# WILDLIFE SPECIES ABUNDANCE IS AFFECTED DIFFERENTLY BY VARYING HUMAN DISTURBANCE

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## ABSTRACT

Human disturbance is a primary cause of habitat and resource loss for wildlife species. Urbanization affects both species abundance and richness differently, with some species being less negatively impacted. To study which species are negatively impacted by human influence throughout the Purchase College State University of New York (SUNY) campus, trail cameras were set up in different locations along an urban-rural gradient of environments. Within these ecosystems, one camera was placed in a human-influenced area and another in a nearby remote section. We found higher species richness in the remote sections in all three sites, as well as a higher Shannon diversity index. The species with the highest occurrences overall were white-tailed deer, raccoon, and grey squirrels. The species with the lowest abundance were coyotes, bobcats, and striped skunks. Our findings conclude human disturbance due to urbanization results in a high or low abundance in the ecosystem depending on the species.

Key Words: Urbanization; Human disturbance; Species richness; Habitat fragmentation; Urban-rural gradient

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## INTRODUCTION

Human beings cause ecosystem degradation and biodiversity loss on a global scale (Cardinale et al. 2012). As human populations expand, we have subsequently spread out further into wild ecosystems and diminished them to drive urbanization. Ecosystems all around the planet are converted into viable land for us to develop commercially, residentially, and agriculturally for our population's ever-growing needs. Human development gears towards the urbanized ecosystem made up of shopping malls, condensed residential areas, paved roads, and limited wild spaces. As society continues to advance in this direction, we have become further removed and disconnected from nature (Miller 2005). This has resulted in the general population finding it hard to fully grasp the extent of biodiversity in an ecosystem (Pett et al. 2016). This disconnect increases with growing distractions of cultural materialism and technological advancements. While demand for industrialization increases and development continues, untouched land

and natural resources decrease at an alarming rate. Wildlife is forced to adapt to and coexist with the human-influenced spaces left behind or face possible extinction (Carter et al. 2012).

In addition to habitat loss, human influence on ecosystems results in other obstacles for wildlife. Urban sprawl has effectively redesigned many ecosystems surrounding cities (McKinney 2002). Commercial and residential buildings along with highways and other infrastructure shape the availability of untouched wild spaces. Habitats become fragmented, decreasing range availability for many species. This affects migrating species and wildlife that need a wider distribution range for territorial reasons, hunting, or looking for mates. A high frequency of roads leads to a greater chance of species falling prey to vehicle accidents (Prange et al. 2003). Additionally, an increase in development naturally results in an increase in pollution. This exhibits that human influence and urbanization can positively affect wildlife species in some ways. Garbage and waste provide supplemental food resources for the more opportunistic species, such as raccoons (Prange et al. 2003). Light and noise pollution from urbanization also have varying effects depending on the species (Newport et al. 2014). These factors all contribute to the abundance of wildlife species.

To get a better idea of which wildlife species are negatively affected by human-disturbed environments, we chose to use the Purchase College, State University of New York (SUNY) campus. There is a perfect blend of urbanized environments and wild ecosystems located throughout campus that are exposed to varying degrees of human influence. The wildlife on campus comes from a diverse ecosystem that has been altered over the years through the gain and loss of habitat due to development. It is crucial to acquire a better understanding of how these species are affected by our presence and by our actions, in addition to how certain species might suffer the consequences more than others (Suvajot et al. 1998). Human impact and disturbance are known to negatively affect the richness and abundance of various wildlife species, including birds and small mammals (Samia et al. 2015). Our main objective is to determine species richness and abundance throughout a gradient of human-influenced locations to see which species are most negatively affected by human presence.

## METHODS

*Study area.* Purchase College, SUNY, and the surrounding area have been subjected to urbanization over the past century. Westchester County Airport was built in the 1940s for WWII (Zingesser 2015) which is still in operation today, now for commercial and public use. Purchase College, SUNY campus itself used to be Strathglass farm, a five hundred acre cattle farm. The farm was in use for fifty years before the land was sold in 1966, to become a SUNY school. The Purchase campus today consists of numerous dorm buildings, three sports fields, and many academic buildings while being nestled in-between patches of forest ecosystems of varying successional stages (Fig. 1). The Purchase College campus proves to be a mix of urbanized, suburban, and rural environments, therefore being an ideal setting for locations along a gradient of humanized influence to more wild ecosystems.

The three study sites chosen for our experiment were to represent a gradient of human exposure. This is similar to many studies done using urban-rural gradient effects on wildlife to determine exposure intensities effects (Prange et al. 2003; Randa and Yunger 2006; Blanchong et al. 2013). We determined our study sites based on the presence of human influence on an already existing wild ecosystem. The Sculpture Garden (SG) is located next to a popular academic building at the forest's edge. Students use the SG as an ongoing art installation and frequent it often to express themselves creatively or as a place to socialize. SG is also located next to a parking lot, which warrants foot traffic from commuters, visitors, faculty, and staff. Therefore, the high human activity results in a comparable urban environment. The remote trail camera for this location was set up deeper into the woods. This location represented the most consistently frequented area by humans that is still part of a wild ecosystem.

The study area Alumni Woods (AW) was chosen next. This location has a slightly lower human presence and slightly more wildlife compared to SG. The entire forest is marked with trails for joggers, walkers, and students to peruse through the woods. It also connects to a nearby campus residence. This presence emulates an environment similar to suburban conditions. The trail camera was placed at a firepit location, not too far from a trail entrance. This location is popular on the weekends for students to gather for bonfires. The remote camera was placed deeper into the woods, further away from the main trail.

The last location chosen to represent rural conditions is the Athletic Fields (AF) study site. It is furthest from the main campus academic buildings and dorms. The AF cameras are located in a strip of woods between road, athletic sports fields, and a parking lot. The AF camera in the human-influenced location is on a walking path trail between the woods and the field. The remote camera is located inside a strip of forest. This area is frequented the least of the three sites by humans, who would only purposefully be there for sports games/practice or walking.

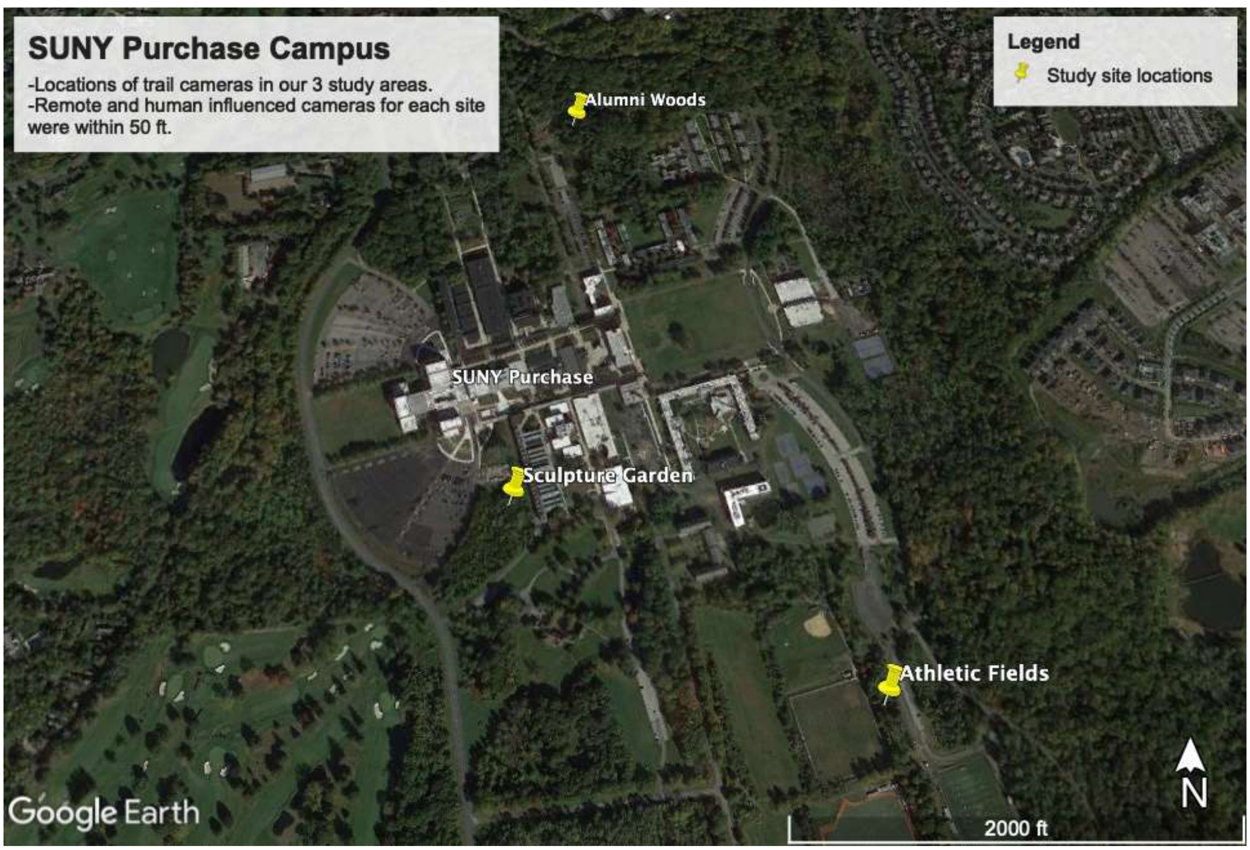


Figure 1. Map of SUNY Purchase College campus, in Purchase, NY. Our three study areas are Sculpture Garden (SG), Alumni Woods (AW), and Athletic Fields (AF).

*Field Work.* At each study site, we used two Browning trail cameras. In the human-disturbed locations, trail cameras were locked in safety cases. Every camera in our experiment had the same settings, with a 1s capture delay, low (4M) picture size, and had long-range night exposure. Each camera was set on trail mode and had multi-shoot capabilities off. The cameras were on and capturing photos continuously, from 10/14/2021 to 10/29/2021. Memory cards were collected once a week during this time period. This was to prevent filling up the memory card storage space and to more easily manage data analysis workflow.

*Data Analysis.* Once the memory cards were collected, the images were uploaded to a Google Drive folder to sort through and examine. Each wildlife and human occurrence were recorded in a Google spreadsheet. This data was organized per location. Occurrences within a similar time frame were deemed separate if there was at least a two-minute gap between appearances, in regards to the animal's directionality. Humans were identified by their clothing when possible to prevent miscounting individuals. Large crowds were otherwise grouped together in estimates, particularly in AW. Cars and dogs accompanied by humans were observed by the trail cameras and counted as part of human disturbance to their respective locations. Due to the camera's capture delay or slow shutter speed, especially in low light, some animals were unable to be identified. They were grouped together in an "unknown" category.

Species richness was determined by the number of different species observed at each location's remote and human-influenced area. Shannon diversity was calculated using the equation $H=\sum -(P_i * \ln P_i)$ for each site's disturbed and remote locations. The Shannon diversity index formula is used to estimate species diversity, taking into account species richness and abundance. Unknown species counts were left out of species richness and Shannon diversity calculations to ensure an accurate representation of species. Our focus with this data was to assess species abundance and diversity at each site as well as to see how wildlife abundance was being affected by the human-influenced areas.

## RESULTS

Throughout the campus study sites, we found varying results of wildlife and human occurrences (Fig. 2). At each site, the remote area had higher wildlife occurrences compared to its disturbed counterpart. Throughout the urban to rural gradient we see this trend persist. No human occurrences were recorded in the remote locations of the SG or AF. In the disturbed areas of the AW and AF locations, there were greater human occurrences and fewer wildlife occurrences. However, at the SG disturbed site, there were still more wildlife occurrences than humans (Fig. 2).

Species richness was higher in the remote sections of each study location (Fig. 3). Species richness in the disturbed sites decreases along the urban to rural gradient and follows no particular trend in the remote sections.

The SG had 9 different species observed in the remote section and 7 species in the disturbed area (Fig. 4a). The remote area had more occurrences overall, but certain species (such as the grey squirrel and raccoon) frequented the human-disturbed site more often. AW also had more species in the remote sections, totaling 7 species in remote and 5 in the human-influenced area

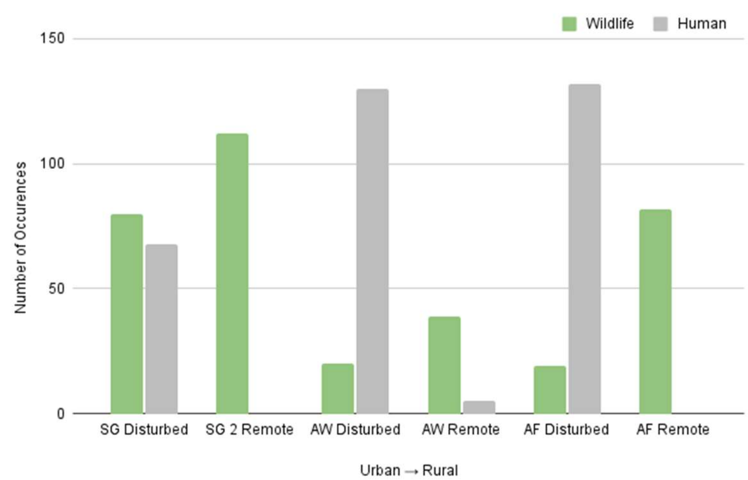


Figure 2. The total number of wildlife and human occurrences per study site across our gradient of human disturbance in urban to rural environments. Includes both

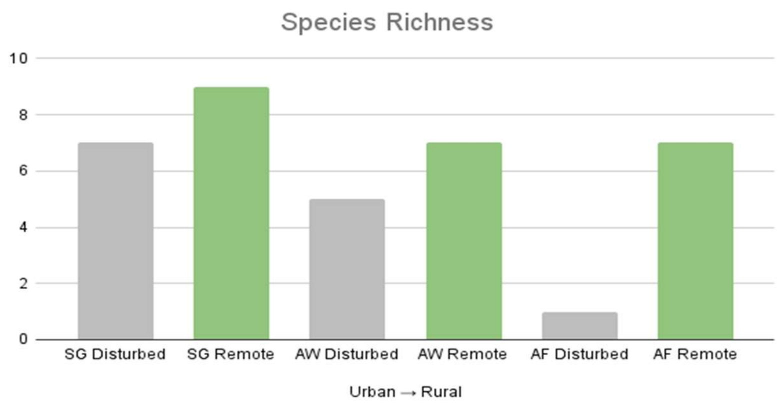


Figure 3. Wildlife species richness for each location.

(Fig. 4b). There was only one species recorded (the white-tailed deer) in the AF human-influenced site, and 7 species in the remote (Fig. 4c). Table 1 displays the total occurrences of each wildlife species recorded in the SG, AW and, AF. Thus deducing which species is absent or the extent of their presence throughout the six locations. Unknown or unidentifiable species were grouped together as "unknown".

The Shannon diversity index is a measure of the richness of a species in regard to abundance and evenness. In the remote locations for all three study sites, the Shannon diversity index was higher than in the disturbed locations (Table 2). The remote location at the SG had the highest Shannon diversity at 1.86, while the disturbed location at the AF had the lowest index at 0.26.

Table 1. The total number of occurrences of each species observed at each location. Dash marks indicate no recorded occurrences in that section.

| | **Sculpture Garden** | | **Athletic Fields** | | **Alumni Woods** | |
|---|---|---|---|---|---|---|
| **Species Observed** | Disturbed | Remote | Disturbed | Remote | Disturbed | Remote |
| Blue Jay | **1** | - | - | **3** | - | - |
| Robin | **6** | **31** | - | - | - | - |
| Dark-eyed Junco | - | **2** | - | - | - | - |
| Yellow-rumped Warbler | - | **5** | - | - | - | - |
| Northern Flicker | - | - | - | - | **2** | - |
| Wild Turkey | - | - | - | - | - | **14** |
| Cottontail | **3** | **11** | - | **8** | - | - |
| Chipmunk | **3** | **5** | - | **3** | - | **1** |
| Grey Squirrel | **19** | **12** | - | **34** | **3** | **1** |
| Striped Skunk | - | **2** | - | - | - | - |
| Oppossum | - | - | - | **6** | - | **1** |
| Raccoon | **45** | **26** | - | **10** | **7** | **12** |
| Bobcat | **1** | - | - | - | **1** | - |
| Coyote | - | - | - | - | - | **2** |
| White-tailed Deer | - | **11** | **19** | **18** | **2** | **8** |
| Unknown | **2** | **7** | - | - | **2** | - |

Table 2. Shannon Diversity of all three sites for remote and human-disturbed locations.

| | **Shannon Diversity** | | |
|---|---|---|---|
| | Sculpture Garden | Athletic Fields | Alumni Woods |
| Disturbed | 1.22 | 0.26 | 1.40 |
| Remote | 1.86 | 1.61 | 1.49 |

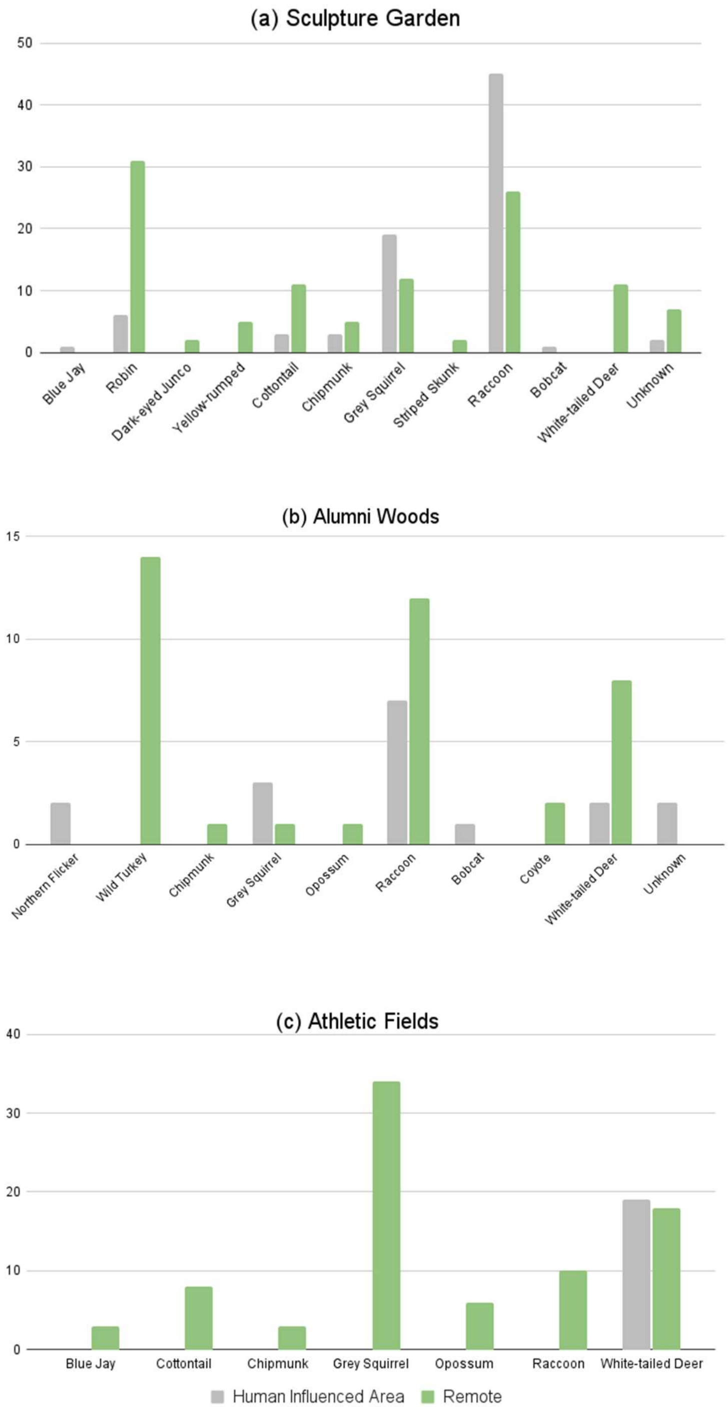


Figure 4. The total number of wildlife occurrences per species, located in the (a) Sculpture Garden, (b) Alumni Woods and (c) Athletic Fields

## DISCUSSION

The species with the greatest abundance in the human-influenced area of the urban SG site were robins, squirrels, and raccoons. Raccoon populations thrive in urban/suburban environments due to supplemental resources (Prange et al. 2003). These three species are notably unaffected by the structures, debris, and man-made art pieces amongst the woods. Species found within the SG and not in the remote area include the blue jay and the bobcat. The bobcat's presence in the human-influenced SG camera may be due to its ability to exist in areas with human activity (Tigas et al. 2002). The blue jay was present in the SG because they have adapted to environments with human disturbance (Kight and Swaddle 2007). However, recording bird species abundance with trail cameras is not the most effective method due to the inability to identify blurry photographs. It is important to assess each species abundance in regards to its own traits and characteristics rather than make generalizations (Brown and Graham 2015). In the remote location of the SG, we saw slightly more species moving through the area. Observed only in the remote area were white-tailed deer, striped skunk, and two bird species. Raccoon occurrences were roughly half of what they were in the human-disturbed area which supports the general decrease of raccoon density further from urban environments (Prange et al 2003).

The site we chose to represent a less urban environment and more suburban was the AW. The remote site of AW had four species that were not seen at the human-influenced location near the firepit.

Likewise, two species were observed at the firepit and not in the remote area. AW was the only location that had human occurrences at the remote location. There were almost twice as many raccoon occurrences in the remote location. However, the total number of occurrences was only a quarter of the occurrences in the SG. A possible explanation for this is that raccoons in urban environments generally have higher density populations (Prange et al. 2003). AW was the only location to have coyote occurrences. Their presence here in the forest environment supports coyote preference for less urbanized locations (Randa and Yunger 2006).

The rural AF site had the largest distinction of species abundance comparing human-disturbed and remote locations. This area is the most remote of all three locations. It is also greatly fragmented with roads, fields, and a walking path. Human occurrences were highest in AW and AF but respectively remained greater than their remote site counterparts for all three locations. This was different than we expected for AF since its location was the most remote but had quite high human occurrences. Only one species was found in the human-disturbed area, being the white-tailed deer. White-tailed deer have traits to combat the negative effects of human fragmented landscapes such as high reproductive outputs and large land dispersal (Blanchong et al. 2013). White-tailed deer are known to adapt to the disadvantages of fragmented land (Blanchong et al. 2013) which could explain their continued abundance. The absence of their natural predators (coyotes) could also explain a high abundance. The high frequency of occurrences of deer in certain areas more than others can be explained by the fact that a species ability to learn its surrounding environment plays a role in how they respond to and avoid threats (Laundre et al. 2010).

Interestingly enough, there were zero fox occurrences spotted on any of the trail cameras. Red foxes are native to these areas. It could be that the presence of coyotes and bobcats deter them. This competition is possibly enough to keep them away, as they otherwise could be violating the competitive exclusion principle. However, foxes are less adaptable to urbanized conditions and urban sprawl (Randa and Yunger 2006). Across the rural-urban gradient red foxes' abundance decreases, the coyote does fairly better, and the raccoon is ultimately the most successful. Raccoons and coyotes do better in more urban environments due to their ability to generally avoid humans by shifting their lifestyle from diurnal to nocturnal (Randa and Yunger 2006).

Potential scientific errors lie within the experiment itself as well as human error. On top of routine memory card collection, equipment settings malfunctioned a few times and therefore lead to excess handling of the cameras. This made it easier to mess up the exact angle captured per site. It was also difficult to identify some species because of blurred-out movement due to the automatic shutter speed and aperture settings of the camera. Trail camera studies, in general, cannot capture a full scope of what species are present, only what walks in front of the view and triggers the camera (Carter and Shrestha 1999). Some improvements for future studies could be using larger-sized memory cards to lessen the amount of handling needed to collect the data. Video footage could also be implemented to collect data on the behavior of the wildlife spotted and possibly aid in identifying otherwise unknown species. Studies involving trail cameras could also be improved by utilizing more cameras with multiple angles. This would increase the accuracy of the data collected in these studies and result in a better depiction of the area being recorded.

Possible future studies could focus on one specific carnivore on campus. It would be beneficial to implement bait boxes to see how the predator species in our area would react. This would provide a better idea of their preferred habitats and their abundance. It could also contribute further data to fox presence or absence. Despite our experiment's urban-rural gradient, Purchase College is located in an overall urbanized area. To ensure that this isn't skewing some of our results, we could compare our data to a strictly rural site, such as a national park, to expose possible discrepancies in data and overall trends.

Our experiment contributes to an important emerging field of the coexistence between wildlife and humans. As urban sprawl continues, it remains unclear exactly how our native wildlife species will fare. Several species such as white-tailed deer and raccoon are known to be highly successful in this gradient of urban-rural environments (Blanchong et al. 2013; Randa and Yunger 2006). However, it is important to see how other species are affected by human influence, especially apex predators higher on the food chain such as coyotes and bobcats. This data of species abundance is important to see the stability of the overall food chain, which is closely tied to the health of the entire ecosystem. Providing data to better understand wildlife species populations' reactions to human disturbance can help sustain wildlife populations and conserve our wild ecosystems.

## CONCLUSIONS

We observed a general trend of decreasing species richness from the urban (SG) to rural (AF) environments. This counters the idea that rural environments (AF) would have a greater species abundance. White-tailed deer, raccoons, and grey squirrels were the most abundant species respectively present at our study sites. Each species only being absent from one location (all of which were human-influenced locations). These species are the most adaptable and less afraid of humans. The least common species throughout campus locations include coyote, striped skunk, and the two bird species yellow-rumped warbler, and the dark-eyed junco. The high abundance of raccoon occurrences and lower abundance of coyote occurrences coincides with findings of carnivore occurrences across an urban-rural gradient (Randa and Yunger 2006).

Our findings conclude that the Shannon diversity index and species richness are greater in the remote sites for all three locations. Human occurrences were most frequent in AW and AF and were higher in the disturbed areas than in the remote locations. Knowing that animal richness and Shannon diversity are highest in areas less disturbed by humans can influence the inhibition of human encroachment on ecosystems. Our findings support that conservation efforts to control human disturbances can benefit wildlife habitats (Qiu et al. 2019).

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## AUTHOR CONTRIBUTIONS

Conceptualization (all), data collection (all), data curation (all), formal analysis (all), methodology (all), project administration (all), resources (all), visualization (KP, AR), writing - Intro (KP), writing - methods (KP, EH), writing - abstract (KP), writing - results (KP, EH), writing - discussion (KP, AR), writing - conclusion (KP, AR), writing - review & editing (all).

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