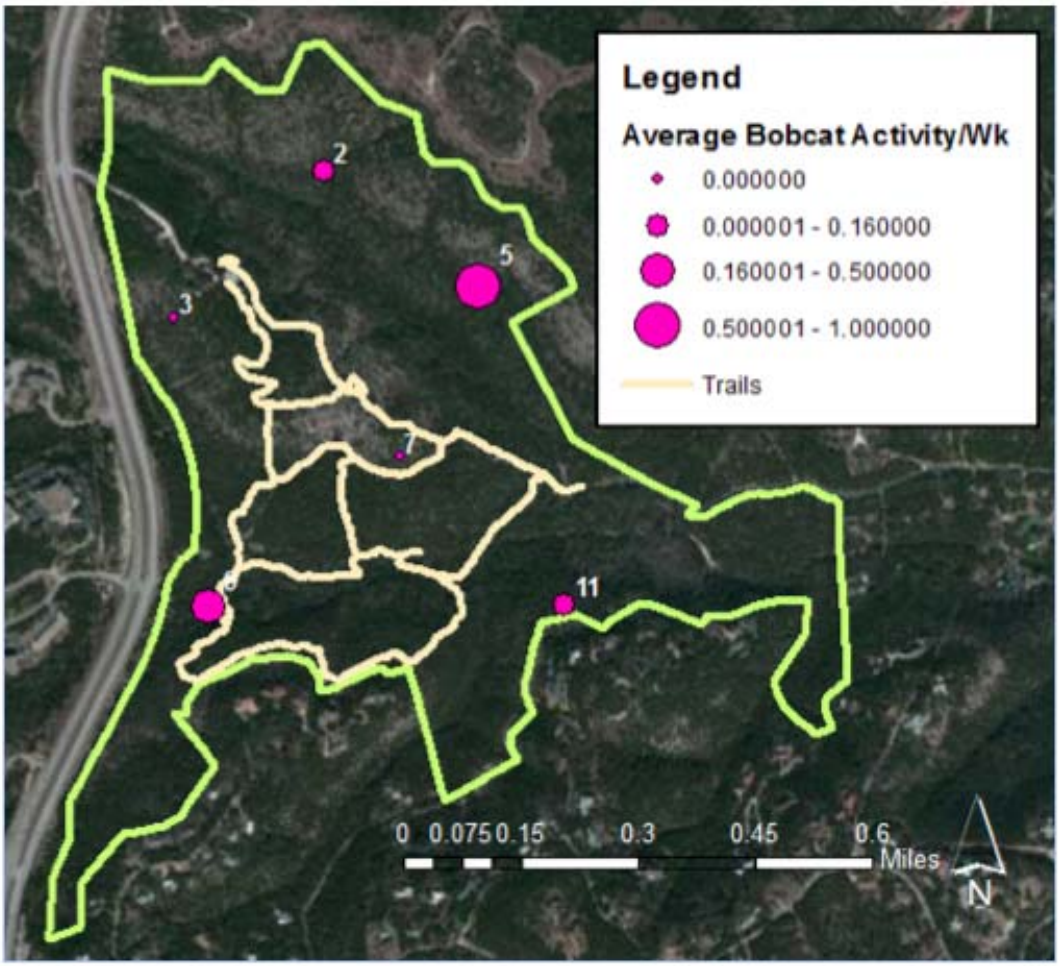


Figure 6a. Average Bobcat sighting per week at each grid camera location. Size of point indicates activity level at each location. Larger points indicate higher bobcat activity while smaller points indicate low activity levels.

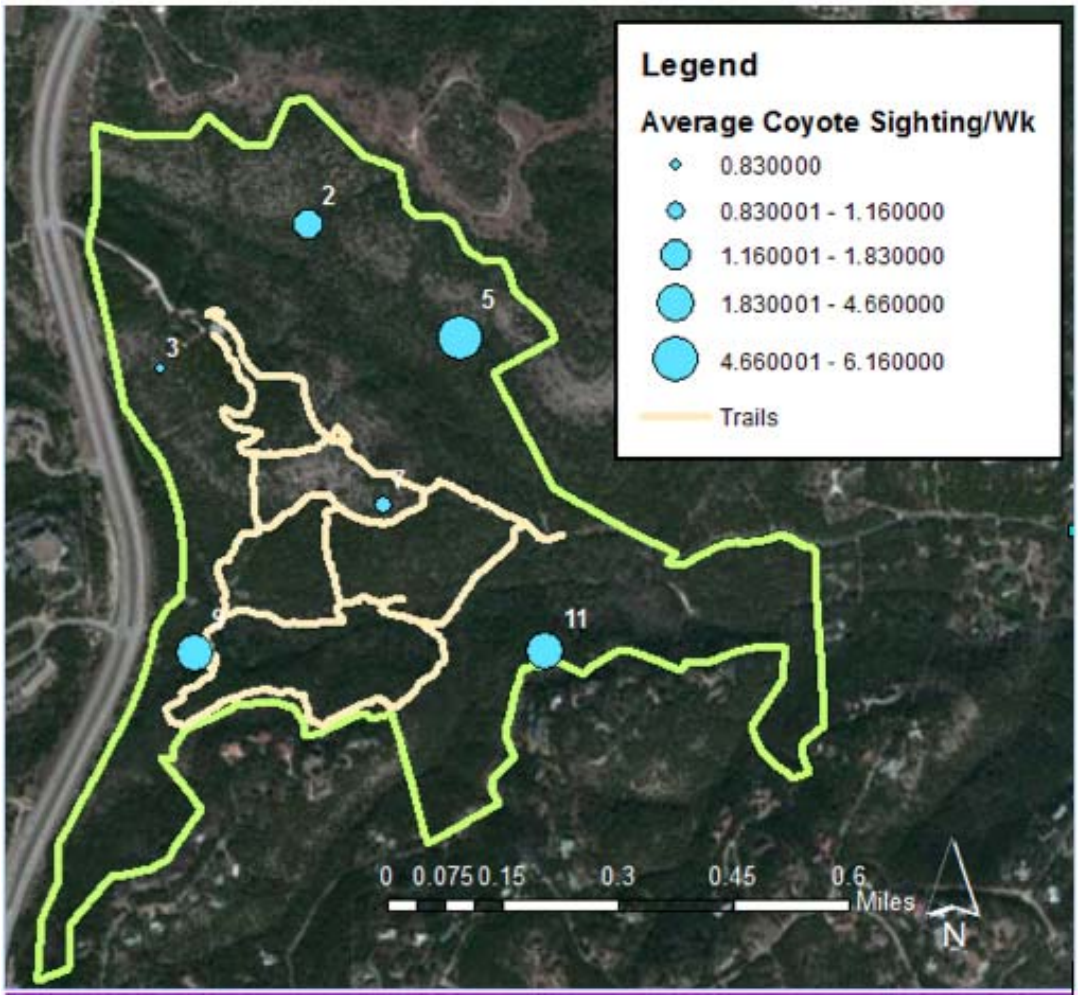


Figure 6b. Average coyote sightings per week at each grid camera location. The size of the point indicates activity levels at each location. Larger points indicate higher coyote activity while smaller points indicate lower activity levels.

**Discussion**

The study of white-tailed deer has become of increased importance due to population growth and a need to assess appropriate management techniques to mitigate human and wildlife conflict. By using noninvasive techniques to collect data on deer density, deer activity, and vegetation at six points in Wild Basin, we were able to identify key factors that may affect wildlife populations such as vegetation growth, proximity to human activity and predation. When analyzing vegetative species richness it appears that areas with a greater number of vegetation species and increased vegetation height show a

higher activity level of deer, as seen on the grid system. Our project is part of a long-term study that aims to gather data on biodiversity and ecosystem health of the Wild Basin Wilderness Preserve through increasing our awareness of the species present and their interactions within the preserve.

White-tailed deer density in Wild Basin was higher near residential areas which were also areas that showed higher average grass height and species diversity. Residential areas could be influencing the health of these ecosystems through gardening and fertilizer runoff or introduction of various other plant species from residential gardens. These gardens could also be attracting more pollinators to these areas, increasing the species richness and biodiversity of the regions surrounding residential gardens (Comba, Corbet, Hunt, & Warren, 1999). Our deer population density estimation is comparable to previous estimations of this area, suggesting that the non-invasive techniques, despite their limitations, could be useful in creating rough estimates of densities for large herbivores. In addition, this technique could be applied to other organisms in the preserve such as coyotes, bobcats, roadrunners, fox, and other medium to large sized species. The technique used does have major assumptions that limit its effectiveness in real life applications. For example, the model assumes that the study site is enclosed, and that there is no major dispersal involved. While Wild Basin does have fences, we cannot assume with complete certainty that there is no movement of organisms in and out of the park. In addition, we had to establish rules while going through the camera traps that defined a sighting. For example, if an individual came into the capture area and left, it would count as a single individual sighting. However, if an individual left the capture area and came back into the area within 15 minutes we would consider that a unique sighting. This allowed us to avoid pseudo replication or duplicating individuals within a sighting. The number of sightings was used for both our density estimations and our activity estimations.

Our sample size was fairly small for a preserve of this size, however, our study pinpoints important relationships that future studies can build upon and define their focus towards. For example, our data found a correlation between vegetation height and deer activity, as well as, deer activity and distance to residence. These relationships can be

further explored with more camera traps and a more in depth analysis of the vegetation at each point. In addition, with more data points we could run a regression analysis between the variables (vegetation and proximity to residences) in order to establish the importance of each variable in this system. From our results, we saw that each point had different species composition of grasses, which suggests there may be different communities within the preserve. The low densities of white-tailed deer in Wild Basin may not create visible effects within the plant diversity however they may be controlling populations of plants that would be overabundant (Embleton, 1993).

The interactions between predators and prey in Wild Basin show a relationship within predator and prey land usage, species activity level and population density. This differential land usage could be caused by anthropogenic impacts, which have led prey towards taking refuge closer to residential areas. Predators wanting to minimize their spatial overlap with humans are also attempting to maximize their spatial overlap with their prey. In contrast, prey species want to maximize their overlap with humans to avoid predation and increase their probability of acquiring higher nutritional quality through gardens and increased vegetation availability (Muhly, T. B., Semeniuk, C., Massolo, A., Hickman, L., & Musiani, M. 2011). This phenomenon can be seen in our data as the camera trap locations closer to residential areas had the high deer density levels and low carnivore activity levels. A reason for this could be deer increasing their comfort with humans while using them for protective purposes as carnivores try to maximize their spatial overlap with their prey.

Through increased sampling we can determine other relationships that might be of importance to Wild Basin. In addition, we could aid in a more precise definition of the communities and the species that inhabit the preserve. This is of particular importance due to the uniqueness of Wild Basin as an urban preserve where people come to interact with nature. Wild Basin can support a diverse web of interacting species in a modern, increasingly urbanized landscape. We can use non-invasive techniques to study these communities and allow us to make better management decisions that can continue to support and preserve the diversity and uniqueness of Wild Basin Wilderness Preserve.

**Implications for Wild Basin and Future Studies**

Our results can lead to exploring correlations between nutritional quality in areas throughout Wild Basin as well as residential areas to gain more insight on the value of vegetation in the Grid Cam locations. Collecting vegetation samples for assessment on the nutritional quality through chemical analysis offers information on the nutritional value of each species. Wild Basin can attempt to plant higher nutritional quality species throughout the preserve with hopes of increasing white-tailed deer activity while mitigating the possibility of deer travelling to residential homes to acquire possible garden foods. This information can offer insight on the white-tailed deer population and spatial migration in the Wild Basin preserve. We can then further assess if white-tailed deer are more likely to visit these areas due to a potential lack of predators or higher quality food. Through increased sampling and vegetation collection we can run a chemical analysis on the plant species to gather information on the nutritional value of each species found within our study. We can also collect more camera trap photos to gather further information on white-tailed deer and predatory interactions. With increased sampling within these areas we can run a multiple regression to designate if the vegetative composition or avoidance of predation is determining an increased activity of white-tailed deer in residential areas surrounding Wild Basin. Based on this information, we can find solutions to human and wildlife conflicts that occur with an increase in human activity in areas with a high proximity to wildlife at Wild Basin. Through these solutions we can better assess how to maintain and possibly increase species richness and biodiversity at Wild Basin, thus increasing ecosystem services provided to the Austin, Texas area.

The broader impacts held within this project are to inform the Wild Basin and Austin community on how to coexist with the white-tailed deer population while maintaining the livelihood of the species through a continuing threat of environmental challenges in the upcoming years. With this data we hope to increase the awareness of how to cohabit with species residing in areas with heightened urbanization to maintain a balance of urban areas and natural landscapes and species.

Possible solutions involve planting the white-tailed deer preferred vegetation along the border of Wild Basin near residential homes. The residential vegetation should

be consumed less due to an increased availability of nutrient rich grasses in Wild Basin. By planting this vegetation we can mitigate migratory effects of white-tailed deer leaving the preserve thus, decreasing potential automobile accidents that occur with increased human-wildlife interactions. We could then conduct a study on white-tailed deer cortisol levels throughout Wild Basin, in order to gather information on potential stressors that may have a negative impact on white-tailed deer in relation to increased human activity in the area. If we are able to understand the cortisol levels of white-tailed deer at the basin we can increase conservation by allowing researchers to quantify the impact of humans and various other stressors such as construction, soundscape increased by the highway or predation on wildlife within a public space. Possible hypotheses for conducting white-tailed deer cortisol analysis could show that either 1) deer cortisol levels may be higher in areas centrally located due to a higher risk of predation and less available grass variation 2) cortisol levels may be higher in areas closer to residential areas due to an increase in human and wildlife conflict or 3) cortisol levels may be higher in regions closer to the highway due to various stressors such as an increase in soundscape. By conducting this research we can modify management plans to limit stress levels at Wild Basin and increase deer activity throughout the region

Wild Basin is a unique area to conduct this study due to the increasing levels of urbanization surrounding the preserve, which can lead to an increase in experienced stress. The white-tailed deer is a highly important species to analyze cortisol levels due to their role as a keystone species. If the deer experience an increase in stress they may become unhealthy which can ultimately lead to a lack of health within their ecosystem thus, negatively affecting various other species that share this habitat and decreasing the overall state of fitness and conservation within the basin.

By using our current search as a baseline to further explore areas to increase vegetation and conduct cortisol analysis of the white-tailed deer we can offer advice to the City of Austin on various ways to mitigate automobile accidents and negative human-wildlife interactions in this area. We can offer assistance to the city by advising the council on adding signs stating migratory patterns of the white-tailed deer and warning

drivers to be particularly careful in certain areas. If the city can produce signage we can potentially increase safety for humans, white-tailed deer and the Wild Basin ecosystem.

Future studies can use our data as a baseline for possible research such as an assessment of the nutritional value of vegetation in various areas of Wild Basin or an assessment of white-tailed deer cortisol levels. Our most fundamental research acquired would be based off of deer activity from the camera trap photos, collection and chemical assessment of vegetation and analysis of fecal cortisol samples. This allows researchers to have prior knowledge and a baseline to begin their research.

## Ethics

We hereby state that all the intellectual material stated above is our own. We have searched guidance from our supervisor Dr. Michael Wasserman and field expert Dr. Amy Belaire. We have used sources for our background and methods and have cited each source. We also state that all help provided to us has been voluntary and all participants have been knowledgeable of our intent. Previous to data collection we gained IACUC approval and an off-trail permit through Travis County showing that no harm was done to any of the wildlife at the Wild Basin Preserve and we adhered to any guidelines that were set forth by the preserve and the county.

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