COYOTE INTERACTIONS WITH HUMANS, WILDLIFE AND FORESTS ON THE PURCHASE COLLEGE CAMPUS

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ABSTRACT

Research into how organisms adapt to urbanized areas is an important aspect of ecological studies; especially with human disturbances becoming more numerous in natural environments. Coyotes are one example of a species that adapts to these environments; primarily in their tolerance of human proximity. Analyzing the behavior of coyotes on the Purchase College campus, and learning how that behavior is impacted by humans and different environmental factors is important to see is coyotes are able to survive in the presence of humans. My goal is to see if the behavior of coyotes is altered by humans on campus, or by any environmental factors like strata coverage. Strata coverage was determined by scoring multiple quadrats at differing heights; while wildlife and human activity were determined using trail cams to document any sightings that occurred within multiple sites. Coyotes on campus were found to avoid humans by limiting their activities to later in the night to avoid any potential competition for resources. Coyotes also preferred sites with large amounts of foliage to use for protection and to flee from anything they perceive as an immediate danger. The results found here can be used to show that coyotes are a species that is able to adapt to urban environments; if more natural patches are left intact within urban environments species will be able to survive in their altered landscapes.

Key words: Coyote; human dominated areas; natural areas: species richness; species diversity

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INTRODUCTION

The rising amount of human dominated areas in favor of natural areas is one of many effects that the ever increasing rate of urbanization is having on various species. Although there are many natural causes that can lead to vast changes in ecosystems and the behavior of organisms residing within them there are also effects that can result from disturbances caused by humans (Kitchen et al. 2000). With regards to these changes certain species have been demonstrating new abilities to adapt and find different ways to survive. One example of a species being able to adapt to these altered environments is the coyote.

Coyotes as a species have been spreading their populations across the United States and Canada (Breck et al. 2018). This expansion can be attributed to the growing human population; this can be especially applied to their expansion in the southeastern United States (Schrecengost et al. 2009). When discussing encounters with humans, many studies show that coyotes are a rather reclusive species. Coyotes show behavior changes to actively avoid human contact even in urbanized areas (Gehrt et al. 2009). One such strategy is that coyotes will limit their activities to a nocturnal time scale to avoid direct contact with humans (Grinder and Krausman 2001). Coyotes have also been found to use the coverage provided by foliage and shrubs to move through certain environments during the day and avoid larger predators (Breck et al. 2018; Atwood et al. 2004). Coyotes have been shown to live around human areas despite their tendencies to avoid humans; coyotes will be found residing in parks and residential areas within cities (Grinder and Krausman 2001). With the amount of coyotes that have begun to reside within city environments there has been a growing concern from the public over the occurrence of coyotes encountering and harming humans and their pets (Poessel et al. 2013; Poessel et al. 2016; Poessel et al. 2017). Coyote offspring have been shown to become more tolerant of humans if their parents have grown accustomed to disturbances (Schell et al. 2018).

The campus of Purchase College located within Harrison, New York has many forested areas that are home to many species including coyotes. There are many areas within the campus grounds that have been disturbed by humans; though the wildlife located on the campus have been shown to avoid encountering these same humans. I wanted to learn if the presence of humans on the campus has any effects on the behaviors of coyotes. Are these coyotes avoiding humans or do they wish to be close to them? I also wanted to learn if there were any natural environmental factors that caused coyotes to favor specific areas of the campus: such as abundance of prey species or access to necessary resources for survival.

METHODS

Field Location. The study occurred within the main campus of Purchase College; the study began with the process of deciding on where the field sampling would take place; different forest plots were labeled on a map of the campus and they were assessed to see which sites would work best for the sampling process. Eventually six plots were chosen for the purposes of this study across the campus (Fig. 1); two sites were chosen on the north side of the campus and four sites were chosen on the south side. A GPS point was created at every site using ArcGIS and Survey123 to mark these sites digitally on a map.

Figure 1. A map showcasing the campus of Purchase College with colored points representing the six sites sampled for the study

Each of the sites chosen can be separated by the size of the plot and the ages of the trees found in the forest.

Forest Sampling. The process of sampling the forest began with deciding on a way to sample the forest sites without collecting data from every tree and shrub in the forest to obtain results that would serve as a good demonstration of forest structure across the entire forest, and provide an efficient means of obtaining these results. It was decided that three groups would establish three quadrats within each site that were separated by 15m; they were measured out using transect tape into 10m x 10m with 9 flags used to designate the corners and midpoints of the quadrat; these flags divided the quadrat into 5m x 5m squares to divide the quadrat into 4 equal squares (Fig 2). The quadrats were marked with a GPS point in ArcGIS to mark them on a map. These squares were designed to contain a large number of trees and foliage within the specified boundaries to help the data collection represent as much of the forest as possible.

The first piece of data collected within every site was the amount of foliage coverage within the four 5x5 squares of every quadrat. This was conducted through a scoring system designed to give the average percentage of coverage across each square which had scores of 0 (> 1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-85%), 6 (85-95%), and 7 (95-100%). The foliage coverage was measured for four types of strata with varying heights to properly represent the amount of coverage. The classification of forest strata was determined to be low (>

0.5m), moderate (0.5-1.5m), high (1.5-4m), and the tree canopy (< 4m). The average score of coverage was determined by every member of the group discussing amongst themselves what they believed the coverage of the strata was among the predesignated scores and agreeing on an estimate of the percent coverage for every height of strata, and within every quadrat square.

Field Sampling. The process of field sampling began with setting one trail camera (trail cam) at each of the six sites. The trail cams were placed along the walking trails located at every trail; they were strapped on trees with locks in order to prevent the cams from being moved during the sampling process. The trail cams were placed on trees at about 0.5 meters in height to take a photo of any mammals that walk past the lens of the camera; the cameras have various photograph settings that were assessed to see which settings would produce a good number of photos to survey. New SD cards were taken to the cams on September 16, 2022; the process of taking photos and replacing SD cards continued until October 21, 2022 where the cams were moved to different locations in the sites to capture small mammal photographs. Once the photograph data was logged into a series of Google Drive folders organized by site, and date sets the photographs were scanned thoroughly to see what forms of mammal species were visiting the site on different days and times; this included humans, dogs (both leashed and unleashed), and vehicles were counted on a separate column for each site. The process of camera scoring had various strategy notes designated by the research team: if no event occurred for a specific species on an hour of the day a 0 was placed to know that species was not observed, times that occurred before and after the cameras were placed and removed were left blank, if the same animal occurred in multiple pictures in the same minute then the animal was counted as 1 individual, if the same human occurred in multiple photos then that represented 1 event, the human would be scored as 1 person, and lastly if the same human or dogs moved past the camera more than 1 minute apart they were counted as separate events. Once the data was fully collected three groups were tasked with proofing the mammal camera data to ensure the scoring strategies were followed properly and the data was logged correctly. There were several issues that occurred while the cameras were in the field that caused the photos taken during certain periods of time to be removed from the data set; the photos from the Alumni site from October 15, 2022 to October 21, 2022 were removed because the camera angle was moved by children during the cross country meet that occurred on the campus during the 15th, the batteries of the Loop site camera died which meant that no photos were taken from October 7, 2022 to October 14, 2022, at the same site once the batteries were replaced the date was not set correctly on the camera and the date was not displayed correctly so the photos from October 15, 2022 to October 21, 2022 had to be removed because we could not determine the exact time the photos were taken, lastly the Softball site camera displayed the incorrect date when the photos from October 5, 2022 to October 7, 2022 were taken so they were removed as well.

The next step of the field sampling process was to observe the amount of small mammal species that visited the sites. We traveled back to every site on October 21, 2022 to replace the full SD cards in the cameras with empty new ones to store new photo data; the cameras were removed from the initial tree they were placed at before and moved to a location deeper into the forest and away from the trail so we would not have another disturbance incident like the Alumni site cam. The cameras were placed on new trees and were wrapped at a lower elevation much closer to the ground to capture proper and higher quality photos of the small mammals; the cams were baited with food and meal worms in front of the camera lens to attract the small mammals.

The same photo capturing settings used in the previous mammal survey were used here; once the cameras were placed they took photos from the night (beginning at 7:00 PM, and ending at 6:00 AM) of October 21, 2022 and into the day (beginning at 7:00 AM, and ending at 6:00 PM) of October 22, 2022. Due to the massive abundance of photos taken during the sampling period it was decided that the max number of photos showing 1 type of species would be scored and the max number of that species seen within the photos would be scored as well. The night settings on the cameras would have a recurring problem where the flash from the camera would cause the picture to become too bright which made it impossible to distinguish many species within these photos so they were ignored for the scoring process. The photos from the mammal and small mammal surveys could be used to give a rough estimate of the diversity of species within the sites; each site will have varying degrees of diversity due to the photos taken and observed during the scoring process.

Data Analysis. Once the data for the 2 camera surveys was recorded the photos were logged into Google Drive folders and the scoring was logged into Goggle Sheets in order to record the data. The species richness (S) and the Shannon Diversity (H) were calculated for the small mammals of every site from the night of October 21, 2022 to October 22, 2022; to the day of October 22, 2022. This was conducted by using the equation:

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

Where P_i = fraction of the entire population made up of species i, s = numbers of species encountered, and $\sum$ = sum from species 1 to species S. This could be used to show how diverse the communities of every site are and can be compared to one another; this data was logged into a table on Google Sheets to record the data. Finally all graphs and tables of the data were made using RStudio version 4.2.1. In order to analyze the trail cam data and properly graph it the data had to be altered; specific species photos were grouped together by site to get the total number of photos of one species for a specific site, also the different species were classified as disturbance (humans, dogs, vehicles), wildlife (all mammal species), and bird.

RESULTS

The richness and Shannon diversity measurements of every site show that a site of high richness also contained a high amount of diversity (Table 1). Certain sites were visited by various species more so than others; the East1, Music, and Softball, sites had high richness values of 9 while Woods had a richness value of 8. Alumni had a richness measurement of 6; while Loop had a richness value of 4. The Shannon diversity measurements of nearly every site fell within the 1.0-1.7 range; the two exceptions to this were Loop which had a diversity of 0.632113, and Music which had a measurement of 2.055595. The wildlife diurnal activity photos within a 24 hour period show that Alumni, East1, Softball, and Woods had a large amount of activity; while Loop Music had the least amount of activity (Fig. 2). Out of all the wildlife species squirrels had the largest presence of any mammal; for Alumni and East1 whenever squirrels were found chipmunks were sure to follow. Deer had a large amount of activity in Loop where little other wildlife species were found.

Table 1. A table showing the richness and Shannon diversity measurements of every site. A site with a large richness usually had a large diversity measurement. Most sites had diversities that fell in the 1.0-1.7 range.

Site	Richness	Shannon Diversity
Alumni	6	1.08288
East1	9	1.750465
Loop	4	0.632113
Music	9	2.055595
Softball	9	1.394917
Woods	8	1.33068

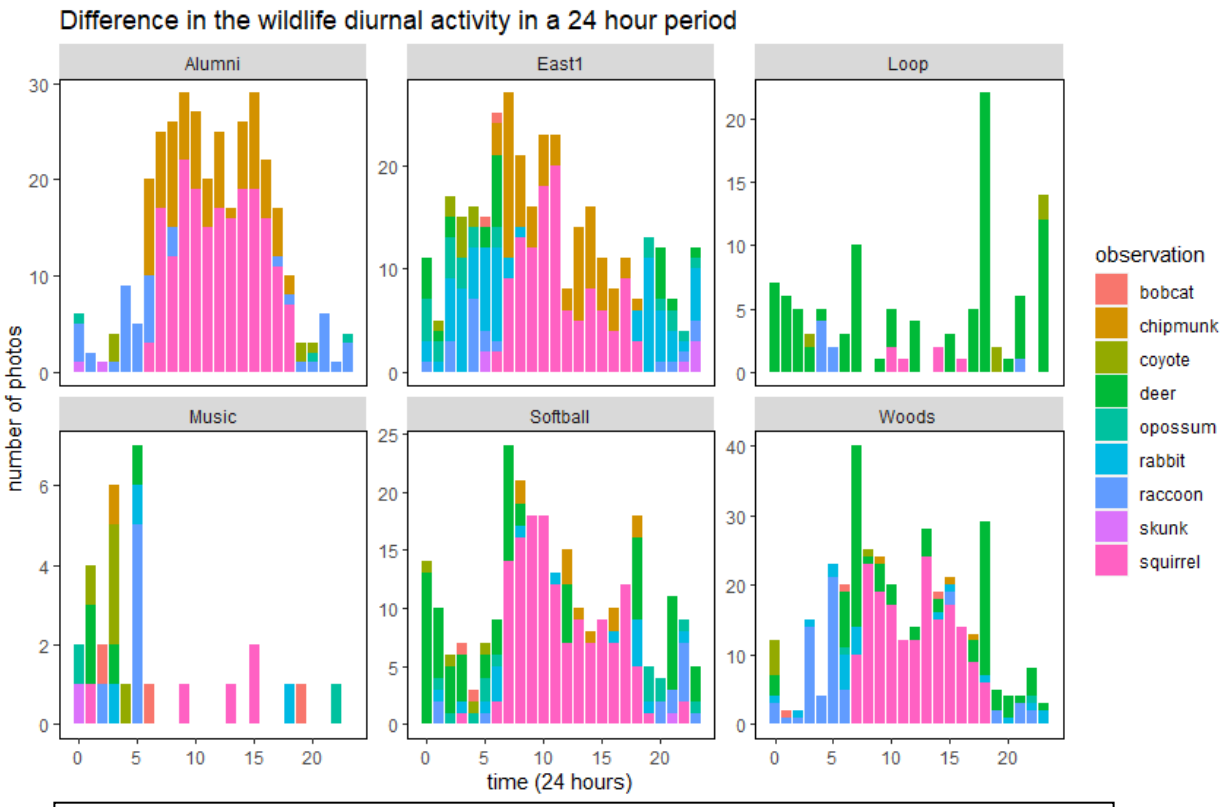

Figure 2. Bar graphs showing the wildlife diurnal activity photos that occurred in a 24 hour period. Alumni, East1, Softball, and Woods displayed a large amount of activity; while Loop and Music had the least amount of activity.

The amount of strata coverage was consistent in regards to height, while the differences among the sites were more prevalent (Fig 3). The low strata possessed high data ranges across each of the sites; while other heights showed much more variation. Music showed the lowest coverage for all four strata heights; but the range was much shorter for moderate, high, and canopy levels. The Woods site showed consistent coverage levels across every height level.

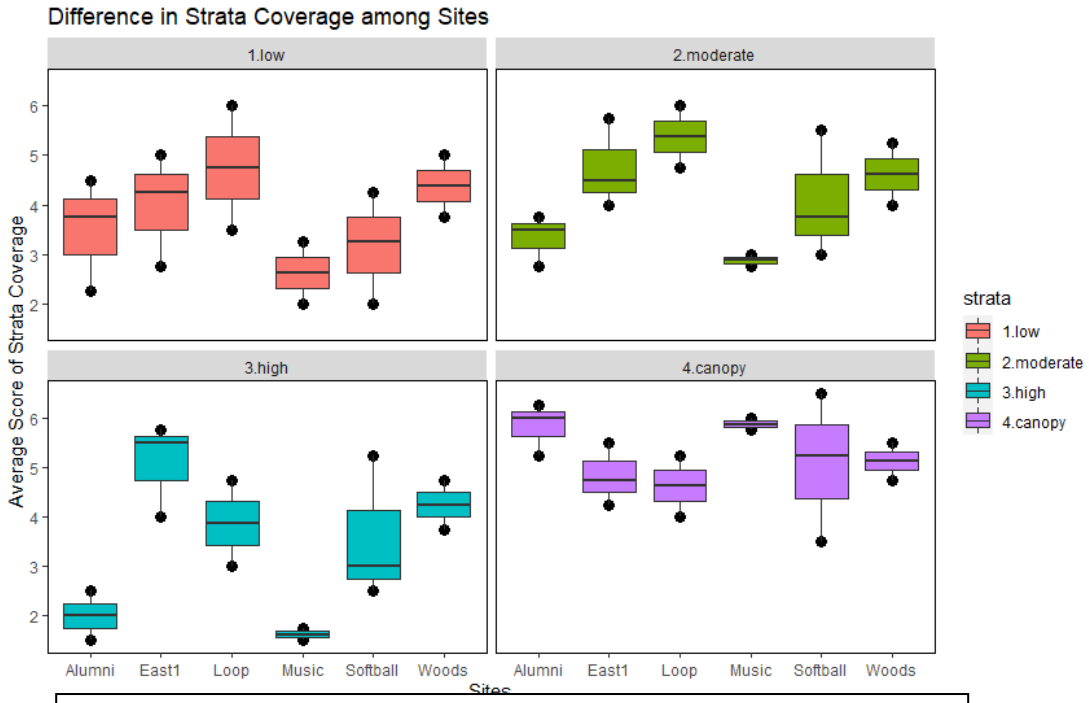

Figure 3. Boxplot graph showing differences in strata coverage among every site. Music had the lowest coverage at every height, with Woods having consistent coverages in roughly every height level.

The disturbance diurnal activity photos within a 24 hour period show that every site contained activity from people; the least human activity occurred in Woods (Fig. 4). East1, Loop, Softball, and Woods each had high increases of human activity at the 16 hour mark. The Alumni site had a large amount of unleashed dog activity occurring for 12 hours in a day. The coyote activity across all 6 sites was shown to occur on a consistent nocturnal basis with most activity occurring at the 0 to 5 hour range (Fig. 5). Both the Loop and Alumni sites showed coyote sightings occur after the 20 hour mark, and the Woods site had the most amount of sightings within an hour with 5 sightings at the 0 hour mark. East1 and Softball had the most amount of coyote activity occurring within multiple hours.

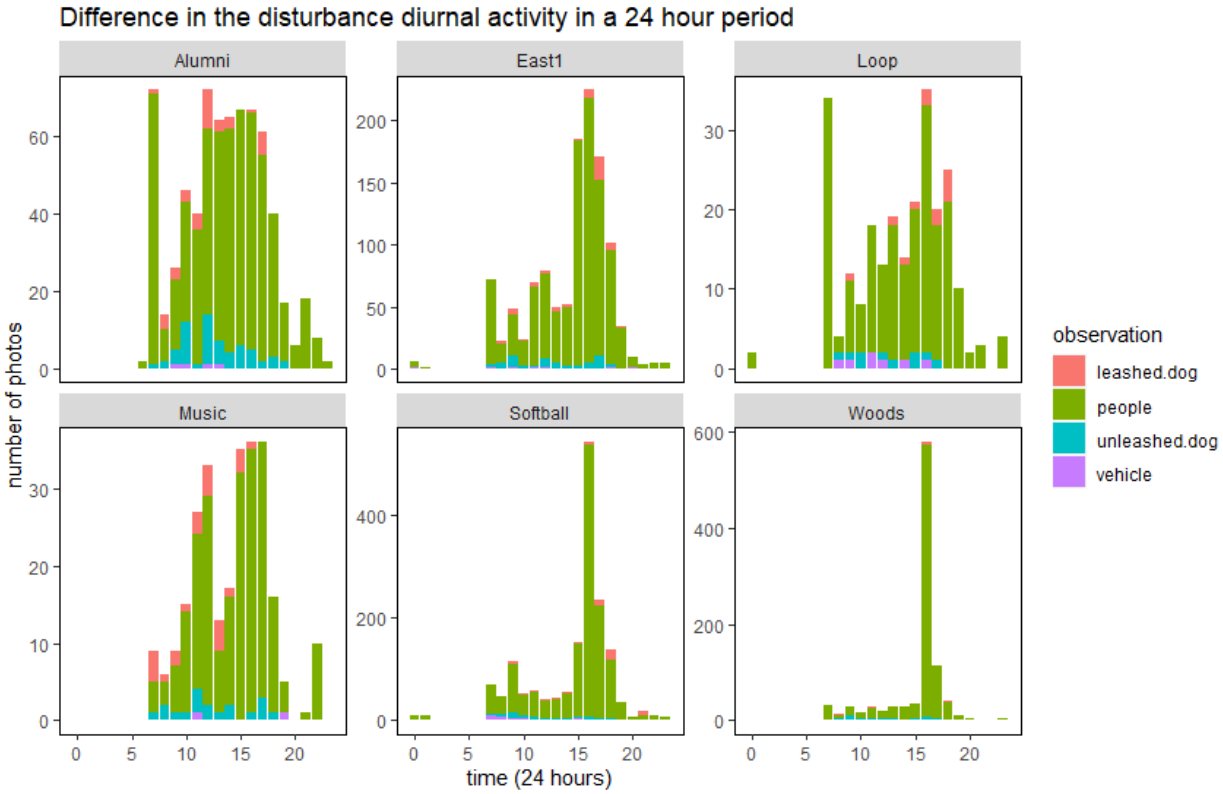

Figure 4. Bar graphs showing the disturbance diurnal activity photos that occurred in a 24 hour period. All sites had activities occurring from humans; Woods had the least amount of activity.

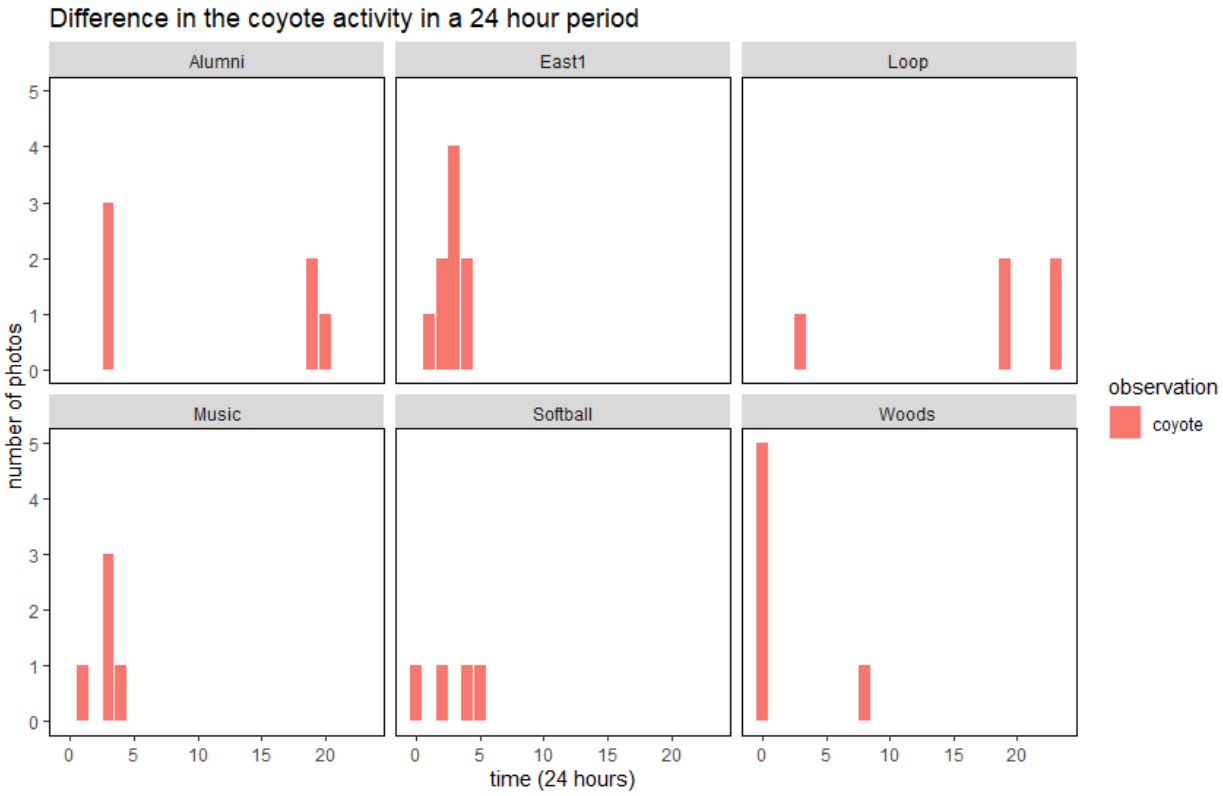

Figure 5: Bar graphs showing the activity of coyotes at the 6 sites during a 24 hour period. All activity occurred nocturnally with most of it occurring during the 0-5 hour range.

DISCUSSION

The campus of Purchase College houses many forested areas within the landscape; these forest fragments are home to many different species which use them to survive. Despite some areas being disturbed by humans, many wildlife species have shown behaviors where they avoid humans. This study aimed to find if humans had an effect on the behaviors of coyotes, and to see if any environmental factors influenced their behavior as well. Coyotes were found to show nocturnal activity which did not coincide with human diurnal activity and coyotes were shown to prefer sites where strata coverage was numerous and sites where wildlife abundances were high.

Coyotes on the campus have activities which occur on a nocturnal time frame to avoid immediate contact with humans which are active on a diurnal time frame. This is consistent with previous studies that show the nocturnal activities of coyotes in contrast with human diurnal activities (Grinder and Krausman 2001). While coyotes may live within human dominated areas on the campus, they do not wish to come into contact with humans so they will actively avoid them as much as possible. This means that the possibility of humans being attacked by coyotes is very unlikely at Purchase College contrary to the findings of previous studies (Poessel et al. 2013; Poessel et al. 2016; Poessel et al. 2017).

Coyotes have the highest amount of activity within the Softball and Loop sites where moderate strata coverage was very abundant. This could be due to coyotes wishing to have cover

during the day to avoid any meetings with larger predator species or humans that may wish to do them harm. These findings are consistent with previous studies which reached similar conclusions about coyotes and strata coverage (Breck et al. 2018; Atwood et al. 2004). Coyotes would only use the foliage to avoid certain species during the day; the light available during the day would make them easier to spot without the usage of the foliage.

The collection of data during the study had various issues occur throughout the process. The designation of quadrats during the process of deciding the strata coverage scores had to be dropped from 3 to 2 due to unforeseen circumstances that occurred in the field which resulted in one of the groups being unavailable to conduct the study. The first location of the trail cams should have been located deeper within the forests of every site. Due to human children moving the camera at the Alumni site the photos taken on October 15 2022 to October 21, 2022 to be removed from the study; placing the cams further into the forests of every site would have prevented issues like this from occurring. Also the Loop site cam had an issue where the batteries dying caused a large number of photo opportunities to be lost and when new batteries were placed in the cam the incorrect date was displayed on the camera so the next photos had to be removed as well. This incorrect dating issue also occurred at the Softball site and those photos needed to be removed from the study; a more efficient management of the cameras in the field could have given more opportunities for data collection. The data collection methods of the mammal and small mammal camera surveys allowed us to gain an estimate of diversity and richness within the site; however they could not be exact measurements because there was one question that always came up during the data collection of both surveys. That question was: is that mammal the same mammal from the previous set of photos that came back into frame or is it an entirely new mammal? We were not able to answer this question because we did not physically observe the mammal in the field, nor did we have any way of tagging the mammals to be sure they were ones we already surveyed. This unanswered question could also be the reason why the coyote photographs were taken during the study; it is a possibility that the coyotes seen at every site were not different coyotes. They could have been the same coyote located within the site that came back to the location of the trail cam multiple times because they frequented that location. This particular study provides a good outlook for the wildlife on the Purchase College campus; however there are ways this study could be expanded upon with future research.

The location of the initial trail cams provided a substantial amount of human disturbance photographs thanks to their placement close to the walking trails within the sites. However they did not provide a large amount of wildlife photographs; during the first mammal survey the small number of photographs had a particularly detrimental effect on the observations of coyotes and bobcats. They avoided the trails more than other species observed which caused a small number of photos to be taken. One way to increase the number of wildlife photos would be to move the cameras further within the forest so the wildlife will be more likely to move in front of the camera. A second factor to consider for future studies is that we placed the trail cams entirely within the main Purchase loop. The landscape of the campus extends further than the main loop which encircles the entire western and eastern sides of the campus. This study provides an in depth analysis of the wildlife and human disturbances that reside within the loop; though trail cams could have been placed outside of the loop to get a larger sample of the wildlife on the campus.

CONCLUSION

Coyotes are demonstrating that they are able to adapt properly within changing ecosystems. Coyotes have demonstrated that they will avoid humans when they are in close proximity with them and coyotes are able to make use of various resources available to them to aid in their survival. This ability for coyotes to adapt is important within the ever changing ecological world we live in with human dominated areas overtaking natural areas. If species are able to adapt to the presence of humans, they will be able to find new ways to survive in urban environments. These new methods will be able to resist the negative impacts humans can have on ecosystems and with the aid of natural patches in these ecosystems, species will be able to survive across the world within these new urbanized environments.

ACKNOWLEDGEMENTS

I would like to thank Dr. Jackson for answering my questions about the paper and offering suggestions for how to build new graphs. I would like to thank the Wildlife Ecology class of fall 2022 for helping in the process of data collection.

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