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Comparative Analysis of Tick Abundance and Wildlife Biodiversity in NYC Urban Green Spaces: Implications for Tick-Borne Diseases

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Abstract

Context: Tick abundance has been on the upsurge in the Midwestern and Northeastern regions of the United States, leading to increased cases of tick-borne diseases such as Lyme disease. Many studies about tick disease hazards are done in suburban and rural areas, leaving a research gap in urban areas.

Objective: Our goal is to fill the gap in knowledge about urban biodiversity and greenspace management on tick-borne hazards in urban areas. Additionally, we wanted to test the dilution effect theory to see if it applies in an urban setting.

Methods: We selected two urban greenspaces, Wave Hill and Van Cortlandt Park, in the Bronx, New York City, NY, for our data collection. We measured biodiversity by observing the Avian and Mammalian populations. We sampled the tick abundance for both parks through tick dragging.

Results: We found similar patterns of biodiversity in both parks, but differing tick abundances. Wave Hill had a slightly higher Shannon diversity, but Van Cortlandt had a higher species richness, abundance, and evenness. We found an established tick population in Van Cortlandt and zero ticks in Wave Hill.

Discussion: We did not find evidence to support whether or not the dilution effect applies in an urban area. Additionally, we found that species diversity may matter less than species identity. Further research is necessary to better understand the role of biodiversity on tick-borne disease hazards in urban areas. However, this study does indicate that Van Cortlandt needs to implement tick management to decrease tick disease hazards in highly used areas like trails and edges where ticks were found.

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Keywords: tick-borne disease, *Ixodes scapularis*, Lyme disease risk, tick abundance, biodiversity, urban ecology, wildlife diversity

1. Introduction

In recent years, cases of tick-borne diseases, especially Lyme disease, have been increasing in the Midwest and Northeast regions of the United States. In New York State, *Ixodes scapularis* (commonly called the blacklegged tick or deer tick) is the main disease vector for the bacteria *Borrelia burgdorferi*, the causative agent for Lyme disease (Piedmonte et al. 2018). Anthropogenic impacts such as land use change, climate change, and deforestation have increased tick abundances, thereby increasing the tick-borne disease risk (Diuk-Wasser et al. 2021). Urbanization creates a mosaic landscape, which increases forest patches and decreases habitat patch size (Wilson et al. 1984). This results in a negative correlation between patch size and density of infected ticks (Allan et al. 2003). Lastly, active forest management may reduce the presence of nymphal and density of adult blacklegged ticks, and exposure to tick-borne pathogens in the landscape (Conte et al. 2021). Nevertheless, less research has been conducted in urban areas, leaving a gap in knowledge about the role of wildlife hosts on tick-borne disease risk in urban contexts (Diuk-Wasser et al. 2025). Although tick-borne diseases in urban settings are studied thoroughly in Europe, there is a major gap in the U.S., in which most tick disease studies are done in rural and suburban areas (Kilpatrick et al. 2014, Diuk-Wasser et al. 2025).

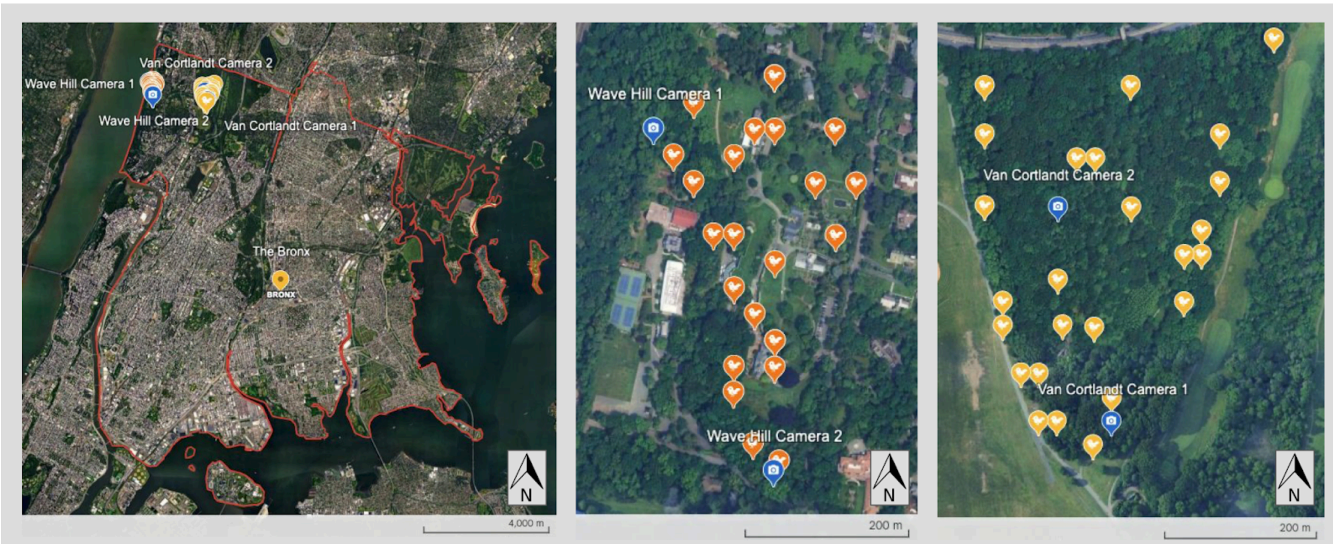
Tick abundance, a proxy for tick-borne disease risk and hazard, in an area depends on the host species and several environmental factors (Lilly et al. 2025). *I. scapularis* feeds on hosts infected with *B. burgdorferi* to become infected. As larvae and nymphs, *I. scapularis* feed on a variety of mammalian, avian, and reptilian host species, some of which are believed or documented to have low reservoir competence (LoGiudice et al. 2003). Hosts with lower reservoir competence have an immune system that clears *B. burgdorferi* faster than hosts with high reservoir competence (Brunner et al. 2008). For example, *Odocoileus virginianus*, the white-tailed deer, is the key reproductive host for *I. scapularis* but is not a competent host for *B. burgdorferi* (Wilson et al. 1985). Other mammalian host species that can host *I. scapularis* ticks, such as raccoons and opossums, have a low reservoir competence for *B. burgdorferi*, while several small mammals, such as the white-footed mouse and eastern chipmunk, have a higher reservoir competence (LoGiudice et al. 2003). On the other hand, there has not been as much research on the relationship between avian species as hosts for *I. scapularis* ticks and *B. burgdorferi* (Brinkerhoff et al. 2009, Loss et al. 2016). However, the American Robin has been implicated as a potentially important host for *I. scapularis* ticks and *B. burgdorferi* (Richter et al. 2000). These host species are present across the Northeast, and their role in Lyme disease transmission is well documented in rural and suburban areas but less so in urban environments (LoGiudice et al. 2003, Kilpatrick et al. 2017, Diuk-Wasser et al. 2025).

Additionally, according to the dilution effect, increased biodiversity in an ecological community can lead to a decrease in the transmission of a pathogen due to differences in predation and reservoir competence of host species in a more diverse community (Schmidt and Ostfeld, 2001). However, the dilution effect theory remains ambiguous with mixed evidence in urban environments, including highly urban New York City, where ticks and hosts are also present (Bastard et al. 2024). Randolph and Dobson argued that the dilution effect theory applies only in certain, limited circumstances (Randolph and Dobson, 2012).

This study tests the dilution effect with tick-borne hazards in urban green spaces. We chose two study sites in the Bronx, New York City, New York, that vary in patch size and land management practices. This study aims to bridge the information gap regarding urban biodiversity and green space management on tick-borne hazards and connect these learnings to already existing knowledge regarding the relationship between tick populations and urban land management. This study identifies whether a highly manicured or a low-managed green space impacts the tick abundance. This study also examines the effect of host biodiversity on the abundance of ticks in urban green spaces.

2. Methods

2.1. Study Area



Map 1: Study area in the Bronx, NYC, NY, at Wave Hill and Van Cortlandt Park. The camera icons indicate the location where the camera traps were placed. The bird icons represent the randomly generated bird point counts, with the orange icons for Wave Hill and the yellow for Van Cortlandt Park. Satellite image basemap from Google Earth.

We collected data in Riverdale, a residential neighborhood located in the northwest Bronx, during July 2025. Within Riverdale, two distinct urban green spaces were selected for comparison: Wave Hill and Van Cortlandt Park. Wave Hill is a 28-acre estate characterized by landscaped gardens and managed woodlands (Wave Hill, 2025), while Van Cortlandt Park is a 1,146-acre urban park characterized by largely unmanaged forest (NYC Parks, n.d.).

2.2 Wildlife Camera Trapping

Two motion-triggered Browning Strike Force wildlife cameras were deployed at each site for a collection period of two weeks. All photographs were reviewed and tagged in Wildlife Insights according to the species present.

Figure 1: This image demonstrates the wildlife camera setup in the study.

2.3. Tick Collection

Tick data collection took place in July, because *I. scapularis* are actively looking for hosts during the warmer seasons (Levi et al. 2015). In the area surrounding each wildlife camera, tick drags were collected over 2 collection days for a total distance of 1000 m^2. Using 1m x 1m corduroy drag cloths, the forest interior, forest/lawn edge, and trail were sampled by dragging the cloth in ten 10m^2 transects for a total transect length of 100m. At the end of each 10m drag, the cloth was examined for ticks. Any ticks found within each 100m transect were collected with metal forceps and placed in 1.5mL preservation vials of 85% ethanol (Lilly et al. 2025). The number of ticks at each life stage (adult, nymph, larva) and the dominant habitat type (unmaintained herbaceous, leaf litter, maintained grass) of each 10m transect were recorded. The species of ticks present in each vial were identified under a microscope based on morphological characteristics using taxonomic keys and expert guidance (Madder et al. 2014).

2.4. Avian Point Counts

Thirty bird survey points within a polygon of each site were randomly generated using AI. Before each count, current weather conditions were recorded. Each count lasted 10 minutes, during which observers recorded the species, distance, minute after time start, number of birds seen if in a group, behavior, and any additional notes necessary (Ralph et al. 1995). Bird species were determined using visual observation and assistance from the Merlin Bird ID app (https://merlin.allaboutbirds.org/). To maintain spatial independence, points surveyed on the same day were separated by at least 100m.

2.5. Data Analysis

Tick data were summarized into the density of larvae, nymphs, and adults by species per 1000m. Camera trap data were filtered by removing avian species and photos of the same mammalian species identified within a 30-minute time frame to avoid pseudoreplication (Lawrence et al. 2018). Bird survey and camera trap data were summarized by species richness, abundance, evenness, and Shannon diversity (Shannon, 1948), which was calculated by site.

Shannon's diversity formula is as follows:

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

The variable H is the Shannon diversity index value. p_i represents the number of individuals of a specific species divided by the total number of all individuals in the community.

3. Results

We set camera traps for a duration of two weeks, capturing a total of 57 different mammalian individuals across Wave Hill and Van Cortlandt. We conducted 28 bird point counts for each site, totaling 56 bird point counts. Through our observation, we recorded 182 avian individuals in Wave Hill and 219 avian individuals in Van Cortlandt, totaling 401 avian individuals at both sites.

3.1. Species Richness

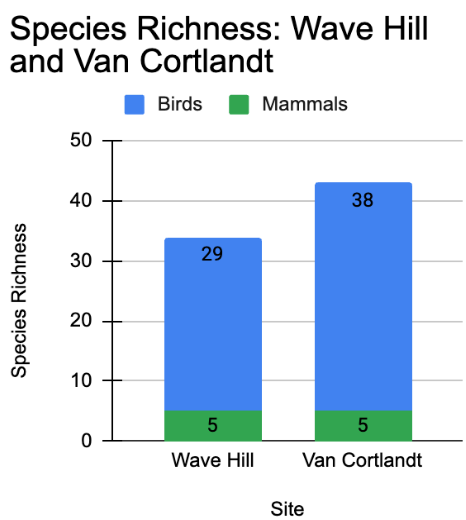


Figure 2: Species richness in Wave Hill vs. Van Cortlandt.

There was higher avian species richness in Van Cortlandt than in Wave Hill. In Wave Hill, we found 29 bird species. In Van Cortlandt, we found 38 bird species. The mammalian species richness is the same for both sites. We captured five different mammalian species in both parks. In Van Cortlandt, we recorded coyote, eastern gray squirrel, northern raccoon, Virginia opossum, and white-tailed deer. In Wave Hill, we recorded coyote, eastern chipmunk, eastern cottontail, eastern gray squirrel, and Virginia opossum. Although the species richness is the same for both sites, they differ slightly in species identity.

3.2. Wildlife Abundance

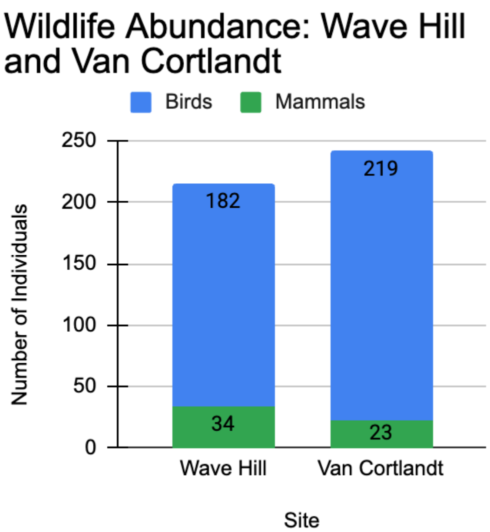


Figure 3: Wildlife abundance in Wave Hill vs. Van Cortlandt.

We found more birds and mammals in Van Cortlandt than we did in Wave Hill. There were 216 individuals across all species in Wave Hill, and 242 individuals across all species in Van Cortlandt. The number of birds in Van Cortlandt was greater than the number of birds in Wave Hill. We recorded 182 avian individuals in Wave Hill and 219 avian individuals in Van Cortlandt. The number of individual mammals was greater in Wave Hill than in Van Cortlandt. There were 34 mammalian individuals in Wave Hill, and 23 mammalian individuals in Van Cortlandt.

3.3. Shannon Diversity Index

The Shannon Diversity Index slightly varied between the sites. Wave Hill had a higher mammalian Shannon diversity index value of 1.43 than Van Cortlandt's mammalian Shannon diversity index value of 0.92. Van Cortlandt had a higher avian Shannon Diversity Index value of 2.80 than Wave Hill's avian index value of 2.64.

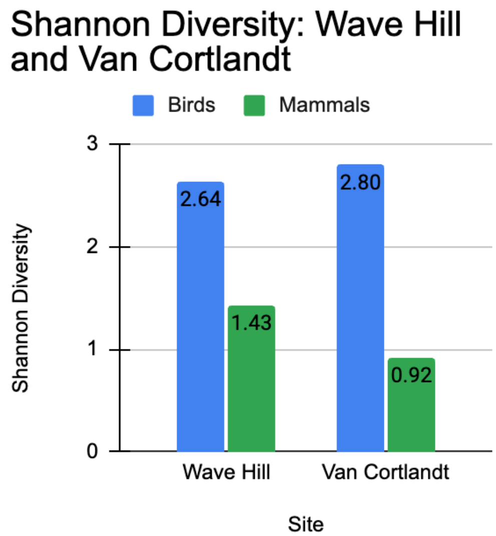


Figure 4: Shannon diversity index in Wave Hill vs. Van Cortlandt.

3.4. Species Evenness

Avian species evenness was slightly higher in Wave Hill than in Van Cortlandt, with values of 0.79 and 0.77, respectively, although the avian species evenness was very similar in both parks.

The mammalian species evenness was higher in Van Cortlandt than in Wave Hill, with values of 0.29 and 0.18, respectively.

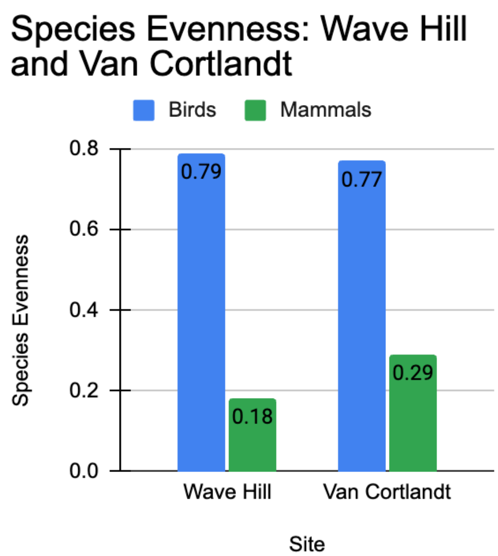


Figure 5: Species evenness in Wave Hill vs. Van Cortlandt.

3.5. Tick Abundance

Table 1: The number of ticks and tick species

Site	Black-legged Tick Larvae	Black-legged Tick Nymphs	Dog Tick Adults
Van Cortlandt	104	5	2
Wave Hill	0	0	0
Grand Total	104	5	2

In Van Cortlandt, we collected 104 I. *scapularis* larvae, five I. *scapularis* nymphs, and two Dermacentor variabilis adults. In Wave Hill, we recorded zero ticks across the 1000m transect.

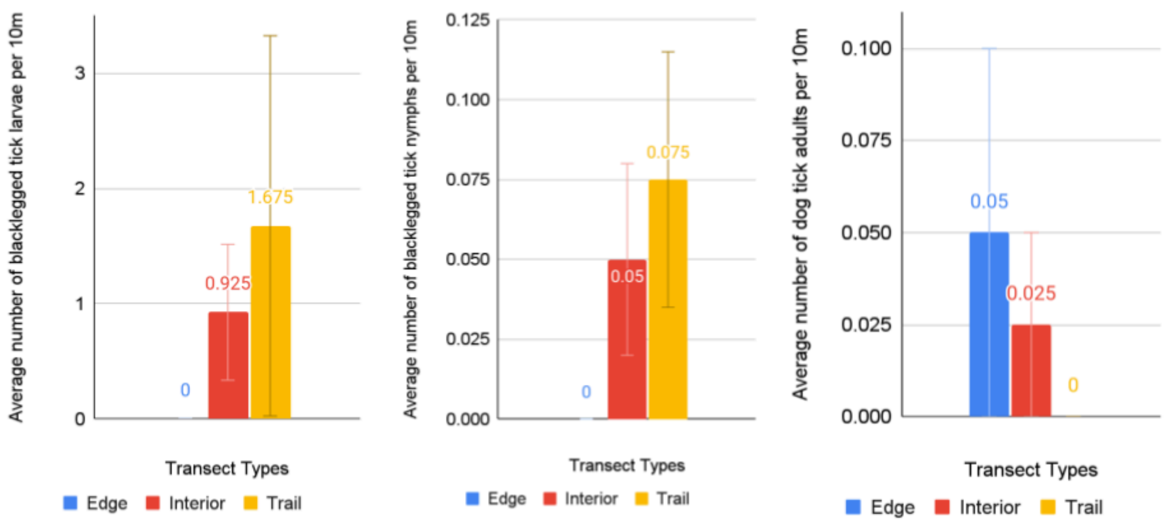


Figure 6: Average number of ticks by life stage and species collected by each transect type at Van Cortlandt Park.

At Van Cortlandt Park, we summarized the tick species and life stage by transect type. For blacklegged tick larvae, we found an average of 1.675 (SE 1.65) per 10m along trails, 0.925 (SE 0.59) per 10m within the interior, and 0 on the edge. For blacklegged tick nymphs, we found an average of 0.075 (SE 0.04) per 10m along the trail, 0.05 (SE 0.03) per 10m within the interior, and 0 on the edge. For adult dog ticks, we found an average of 0 per 10m along the trail, 0.025 (SE 0.025) within the interior, and 0.05 (SE 0.05) on the edge.

3.6. Camera Trap Highlights

Some camera trap highlights of the mammalian species within the two urban parks are shown in Figure 7. In Wave Hill, a coyote and a raccoon were captured at night. In Van Cortlandt Park, a coyote and two white-tailed deer are shown active in the morning.

Figure 7: Highlight photos from the camera traps at Wave Hill and Van Cortlandt Park

4. Discussion

4.1. Land Management

I. scapularis populations prefer forested habitat over habitat composed of ornamental vegetation or manicured lawn (Maupin et al. 1991). This is consistent with our findings, as a total of 109 *I. scapularis* were found in Van Cortlandt Park, which contains a larger area of forested habitat than Wave Hill, where none were found (Fig. 5). Our results highlight that urban forested areas had higher tick abundance than well-manicured spaces, which is consistent with other studies of tick-borne hazards in New York City (Gregory et al. 2022, Lilly et al. 2025).

4.2. Species Identity

Although both sites had similar species richness, the identity of those species differed slightly. Based on our findings, species identity may matter more than species richness when it comes to tick abundance. *O. virginianus*, a major reproductive host for *I. scapularis* adults (Wilson et al. 1985), was present in Van Cortlandt but not in Wave Hill, which could explain the large tick abundance in Van Cortlandt that was not present in Wave Hill. Recent research in New York City has shown that O. *virginianus* occupancy in urban parks is the most important driver of nymphal blacklegged tick abundance (Lilly et al. 2025), which supports our results. Wave Hill has a fence that gates off larger mammals, preventing deer from entering Wave Hill. The absence of fencing in Van Cortlandt Park allows deer movement, which likely increases the tick abundance; in contrast, the fencing around Wave Hill prevents the entry of larger mammals. The presence of coyotes, a keystone predator species, in both urban parks potentially indicates a regulation of rodent populations, which are a key host for ticks and a reservoir species for B. *burgdorferi* (Weckel & Wincorn, 2016). Interestingly, we found a relatively high abundance of American Robins at both of our sites, which is a host of I. *scapularis* (Richter et al. 2000), underscoring the need for further research in urban tick-borne diseases relating to birds.

4.3. Dilution Effect

We did not find evidence to support the dilution effect. Van Cortlandt and Wave Hill had similar Shannon diversity index values, and we found 111 ticks in Van Cortlandt Park and zero in Wave Hill (Fig. 5). Even with similar Shannon diversity values, tick numbers differed greatly, implying that the makeup of species—not just overall diversity—influences tick hazard in urban settings. The dilution effect theory was developed in suburban and rural areas (Schmidt and Ostfeld 2001); this study was done in an urban area. There have been fewer tick ecology studies done in urban areas, so further research needs to be done to test ecological theories since our results suggest there may be differing ecological processes contributing to tick hazard.

4.4. Human Disease Risk Implications

We did not test the ticks for tick-borne pathogens, but tick density is often used as a metric for human hazard (Lilly et al. 2025). Our study shows that there was an established tick population in Van Cortlandt: more than six I. *scapularis* of one life stage and two different life stages (CDC, 2025). We found ticks on the trails, edges, and interior of Van Cortlandt Park. Our results strongly suggest that there are more blacklegged tick nymphs and larvae on forest trails and in the forest interior than on forest/lawn edges. Areas that are highly used by people, such as trails, can be hazardous. We recommend implementing tick management along high-use trails, such as signage encouraging visitors to perform tick checks and other personal protective measures.

4.5. Limitations

We made an effort to sample the entire tick and wildlife host community at both of our collection sites. Our two-week sampling period may have underestimated mammalian richness, as shown by the variation between the camera trap data. For example, one of our cameras in Van Cortlandt only picked up an eastern gray squirrel, while the other camera picked up 5 different mammalian species, indicating that other cameras could also be missing species observations due to camera placement or the limited time period. Additionally, our methods did not capture small mammals, which are critical hosts for immature ticks and tick-borne pathogens (LoGiudice et al. 2003). Future studies should extend the sampling period and include additional urban green spaces.

5. Conclusion

Our findings highlight the importance of tick-borne disease dynamics in urban environments. Despite possessing similar diversity metrics, we did not find evidence to support the dilution effect, indicating that different ecological processes may operate in urban settings. We did not find evidence to support a pattern typically observed in both rural and suburban landscapes for the dilution effect. The relatively high numbers of American Robins—key hosts for *I. scapularis*—underscore the need for additional research on avian roles in urban tick-borne disease risk. Our data indicate that Van Cortlandt has an established tick population, potentially due to the presence of O. *virginianus*, suggesting the need for targeted tick management strategies, such as signage, raising public awareness, and habitat modification in high-use areas.

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Author Biography

Hoa Van, Diego Benitez, and **Audrey Effros** conducted an independent research project as part of Wave Hill's Woodland Ecology Research Mentorship program for high schoolers in New York. They are interested in biological and environmental sciences, dedicating their summer to looking into the tick disease risks in New York City's urban parks. They were mentored by Ph.D candidate Marie V. Lilly, who helped them develop research skills and science writing skills.

Mentor Contribution Statement

Marie Lilly is a PhD candidate at Columbia University, where their research focuses on the eco-epidemiology of urban tick-borne disease risk. She mentored the authors on their collaborative research project through Wave Hill's Woodland Ecology Research Mentorship program in the Bronx, New York City, NY. Marie provided guidance in formulating research questions and reviewing background literature, taught and assisted with methodology for data collection, and advised on data analysis. Lastly, Marie reviewed and provided feedback on the research paper.