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PREFERRED SOIL CONDITIONS OF INVERTEBRATES AT SUNY PURCHASE

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ABSTRACT

There is a lack of research and experimentation into the habitat preferences of invertebrate organisms, but what has been well documented is that higher abundance and diversity of soil invertebrates indicate a healthy soil. In our experiment, we aimed to collect soil samples from four different sites with four different soil quality types. In each soil sample we measured the moisture content, pH, temperature, and the invertebrate diversity. The four types of soil were: Site 1-hot/dry, Site 2-cool/dry, Site 3-cool/moist, Site 4-hot/moist. We found that there weren't large differences of temperature between the soil samples and the pH differences between the soil samples were consistent. Between the different soil sites the largest difference was the abundancy and the diversity of different invertebrate species. While site 2 (cool/dry) had a higher diversity of invertebrate, site 4 (hot/moist) had a larger amount of invertebrate organisms.

Keywords: Ecosystem, Invertebrate diversity, Soil Content

INTRODUCTION

Soil is the relatively shallow upper layer of the earth's surface and it crucial to all living organisms. It is formed by several factors such as climate, organic and inorganic materials. These factors affect major ecosystem processes, such as primary production, decomposition, and nutrient cycling, which lead to unique soil types and ecosystems. Organisms have evolved in the soil since the pre-Cambrian era (600 million years ago) and many soil-dwelling prokaryotes are responsible for the fixing of atmospheric molecules that are imperative to the evolution of plant and animal life on the planet. Soil ecosystems are comprised of many largely unseen domains, with an array of biota, such as microbes, vegetation and herbivore, carnivore and detritivore consumers, which affect and are affected by mineral, organic, aquatic and aerial habitats. Soil ecosystems can be viewed as the intersection of four principal entities: the atmosphere, biosphere, lithosphere and pedosphere (Coleman et. al. 1992). Therefore as climate changes, the effects it has on the conditions present in the soil will be translated to every aspect of biodiversity. This is why scientists are interested in understanding soil ecosystems and how rising temperatures may affect it (Kardol 2011).

As with all ecosystems, biodiversity is an important factor in measuring the overall health of the soil. An ecosystem's ability to sustain a wide array of organisms is a great indicator that the environment is nutrient-rich and has a high economic value (Renaud et al. 2017). In contrast, if biodiversity is suffering in an environment we can note that the health of the environment is being affected negatively. Because of this, ecologists are concerned with distribution and abundance of organisms in the environment. Thus, in soil habitats, collecting data on invertebrate species diversity, which consume organic matter in the soil such as termites and earthworms, indicates soil health. (Waring et al. 1985).

Invertebrates, as with all living things, must deal with the consequences of human actions. Climate change has had a measurable effect on these organisms and this effect varies wildly. Ants have started borrowing deeper into the soil to escape the rising soil temperatures at the surface (Del Toro et al. 2015), increased ocean temperatures have moved whole ecosystems to higher latitudes (Takolander et al. 2017) and even worst of all warmer temperatures coupled with invasive species have led to instability that could cripple an ecosystem altogether (Holopainen et al. 2016, Ransom et al. 2015).

Aside from the indirect effects caused by climate change, the direct effects that humans cause still create a heavily detrimental outcome on the ecosystem. Agriculture and all the processes involved with it, have caused hardship for various species of invertebrates (Callaham et al. 2003, Houston et al. 2014). Pollution from factory wastes have contaminated the surrounding soil (Vincent et al. 2018) affecting the delicate balances, such as pH, required for invertebrates to survive (McCay et al. 2017).

With all the different artificial stresses, this gives rise to the question of how the variables will manifest. In experimental forests, Nitrogen levels are artificially manipulated to be higher in accordance with predicted values in an effort to observe the most realistic outcome (Romanowicz et al. 2017). Experiential treatments of the different microbial communities present in the ecosystems are also being observed in order to determine how they will adapt to environmental changes (Noronha et al. 2017). Both areas of studies focus on similar variables but the reaction of different organisms will be heavily observed.

In our experiment, we compared the species diversity of macrofaunal invertebrates present in four separate soil conditions: warm and dry, warm and moist, cool and dry and cool and moist. With a focus on comparing the effects of the two main abiotic factors (temperature and moisture) on the organisms abundance and distribution. It is known that conditions present in tropical rainforests, higher temperatures and greater precipitation, lead to greater biodiversity than dryer and colder environments located at higher latitudes. Based on this information and discounting other environmental factors, it is hypothesized that invertebrates will be more abundant in soil that is both warm and moist.

METHODS

Field Sites. There were 4 different field sites that were chosen to collect soil samples. Field site 1 was located on the edge of a woodland area in direct sunlight with little to no moisture. Field site 2 was located within a woodland area that had a large canopy resulting in an area that was cool, little sunshine but also a low moisture area as well. Field site 3 was located on the south western bank of a stream within a woodlands area that also had a canopy resulting blocking much of the sunlight. This site was near a small stream making the area a high moisture area. Field site 4 was located on the northern edge of a roadside storm drain in direct sunlight. With the presence of the storm drain this also made the area a high moisture area.

The exact location of each field site was recorded using the GPS fuction of a Samsung Galaxy 5S smartphone. In conjuction to the the smartphone GPS tracking abilities, an app called Realtime GPS

Tracker was used to ensure the accuracy of the coordinates given by the Samsung Galaxy smartphone. The coordinates for the 4 field sites area as follows:

Site 1: 41°3'2.52" N 73°42'13.32" W

Site 2: 41°3'3.96" N 73°42'19.8" W

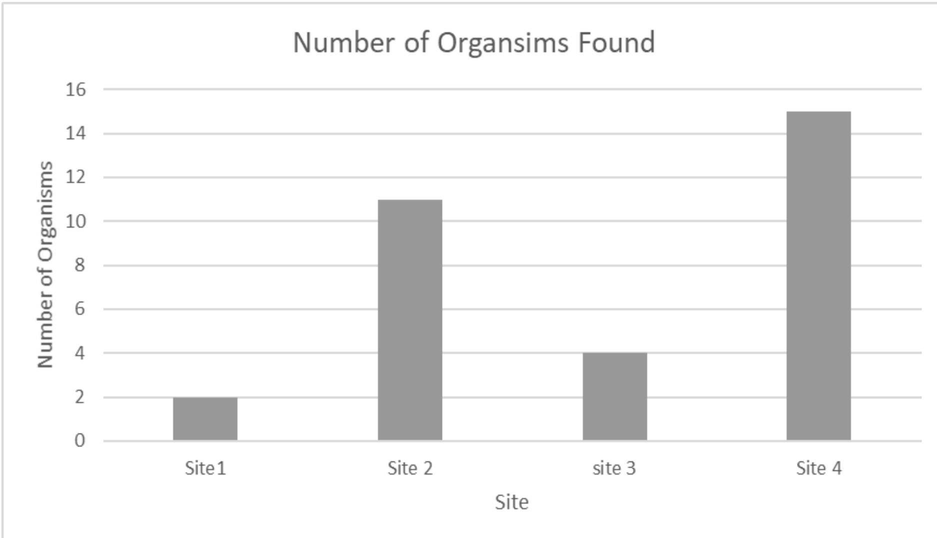
Site 3: 41°3'17.64" N 73° 42'13.86" W

Site 4: 41°3'11.16 N 73°41'15.12" W

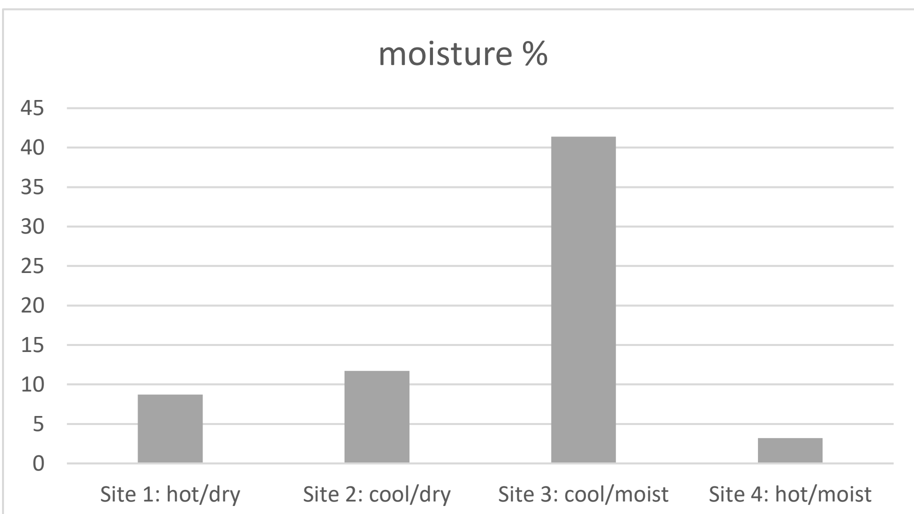
Soil Sampling. In each site a 200-mL soil sample was collected from a 2 by 2-meter area. Prior to collecting the soil sample, each field site was tested. A Covery 3-in-1 Soil Moisture Meter, Light and pH Tester was used to analyze the soil composition. A soil corer was used to collect the samples from each site. Once the soil was collected, it was then placed into a Ziploc bag and returned to the lab.

In the lab each soil sample was sifted individually using a SE GP2-14 Patented Stackable 13-1/4" Sifting pan, and a ¼" Mesh Screen. After sifting each soil large rocks were removed from the sample and the sample was analyzed. Any invertebrate found were placed in small beaker containing ethanol to preserve the organisms. Each site had its own ethanol beaker for the invertebrates found. The invertebrates were later counted and classified by Genius and Species. The data collected from each soil site was recorded and graphed using Microsoft Excel Spreadsheet.

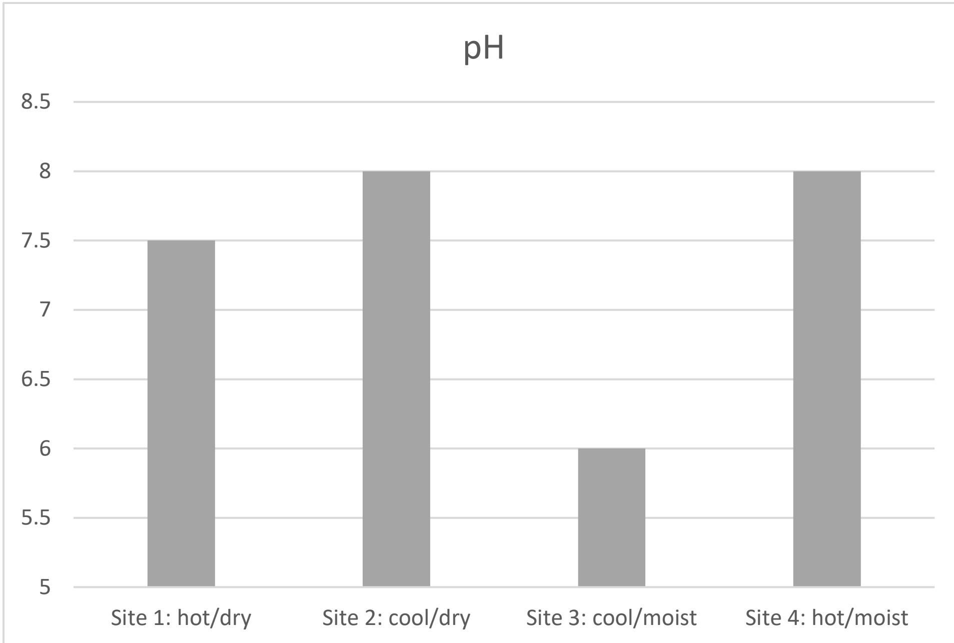
RESULTS



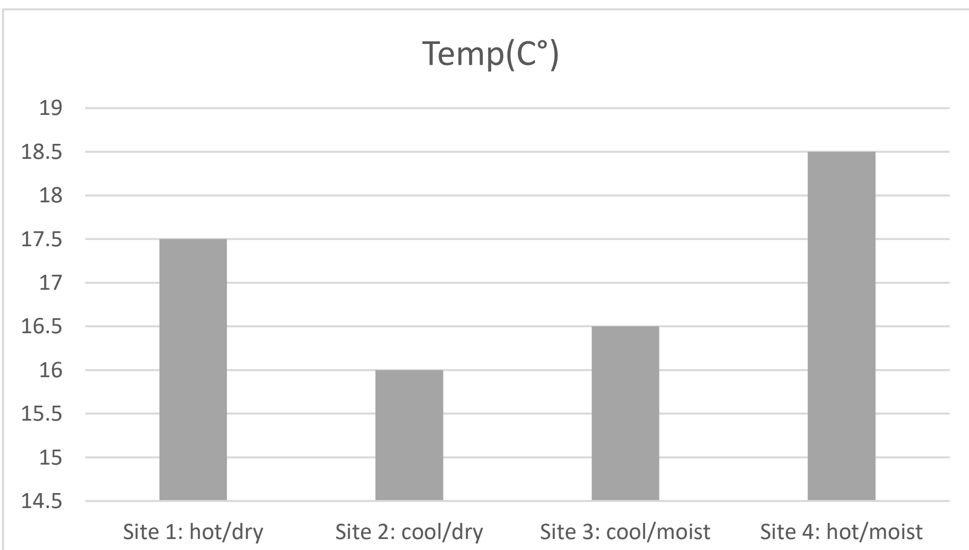
The site with the highest number of Organisms was site 4 with 15 individuals. Site 2 was second most with 11 individuals, followed by site 3 with 4 individuals and site 1 with 2 individuals.



In each soil sample moisture, pH level, temperature, and invertebrate content was measured and recorded. Each site held varying amounts of moisture. Site 3 held the most amount of moisture at 41.4%. Site 2 had the second largest moisture content of about 11.7%. Site 1 had a moisture content of 8.72% and Site 4 had the least amount of moisture content of 3.22%.



The pH was also recorded for each soil sample as well. While all of the soil sites held a pH near 7 (neutral) they were not all neutral soil samples. Site 3 had the most acidic soil measuring at pH of 6. Site 2 and Site 4 held a more basic pH value measuring a pH of 8. While Site 1 had a nearly neutral value pH of 7.5.



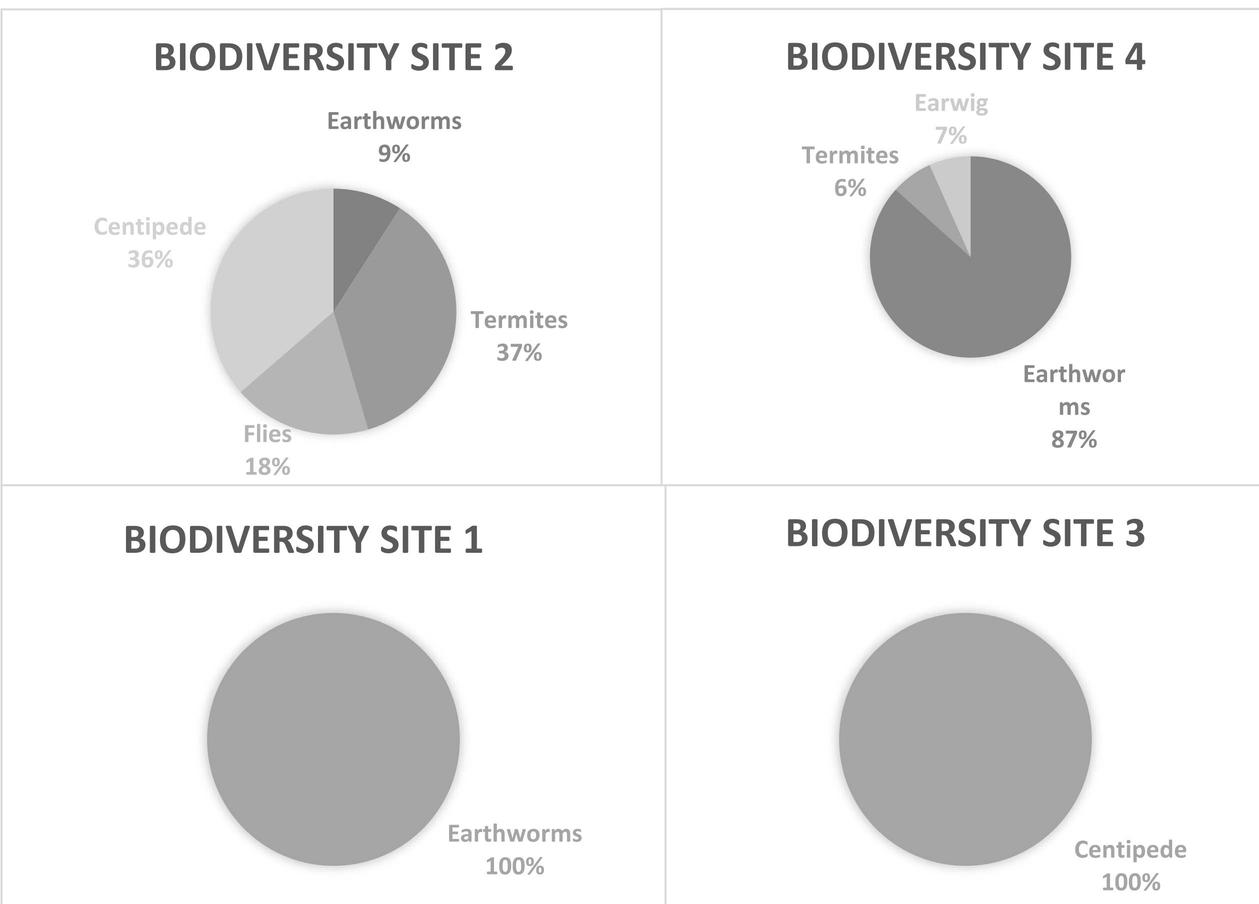
Similar to the moisture content and the pH, the temperature of the different soil sites were fairly consistent. There wasn't large variety in temperature of all the soil sites.

Each of the temperature recordings were measured in degree Celsius. Site 4 was the warmest of all the soil samples measuring a temperature of 18.5°C. Site 1 was the second warmest of the soil samples measuring at 17.5°C. Site 3 was the second coolest sample measuring at 16.5°C. Site 2 was the coolest out of all of the samples measuring at 16°C.

Measuring for biodiversity held the greatest amount of variability between all of the soil samples. Site 2 held the most diverse invertebrate organism that were collected. Termites made up for roughly 37% of organisms found at the site. Centipedes were the second largest organisms that were found roughly making up 36% of the organisms that were found. The rest of the sample from site 2 had consisted of earthworms and flies.

Site 4 was the second most diverse sampling site. Site 4 consisted of 3 different invertebrate species. Earthworms was the most abundant of the organisms that were found roughly making up about 87% of the invertebrate found. Earwigs were the second most abundant organism in site 4 roughly making up 7% of the invertebrate found in the site. Termites held roughly 6% of the invertebrate organisms found at site 4.

Measuring for biodiversity held the greatest amount of variability between all of the soil samples. Site 2 held the most diverse invertebrate organisms that were collected. Termites made up for roughly 37% of the Sites 3 and 1 held the least diverse samples. Site 3 consisted of only centipedes in the sample. While Site 1 only contained 1 earth worm. The diversity between these two sites were very little compare to site 2 and site 4.



DISCUSSION

Based on the data collected, the most invertebrate diversity was found in the cool and moist site. This was contrary to our original hypothesis, that the warm and moist site would have a large variety of invertebrates. Several factors may have contributed to these results. One of which could be due to the low sample size of our study, but it is also possible that the conditions of the selected sites were not varied enough to elicit an observable pattern. For example, the greatest difference in temperature between all sites was 2 C°. A variable unaccounted for in this survey is nitrogen concentration. Studies show that increases in soil Nitrogen provide earthworm species with preferable habitats to occupy (Romanowicz et al. 2017), thus nitrogen levels might explain the differences in earthworm numbers between the study sites.

This lack of Nitrogen data may explain why the cool and moist site showed the most biodiversity. If this is the case, the lower temperature of this site, fallen leaves from these trees and waste from animals that inhabit this area would no doubt increase the amount of nitrogen in the soil making the habitat more desirable to soil invertebrates. Further research on the Nitrogen characteristics of SUNY Purchase soil might clarify why each site contained what we found.

Our moisture measurement in site 4 which was labeled as cool and moist shows a discrepancy because of the content of the soil itself. The soil at this site had a high percentage of stones which contributed to the weight of the soil. Therefore when moisture was measured as the percent of water to the overall weight of the soil it was less than what was expected based on the wetness of the site.

The fact that this site showed the least amount of invertebrate diversity may be due to oversaturation of the soil caused by its proximity to Blind Brook as well as the large amount of rocks present. Although the site was not submerged at the time of sampling, its location within bankfull width would place it underwater during periods of high rainfall making the site inhabitable to many terrestrial arthropods.

More earthworms were found than any other invertebrate species. We were unable to identify the species of the earthworms we found, but it is possible that they are invasive. Invasive species often have an advantage in foreign environments because the center of the invasive species' evolutionary history is often located in different conditions, thus they can be uniquely adept at tolerating rare or unusual conditions in foreign lands (McCay et al. 2017).

Identifying the species name for earthworms present in SUNY Purchase would be an interesting addition to the study, and might help to further focus this project on invasive earthworm preferred environmental conditions.

It is also likely that the abundance of soil organisms on our campus is lower than that of a more natural system where human presence would be lower. Soil dwelling organisms often respond with high sensitivity to human disturbance and presence (Doran et al. 2000). This lower presence of soil organisms might have interfered with the accuracy of our sampling, likely exacerbated by the low sample size used. More complicated variables determine the distribution of invertebrates across the woodland sections of our campus. Overgeneralizations may not always be productive ways to describe ecosystem interactions (Kozlov et. al. 2017). Further sampling using both a larger quantity of samples and a larger variety of environmental conditions is required to make conclusive statements about how soil and invertebrate distributions on our campus are related.

CONCLUSION

Abiotic factors such as temperature and moisture may play an important role in the invertebrate diversity of soil ecosystems. However, biotic factors such as soil nutrient and microorganisms are also extremely important in the abundance and distribution of soil invertebrates. Sampling from field sites makes it impossible to control for all of the biotic variables, but this may be helpful in understanding the effects of abiotic factors on organisms in natural environments.

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FREQUENCY OF RACCOON OCCURRENCE AT TWO DUMPSTER SITES ON SUNY PURCHASE COLLEGE CAMPUS

Danielle Barone and Matthew N. Leichman

ABSTRACT

Purchase College campus is a leading example of how urbanization affects mammal abundance and distribution. Raccoons have been spotted around campus by students in large numbers. We conducted a study to further our understanding of raccoon feeding behavior near areas of high human population density. Human impact results in raccoons being able to find a constant food supply, and are able to successfully persist around college campuses and urban/suburban areas. Two dumpster sites with different human usage patterns were observed for raccoon frequency over three nights. Results indicate the steady production of trash contributes to successful raccoon populations in this area.

Keywords. Abundance; Density; Fragmentation; Habitat; Management; Raccoon; Urbanization.

INTRODUCTION

As our population continues to grow at an exponential rate, the development of human altered land follows. The landscape of a once pristine natural world grows smaller with the construction of each new town, neighborhood and individual residence. Urbanization shifts land usage from agricultural to the industrial with more and more commercial and residential fixtures appearing as part of the suburban sprawl. Ecosystem structure and function is heavily impacted by anthropogenic modification, often negatively. These patterns of human expansion have resulted in the change from once prevalent rural land into the rise of the rural-urban gradient (Yunger 2006). Urbanization and habitat fragmentation can both displace local species populations and introduce several alien pest species, potentially devastating existing ecosystems.

Human induced habitat fragmentation often results in the creation of “edge habitats” which are isolated patches of natural habitat. This affects raccoon’s geographical range and dispersal capability due to roads and other barriers. Emergence of edge-habitats and increased habitat fragmentation is a direct result of anthropogenic influenced expansion. Many species prefer habitat-edge areas (i.e. suburbs) that provide a readily abundant food supply, which would otherwise be difficult to find in their natural habitats. Human usage, residential and commercial land use, distance from urban center and road density were the most significant factors relating to species distribution and abundance in urbanized areas (Yunger 2006). Certain species are skilled urban adapters, showing equal preference for wooded edge habitats and human occupied areas. This may reflect their compromise between food and refuge (Houle 2011).

Of all mesopredators, including red fox, possums, coyotes, marmots, stripped skunks, the raccoon (*Procyon lotor)* is of interest, for both its keen urban adaptability and the many problems associated with their presence amongst human populations. Often referred to as an efficient "edge species", raccoons are incredibly effective at exploiting several human-subsidized food sources, specifically vegetative compost and trash (McKinney 2002). Existing "super rich" patches are abundant in human-subsidized food waste and have proven to modify the movements and spatial distribution of raccoons. Even compared to other urbanized mesopredator species such as opossums and skunks, raccoons benefit the most from the effects of urbanization (Ordenana 2010).

Consistency and prevalence of spatially fixed structures (i.e. dumpsters), and the artificial food sources contained within them contribute to increasing human-animal encounters (Prange 2004, Yunger 2006). Several species rely on artificial, concentrated and abundant food sources to maintain a viable population amidst continually changing habitats. In areas with high a human population density, the raccoons only natural predators, the grey/red fox and coyote are less inclined to hunt raccoons a possible reason for raccoon's high survivorship, high reproductive rate and abundance (Ordenana 2010).

Overabundance of raccoons and subsequent raccoon-human interactions can be problematic, and often dangerous. Problems such as reoccurring property damage, interspecies aggression, disease transmission and loss of biodiversity can all be attributed to high raccoon density within urban and suburban areas (Barden 1993). Overabundance in urban-suburban areas results in increased nuisance problems (Prange 2003). Over 40% of North American animal-damage-control jurisdictions deem the raccoon as the primary urban/suburban nuisance animal (Prange 2003). Unwanted animal-human interactions are becoming more frequent in urbanized areas which brings on the risk of attacks and disease transmission (Hirsch 2013). Notorious for hosting an array of deadly zoonotic pathogens (i.e. canine distemper, parvovirus, leptospirosis, rabies), raccoons pose an immediate threat to humans. The frequency of epizootic episodes depends upon host density. Areas with high raccoon population density, such as apartment complexes or restaurants are directly linked to more frequent epizootic episodes (Houle 2011).

Loss of biodiversity, growing extinction rates of local species and increased habitat loss due to anthropogenic influence may increase with continual human development along the urban-rural gradient (McKinney 2002). Several studies address the positive linear relationship between a higher non-native species population density and proximity to a city-center (McKinney 2002). High raccoon density can directly affect other population several native species distribution and abundance.

Present management practices agree that live-baiting, culling, and legal ordinances are the most effective and widely used techniques (Broadfoot 2001, Barden 1993, Lipske 2014). Population reduction through culling can be effective at minimizing potential raccoon-human interactions but the local short-term gains won't translate into long-term wins when applied on a broader scale (Rosatte 2007). This mentality illustrates the problems faced with providing management tools to an ecologically inept public. In response to this issue, several animal control agencies began to halt the publicly misused, reactive catch-and-release practice. A newer, more effective approach was designed to substitute live-trapping with education of the public. Mailing information, pamphlets, public workshops and additional literature was proven to better manage raccoon abundance than more traditional techniques (Barden 1993).

This study investigates the relationship between frequency of raccoon occurrence near dumpster locations at two building sites, and how each site's specific human usage has an effect on local raccoon feeding behavior. We aim to find significant variation of occurrences at each site based on the differing uses of each dumpster site's respective building(s). We predict to find a higher rate of raccoon occurrence at the dumpster site adjacent to "the HUB", a heavily trafficked dining hall compared to "Alumni Village", a moderetly trafficed network of student-used condominiums. Ideally, the findings will be used to develop methods of properly handling local raccoon overpopulation in urban/suburban areas.

METHODS

Study area. – Our study took place at Purchase College in the town of Harrison in Westchester County, New York. Local biota includes various species of oak, tulip, maple, dogwood, willow, grape etc. Mammal species include squirrels, skunks, raccoons, groundhogs, white tailed deer, and birds such as the red-tailed hawk, sparrow, blue-jay and chickadee. The campus's buildings are situated on the interior of Bridget Flannigan Dr., a continuous loop road that surrounds the campus and acts as a barrier between human occupied areas, the surrounding woodlands and the tributaries of "Blind Brook". On the eastern end of campus, a network of three adjacent residential apartments border Bridget Flannigan Dr., including Alumni Village, the Olde and the Quad.

"Alumni Village"- Alumni Village is perhaps the most populated of the three apartment complexes and it's parking lot (E5-E6) houses the largest dumpster cohort on the east side of campus. Between the E5 & E6 parking lots are four large dumpsters lined up side by side inside a 20'x8' fenced in area. The fences are rarely locked, allowing 24/7-hour access for residents of all three apartment complexes. Sufficient lighting was available due to several street lamps hanging above the dumpsters, ensuring we had an accurate view of the study area.

"The HUB"- Situated in arguably the most trafficked area on campus, the HUB serves as the schools main dining hall. Thousands of students and faculty frequent the HUB for several meals a day. The HUB produces tones of human refuse each week, with human-subsidized food waste being the main source of garbage. The HUB's dumpster area is located behind the main building, approximately seven meters away from the loading dock and 30 meters away from the faculty parking lot facing northeast. Many people walk directly past the dumpsters on their way to the apartment buildings many times a day. Compared to the dumpster site at "Alumni Village", the HUB's dumpster area contains only two dumpsters, surrounded by a 12'x7' fence that is almost always locked. Dumpsters are emptied daily, sometimes more than once a day. The fenced in area is inaccessible without granted admittance but a noticeable bend at the top of the fence is indicative of frequent raccoon activity around and inside the HUB's dumpster area.

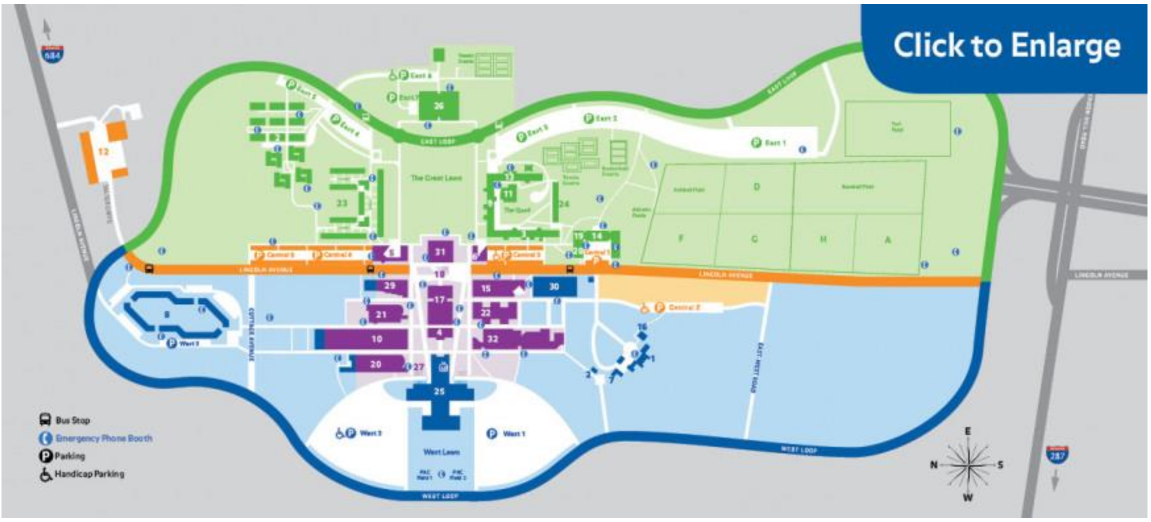

Figure 1: SUNY Purchase College Campus Map. The green shaded area of the map contains the three residence apartments, with Alumni Village being the leftmost, the Olde to the right of Alumni Village and The Quad to the right of the Olde. Also shown in Bridget Flannigan Dr., the entire campus being separated by the road. The grey areas represent the surrounding woodlands, which contain Blind Brooke and are home to dozens of native species. Building #24 represents the HUB and the dark blue square behind it represents the HUB's dumpster site. The Alumni Village dumpster area is between the E5 and E6 parking lots.

Raccoon counts. - Raccoon counts at "Alumni Village" were taken from 32 meters, measured from the nearest dumpster to a patch of grass on the edge of a dark, well-hidden and small wooded area. The observation site at the HUB was situated 17.3 m away on an adjacent, downward sloping walkway leading to the HUB. Observations were conducted from 10:00 pm-12:00am on the nights of 10/20/2017, 10/25/2017 & 11/13/2017. We set our phone alarms at fifteen-minute intervals (i.e. 10:45pm-11:00pm) for two hours and using a tally sheet, we counted each raccoon entering, leaving or walking nearby the dumpster area. The study's aims were completely unrelated to an individual's sex, size and group composition, so these attributes weren't recorded. No account was taken of a raccoon's individual features (i.e. size, stripe patterns, sex, and number of group members and reoccurrence of the same individual).

RESULTS

Observations at both the HUB and Alumni Village locations totaled 53 raccoons for all three nights. Total raccoon count for 10/20/2017 is 17 for Alumni Village and 9 for the HUB. Total raccoon count for 10/25/2017 is 6 for Alumni Village and 15 for the HUB. Total raccoon counts for 11/13/2017 is 1 for Alumni Village and 5 for the HUB. Total raccoon count for Alumni Village is 24 individuals for all three nights. Total raccoon counts for the HUB is 29 individuals for all three nights.

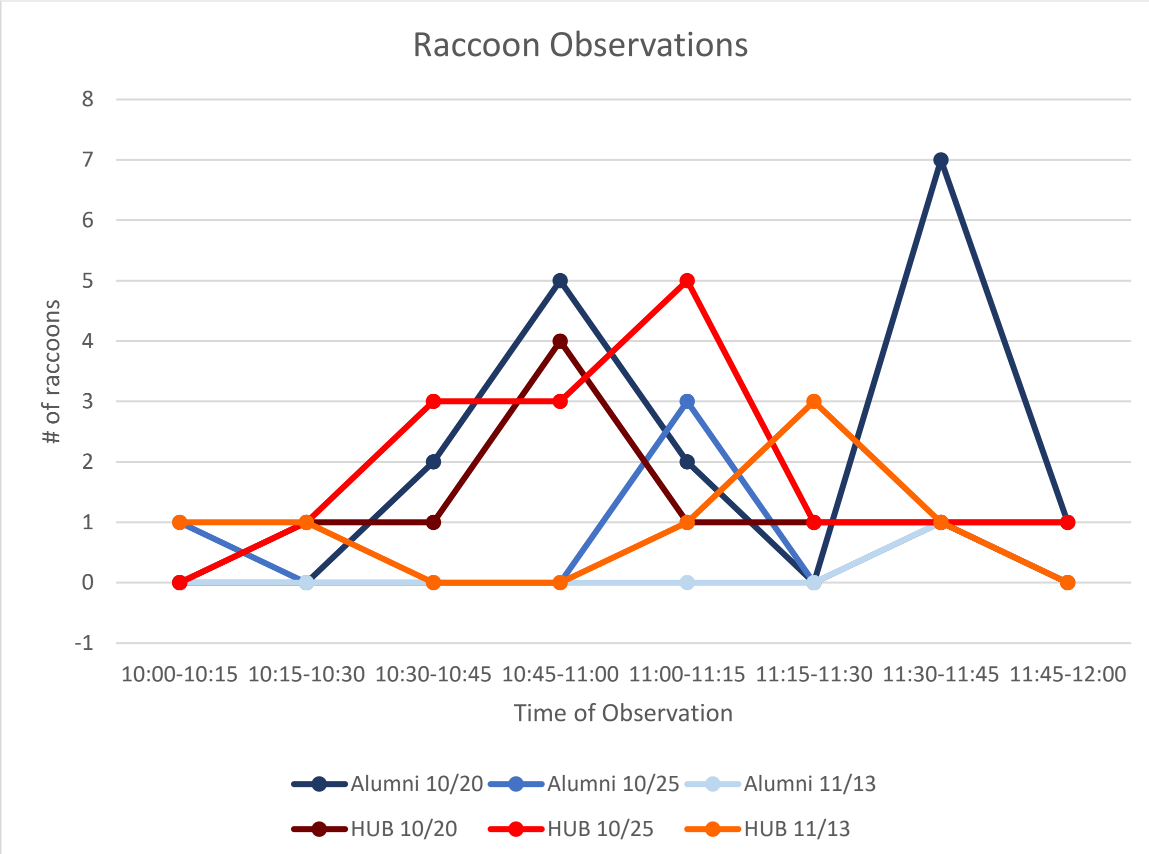

Figure 2. Graph representing the number of raccoons spotted at each time interval on the nights of 10/20/2017, 10/25/2017 & 11/13/2017. The blue shaded lines represent the number of raccoon spotted at the Alumni Village location and red shaded lines represent the raccoons spotted at the HUB location.

Table 1. Raccoon counts at Alumni Village and the HUB on 10/20/2017

10/20/2017	**Alumni Village**	**The HUB**
	0	0
	0	1
	2	1
	5	4
	2	1
	0	1
	7	1
	1	0
Total	17	9

Table 2. Raccoon counts at Alumni Village and the HUB on 10/25/2017

10/25/2017	Alumni Village	The HUB
	1	0
	0	1
	0	3
	0	3
	3	5
	0	1
	1	1
	1	1
Total	6	15

Table 3. Raccoon counts at Alumni Village and the HUB on 11/13/2017

11/13/2017	Alumni Village	The HUB
	0	1
	0	1
	0	0
	0	0
	0	1
	0	3
	1	1
	0	0
Total	1	5

DISCUSSION

Results of the study coincide with our original prediction that raccoon occurrence frequency would be highest at the HUB. We assumed this because of the larger daily volume of trash, dumpster contents being mainly composed of human-subsidized food waste and high human foot traffic. We thought because Alumni Village is less trafficked than the HUB, had a lesser volume of trash and a wider variety of trash contents that there would be a significantly lower raccoon count. While Alumni Village had a lesser frequency of raccoon visitation, the difference is so insignificant (Alumni-24 & the HUB-29) that other factors must be considered before coming to any conclusions.

Alumni Village's proximity to an edge of small wooded area may contribute to less raccoon counts. Edge-species, such as the raccoon use these habitat edges to choose between higher food abundance and the safety of the wooded refuge. Alumni Village's trash contents, which contain a higher variety of refuse compared to the HUB may deter raccoons from visitation compared to the HUB.

Uncertainty of the trash pick-up schedule may have skewed our data. We had no way of knowing when dumpsters were last emptied, how soon they've been emptied or even the specific volume of trash at the times of observation. It may have been random chance and uncertain timing that the HUB had higher raccoon visitation than Alumni Village. The locked fenced area surrounding the HUB dumpsters and unlocked fenced area surrounding the Alumni Village dumpsters seemed to have little effect on raccoon frequency when comparing results.

The study's small sample size and two categories of human usage per site may have contributed to the study's insignificant results between each observation site. Since we only made observations at nighttime between the hours of 10:00pm-12:00am, the fixed time intervals may have been a reason why the data seems so irrelevant. Other possible sampling errors may include raccoons we accidently didn't see, poor choice of observation site and wind speed, which may influence raccoon movement due to olfactory responses to the air's smell.

Through personal experiences, student accounts of aggressive encounters and relevant literature, the often-ignored issue of SUNY Purchase College's overabundant raccoon population needs to be officially addressed. If unresolved, raccoon numbers will continue to grow, as will the risks of disease transmission, biodiversity loss and property damage.

Frequent raccoon occurrences near areas of high human traffic requires further research to understand the feeding behavior of local raccoon populations and its relationship to the specific human uses certain areas of campus have. Site-specific management practices are run completely by Westchester Animal Control, and the school hasn't investigated local raccoon populations and the effect our presence, specifically our refuse has on their behavior, distribution and abundance. There is no specific literature on the current state of SUNY Purchase College's expanding raccoon population. Currently, regional variation of study sites and differences in sampling methods among researchers makes understanding the effects of artificial food sources on the distribution and abundance of species (specifically mammals) uncertain (Baldwin 2006, Wilson 2006). Understanding the spatial relationship to surrounding landscape structure is crucial in determining specific species habitat associations. Presently, most of our knowledge about raccoons' association with their habitat is derived from a series of broad, landscape-level macrohabitats. There is a need for a greater volume of research conducted on raccoon population occurance at the small-scale, local microhabitat level.

CONCLUSIONS

Higher raccoon counts were recorded at the dining hall "the HUB" location, compared to the apartment complex "Alumni Village". Although there's no significant difference in results between each site, a slightly higher count at the HUB can be contributed to larger volume of trash and a higher density of human-subsidized food waste compared to Alumni Village. Insignificant results can be indicative of poor experimental design, small sample size and time constraints, therefore more consideration should be given before committing to similar studies.

Results show that raccoons certainly exploit easily accessible human food waste which may increase overall survivorship and reproductive health of raccoon populations on campus. Variation in human use per area doesn't directly address the issue of overall raccoon overabundance on campus, the implications for student/faculty safety, biodiversity and best management practices for raccoon population control.

ACKNOWLEDGEMENTS

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DIFFERENCES IN PLANT DIVERSITY AND DIMENSIONS BETWEEN EDGE AND CONTIGUOUS FOREST HABITATS

Jessica Lau and Luz Medina

ABSTRACT

During the construction of Purchase College, a large proportion of forest habitat was removed, resulting in many habitat fragments. The plant species diversity, area density, and area coverage of edge and contiguous forests habitats of different fragments on the Purchase College campus were studied to find any differences between these factors. Several significant differences were found: 1) contiguous habitats have higher plant density and overall tree coverage than edge habitats, 2) both contiguous and edge habitats have more shrubs and bushes than trees, and 3) species diversity and area coverage of shrubs and bushes were highly variable between the habitat types. These differences imply that habitat fragmentation affects plant composition and diversity, but also that the ecology of habitat fragments vary widely from one another. Furthermore, ecosystem management decisions should be made based on the individual ecologies and these effects for particular fragments.

Keywords. Diversity; Edge habitat; Forest habitat; Habitat fragmentation; Plant dimensions

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INTRODUCTION

Habitat fragmentation is a widespread result of converting natural landscapes for human developments. This conversion results in the formation of two distinct habitats: outer edge habitats and inner contiguous habitats. When contiguous habitats become edge habitats, there are many changes in its ecological attributes, such as biodiversity, population dynamics, and ecological processes (Hanski et al. 2015, Magnagno et al. 2014, Riutta et al. 2014, Young et al. 1996). Although there are many known types of changes that distinguish edge and contiguous habitats from each other in most fragmented habitats, the degree of change in ecological attributes between these habitats can vary widely from one another in various parts of the world (Haddad et al. 2015, Young et al. 1996). Oftentimes, these changes caused by habitat fragmentation greatly affect the abundance or distribution of certain plant and animal species. The degree of change in abundance or distribution depends on the fragment’s size and degree of connectivity, which is why many conservationists advocate for preserving as much contiguous habitat as possible (Damschen et al. 2014, Davies and Margules 1998, Haddad et al. 2015, Hanski 2015, Riutta et al. 2014).

Habitat fragmentation of forests have been shown to result in a variety of biotic as well as abiotic changes that impair ecosystem function; most fragmented forests have a distinct reduction in biodiversity, altered nutrient cycles, decreased biomass, and a reduction in plant and animal dispersal (Damschen et al. 2014, Haddad et al. 2015, Turner et al. 1996, Young et al. 1996). Like in most habitat fragments, the smaller and more isolated forest fragments often have more adverse declines in ecosystem function, and become worse as time passes (Haddad et al. 2015, Hanski 2015, Riutta et al. 2014). Long-term fragmentation experiments have shown that 70% of remaining forest are within 1 km of edge habitat, and that the remaining contiguous habitat within the fragments are vulnerable to facing the declines in ecosystem function as seen in their edge habitats (Haddad et al. 2015).

The construction of Purchase College resulted in deforestation, leading to habitat fragmentation of its forests. Although most of the forest removed during the campus' construction was secondary forest, some of the remnant forest is primary forest which already has distinct ecological attributes from secondary forests. Although it is easy to distinguish edge and contiguous forest habitats on Purchase College's campus visually, we wanted to quantify the differences between the contiguous and edge forest habitats to determine how significant the differences between these habitats were from one another by comparing the diversity and physical dimensions of their plants.

Our objectives were to quantify the plant density in edge and contiguous forest habitats, quantify the abundance of different plant types within each habitat, evaluate species richness of each habitat, and estimate the total area taken up by plants within each habitat. We predicted that contiguous habitats have higher species richness than edge habitats and that plants in contiguous habitats cover more area than those in edge habitats.

METHODS

The edge and contiguous forest habitats near Purchase College's W2 and E2 parking lots were studied for plant species richness, total plant density, total number of plant types, and estimated area coverage.

Field site. The field sites for edge habitat and contiguous forest habitat near Purchase College's West 2 (W2) and East 2 (E2) parking lots (Fig. 1). The field sites were studied during the month of October in 65°F (18°C) weather and no precipitation. Each sampling site had a standard area of 8x8 m (64 m^2) for final calculations, but the area measured per site was 2x2 m (4 m^2). Measurements and counts from each site were multiplied by 4 to estimate the total sample for each forest habitat type (edge and contiguous) from each parking lot. Measuring tape was used to determine where to isolate the field sites to be studied, and marked with stakes.

Figure 1. A total of four sites were studied: 8x8 m (64 m^2) sites were selected to represent edge or contiguous habitats near parking lots W2 and E2.

Total number of plant types. Plants were categorized by discrete plant types in order to count whole, singular organisms: trees and shrubs/bushes. Grasses in small bunches were counted as shrubs/bushes because most grasses are hard to define as singular organisms. The total numbers of trees and shrubs/bushes were counted in positive integers within each site. The total numbers of trees and shrubs/bushes counted in the study site were then multiplied by 4 to estimate the total numbers of trees and shrubs/bushes within the standard area (64 m^2).

Total plant density. The number of plants in each study site was determined by counting the number of individual trees and shrubs/bushes in each sample plot at each site. The total number of trees and shrubs/bushes were added together to determine the total number of plants at each sampling site. The total number of plants was then multiplied by 4 to calculate the total plant density in the standard area (64 m^2). The result was divided by 8 to estimate the total number of plants per m^2.

Plant species richness. The total number of plant species in each plot was determined by identifying distinct each plant species based on their leaf shapes and other physical characteristics, and referring to books that are guides about forest plants.

Estimated Area Coverage. The area covered by the trees and shrubs/bushes was estimated by determining average plant dimensions (tree circumferences, average tree heights, bush area) in each habitat, based on the measurements of individual plants in each plot, and multiplying the average plant dimensions by 4 to estimate the total area coverage within the standard area (64 m^2).

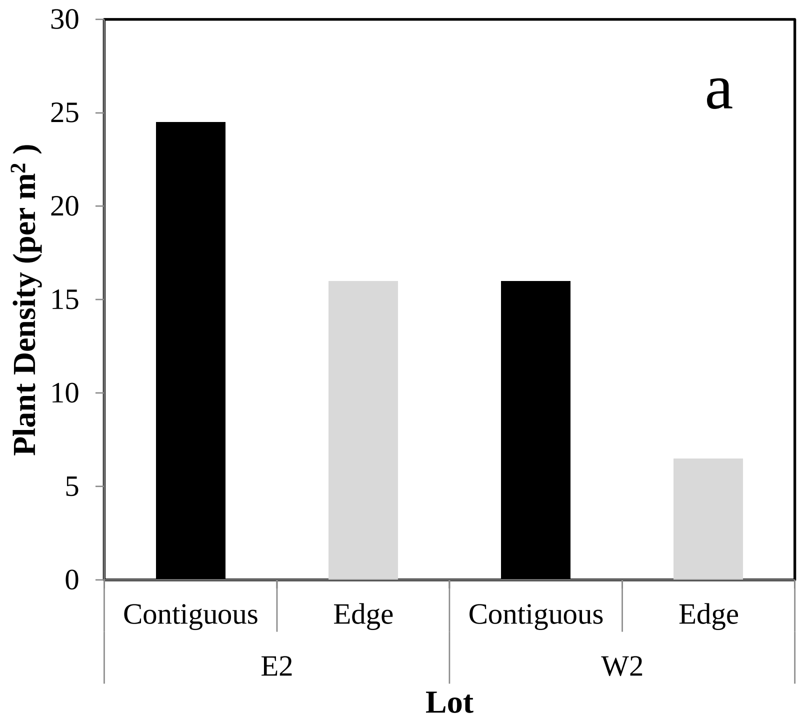
RESULTS

In both parking lots (E2 and W2), the total plant density per m^2 in the contiguous habitats was higher than in the edge habitats (Fig. 2a). All of the plots had proportionately more shrubs/bushes than trees per m^2 (Fig. 2b). The contiguous habitats of both parking lots had more shrubs/bushes than the edge habitats. However, the edge habitat of E2 had more trees than its contiguous habitat, while the contiguous habitat of W2 had more trees than its edge habitat.

The plant species richness (total number of plant species) was higher in the contiguous habitat (7 species) than the edge habitat (4 species) of parking lot E2, but there was a higher species richness in the edge habitat (9 species) than the contiguous habitat (14 species) of W2 (Fig. 3).

Overall, tree coverage was higher in the contiguous habitats than in the edge habitats (Fig. 4). The area coverage of trees based on the estimated average trunk circumference in each plot was higher in the contiguous habitats than in the edge habitats (Fig. 4a), and the estimated average tree height was higher in the contiguous habitats than in the edge habitats of both parking lots (Fig. 4b). Additionally, the tree coverage of the contiguous habitat of W2 (circumference: 110.75 cm, height: 907.5 cm) was higher than the tree coverage of the contiguous habitat of E2 (circumference: 42.5 cm, height: 650 cm).

The area coverage of shrubs/bushes based on the estimated volume in each plot was higher in the edge habitats than in the contiguous habitats of both parking lots (Fig. 5).



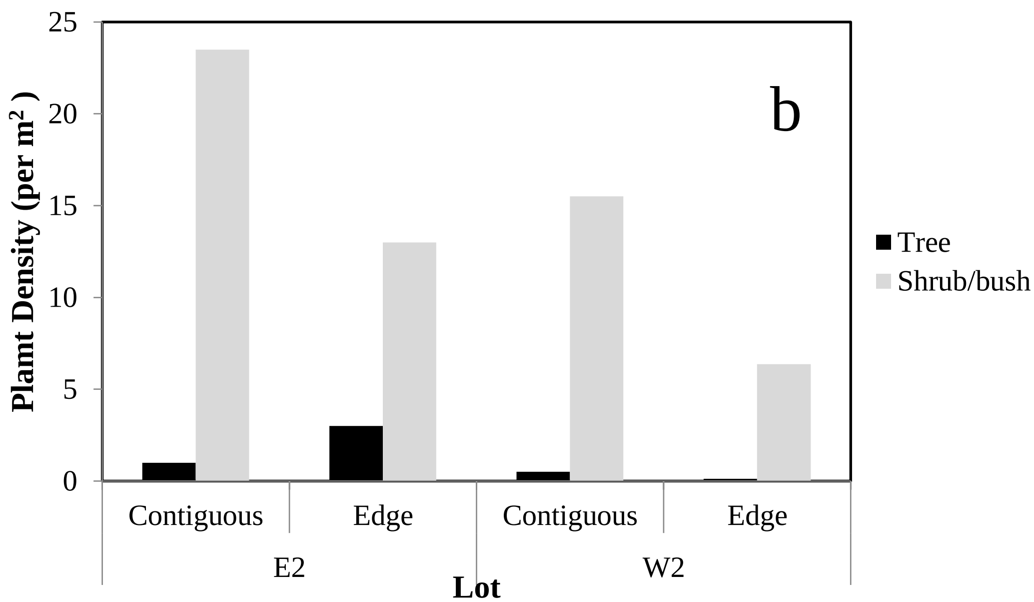


Figure 2. Plant density per m^2. a) The total plant density per m^2 of trees and shrubs/bushes for the contiguous and edge habitats in each parking lot E2 and parking lot W2. The contiguous habitats had a higher total plant density than the edge habitats. b) There were more shrubs/bushes than trees throughout all 4 study plots. The contiguous habitats had more shrubs/bushes than the edge habitats. The edge habitat of E2 had more trees than its contiguous habitat, and the contiguous habitat of W2 had more trees than its edge habitat.

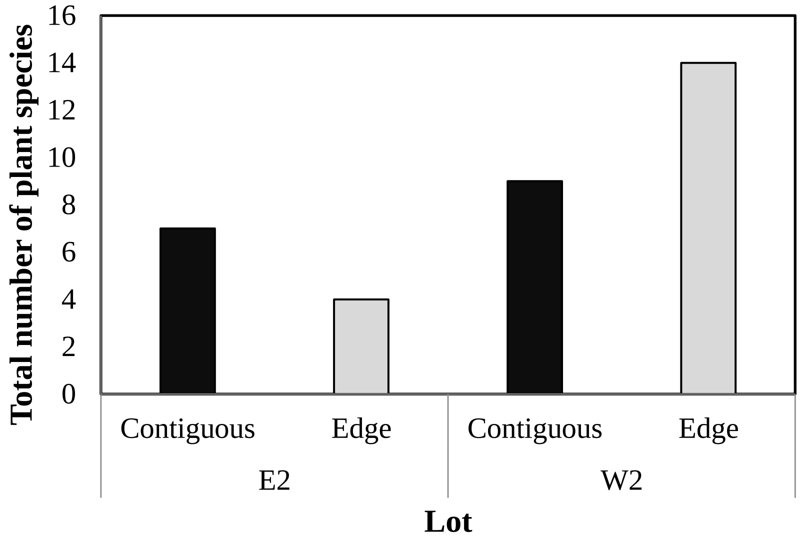


Figure 3. Total number of plant species. The total number of plant species found in the contiguous habitat of E2 was higher than that of its edge habitat, while the total number of plant species found in the edge habitat of W2 was higher than that of its contiguous habitat.

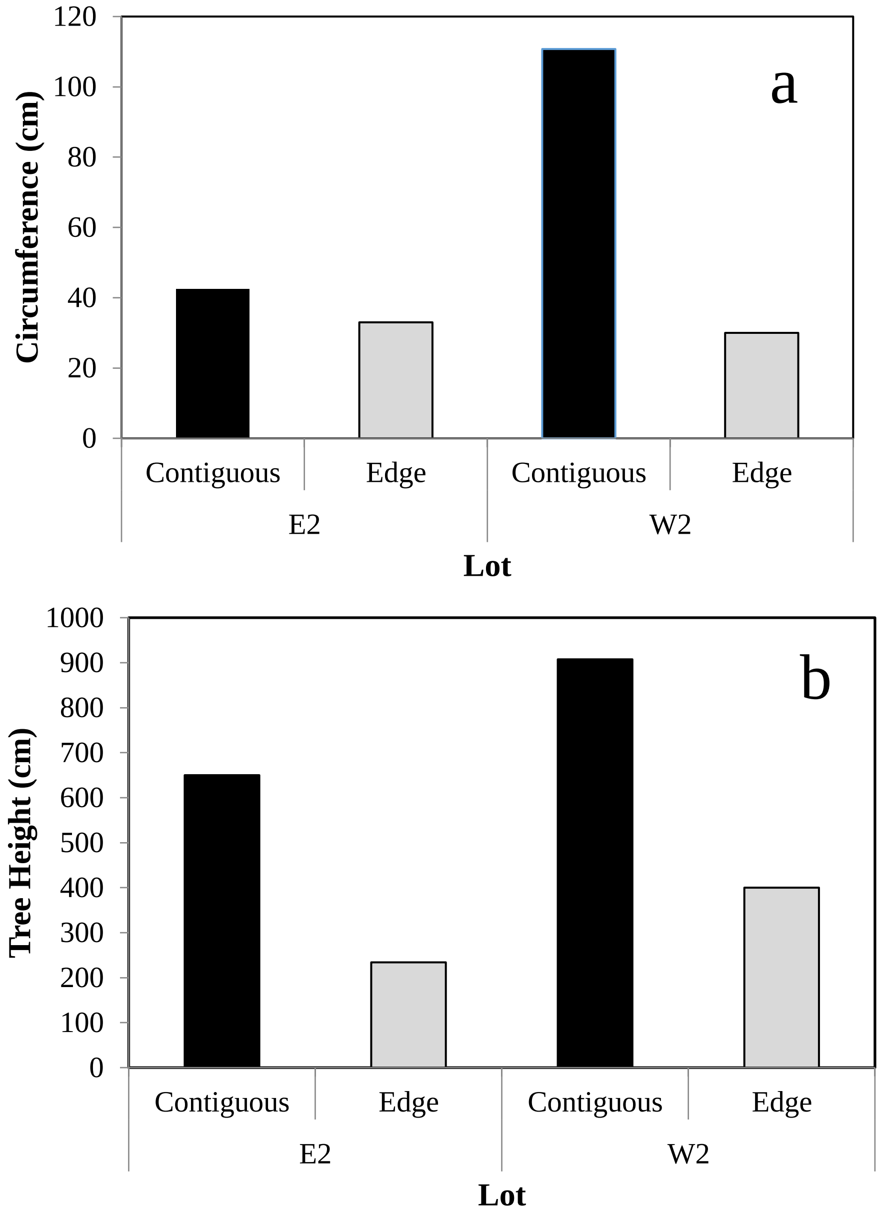


Figure 4. Area coverage of trees. a) The average tree trunk circumference (cm^2) of trees was higher in the contiguous habitats than in the edge habitats of both parking lots. b) On average, the trees in the contiguous habitats were taller than trees in the edge habitats.

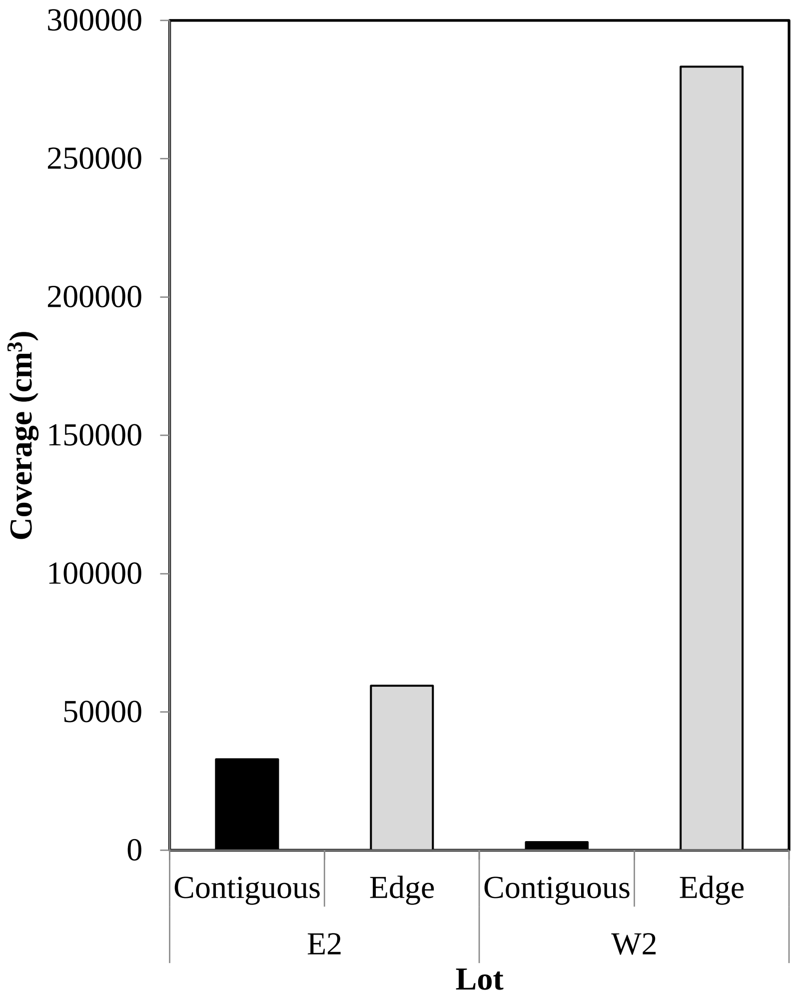


Figure 5. Area coverage of shrubs/bushes (cm^3). The shrubs/bushes in the edge habitats had more area coverage than the shrubs/bushes in the contiguous habitats.

DISCUSSION

Differences between edge and contiguous forest habitat were found by comparing the physical dimensions, composition, and diversity of the plants residing within these habitats. Some of the differences found in this study had more clear relationship than others.

The total plant density and tree coverage were consistently higher in contiguous forest habitats than in the edge forest habitats. These differences were consistent with our prediction that plants in contiguous habitats cover more area than those in edge habitats, indirectly implying that trees in the contiguous habitats have more biomass than trees in the edge habitats (Haddad et al. 2015, Ziegler 2000). Additionally, the trees in W2 were taller (907.5 cm) and had wider trunks (110.75 cm) than the trees in E2 (height: 650 cm, circumference: 42.5 cm), most likely because W2 had primary, old growth forest while E2 had secondary, new growth forest (Ziegler 2000).

Our prediction did not take differences in area coverage between trees and shrubs/bushes into account. The shrub/bush densities were higher than the tree densities in all four lots and the differences in tree density were inconsistent throughout each lot. These results showed that there was an overall higher abundance in shrubs/bushes than trees, but because the area coverage of shrubs/bushes were measured by volume, their area coverage could not be compared against trees.

The differences between tree densities most likely occurred because of differences in nutrient or light availability in each habitat as a result of habitat fragmentation (Haddad et al. 2015). On a broader scale, these differences imply that the ecologies of the habitat fragments vary widely from one another, greatly affecting the abundance and distribution of the trees (Damschen et al. 2014, Riutta et al. 2014).

The differences in species richness were not consistent with our prediction that contiguous habitats have higher species richness than edge habitats. Although the differences in species richness between the contiguous and edge habitats of E2 was consistent with our prediction, these differences in W2 were not consistent, most likely because our prediction did not take plant competition into account. Because the contiguous forest of W2 is a primary forest, the old growth trees outcompete the other plants for space and sunlight because they have larger physical dimensions than those in secondary forests (Ziegler 2000). Furthermore, the trees in the contiguous forests outcompeting other vascular plants is the most probable cause for the higher shrub/bush density in edge habitats than in contiguous habitats (Magnagno et al. 2014).

Further studies should be done on a larger scale and on a frequent basis in order to provide better estimates and predictions for ecological changes in these habitats (Haddad et al. 2015). In order to quantify which type of vascular plant has the highest percentage of biomass in edge and contiguous habitats, the differences in biomass between shrubs, bushes, trees, and grasses should be directly compared in further studies. Furthermore, plant competition should be evaluated by studying the biological characteristics of the plants in each habitat in order to determine which species will most likely outcompete the others, especially when trying to manage invasive species. The differences in these factors between primary versus secondary forests should also be studied in order to encourage habitat preservation (Ziegler 2000). By conducting more thorough studies about what biotic and abiotic factors affect species richness and physical plant dimensions in forest habitats, more informed, individualized decisions for ecosystem management of specific fragmented habitats can be made to prevent further decline in ecosystem function.

CONCLUSIONS

In order to tailor the best ecosystem management strategy for a specific fragmented habitat, long-term studies about the ecological attributes of each fragment and physical characteristics of their plants should be conducted in order to evaluate the ecosystem status of the fragments. By understanding the current status of particular habitat fragments, the most appropriate decisions for these fragments can be made in order to prevent edge effects from spreading to intact contiguous forests. These various edge effects are highly likely to impact the diversity of many ecosystems by affecting their plant and animal species.

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EFFECT OF SPECIES DIVERSITY AND HABITAT TYPE ON DISPERSAL OF BLACK TAR SPOT DISEASE IN *ACER PLATANOIDES*

Camille Rossiello, Jon Matkowski, and Matthew Garafalo

ABSTRACT

Acer platanoides is an invasive tree species in the eastern Unites States that has negatively impacted native tree populations. One of its natural pests, Black Tar Spot (Rhytisma acerinum) infects A. platanoides with few deleterious effects on tree health and it shows up as large black spots on leaves. We measured the varying degrees of severity of R. acerinum infection on A. platanoides, in edge and non- edge (interior) habitats, and the diversity of tree species around the tree. We randomly selected trees to sample severity and we found that trees in edge habitat had a higher severity of the fungus as opposed to trees in interior forest habitat. The average severity for edge habitat was 2.2 compared to interior habitat average of 0.7. It was found that habitat type significantly correlated with severity of tar spot infection. (P = 0.001).

Keywords. Habitat type; invasive species; Norway maple; species richness; Tar Spot disease.

INTRODUCTION

Invasive species can have a significant impact on the species diversity, species richness, and species evenness of an ecosystem. Impacts on native forest structure depend on the invading species. The height and canopy cover of the invading tree species will affect the fluctuation of native forest composition and structure (Hejda 2009). The abundance and dispersal rate of non-native tree species are dependant upon light and soil conditions; however, in the case of *Acer platanoides* (Norway maple), light and soil limit growth rate only, not dispersal. Dispersal limitations and varying forest stability dynamics have the greatest effect on dispersal rates (Martin 2006).

A. platanoides, a native of Eurasia, had its first documented introduction approximately 250 years ago when saplings were imported from England. It is estimated that *A. platanoides* is the most abundant ornamental tree planted in the United States, favored for its rapid early growth rate, as well as its hardiness. Ideal for transplantation, *A. platanoides* fares well against urban impacts, and outcompetes native maples when it comes to frost resistance and soil tolerance (Nowak & Rowntree 1990). Creation of edge habitat or disturbed soils can facilitate the establishment of *A. platanoides*, which can have detrimental effects on species richness and tree regeneration in forest understories (Lapointe & Brisson 2012). In its native range, the average total herbivory on *A. platanoides* leaves was significantly higher at 7.4% compared to 1.6% in North America. In both continents the main forms of herbivory were chewing and skeletonizing with a positive correlation of leaf herbivory and temperature. In all sites but one studied in North America, the total herbivory or fungal damage did not exceed 4% compared to European sites (Adams et. al 2009).

Experimentation has shown that *A. platanoides* grow taller and faster in simulated gap conditions; however, in deep shade simulated understory the growth rates of *A. platanoides* and sugar maples were not significantly different. It also found that the *A. platanoides* had significantly greater photosynthetic capacity in all lighting conditions compared to sugar maples, enabling *A. platanoides* to recruit in the overstory 12-22 years faster than sugar maples. Contrary to sugar maples, *A. platanoides* have longer growth periods through the fall. *A. platanoides* can reach minimum canopy height in as little as 21 years while native trees take between 47 and 82 years to reach the same height. *A. platanoides* were considerably more pernicious in gap scenarios and due to their low root: shoot ratio are capable of outcompeting many species as they will exceed them in overall growth rate (Paquette et. al 2012, Webster et. al 2005). *A. platanoides* is a shade-tolerant species, and intact forests provide weak resistance to its colonization (Martin & Marks 2006).

Tar spot, which appears as a large dark blemish on the leaves of *A. platanoides*, has been increasing in prevalence in the Eastern United States since the 1990's. Tar spot affects both native and non-native maples, but each infection is caused by different species of fungus: *Rhytisma acerinum* and *Rhytisma americanum* (Hsiang & Tsian 2007). For the purpose of this study, we will focus on *Rhytisma acerinum* (Black Tar Spot), a non-native fungal species that affects its host *A. platanoides*, in its native range as well as in North America. Tar spot fungus overwinters in the fallen tar spot-bearing leaves of the *A. platanoides*. Once the maple's leaves begin to bloom again in early spring, spores are released from the previous year's leaf litter to infect the new growth. It takes about two months after initial infection for symptoms of tar spot to appear. Since tar spot infected leaves lose mass slower than uninfected leaves, a higher concentration of leaf litter could increase the frequency of tar spot in *A. platanoides* trees in North America (Gosling et. al 2016, Grimmett et. al 2012).

We hypothesized that tar spot severity would be highest in areas with high densities of *A. platanoides* and fewer non-maple tree species and in edge habitat due to the prevalence of *A. platanoides* in edge habitats on campus. Our goals were to determine: the effect of *A. platanoides* abundance within sampling sites on tar spot severity, the effect of tree diversity within sampling sites on tar spot severity, and the effect of habitat type on tar spot severity.

METHODS

Field site. There were 20 sites randomly sampled on the north side of SUNY Purchase College campus (Figure 1). The forest containing most of our sites is a 90-year-old hardwood forest located behind the Alumni Village apartments. It contains *Acer platanoides* (Norway Maple), *Acer saccharum* (Sugar Maple), *Quercus spp.* (Oak tree genus), *Liriodendron spp.* (Tulip tree), *Fagus* (Beech tree), and *Carya ovata* (Shagbark hickory). Other sites were located on edge habitats on the main road (Lincoln Ave.) and hardwood forest located behind the Music Building. This forest contains a stormwater basin and is classified as a wetland, although it is dry in most areas (includes most of the trees mentioned above). These sites were chosen due to the stands of *A. platanoides*.

Site Selection. A region was chosen based on the number of *A. platanoides* and the size of the area. One member of our team then selected a point of reference (usually a rock) and we measured a 15 m radius to assign numbers to each *A. platanoides* in the plot. We then used a random number generator app called “Pretty Random”, to select a tree to study. Once we selected a Norway maple we used a 5 m radius around the tree of interest to determine the tree diversity in the plot. We determined tree diversity of sample sites by ascribing them the values of “No diversity”, “Low diversity”, “Moderate Diversity”, and “High diversity”. We assigned these values based on the number of *A. platanoides* compared to non-Norway maples, with no trees other than *A. platanoides* within the sample site as no diversity, non-Norway maples making up less than half of total trees within sample site as low diversity, non-Norway maples about half of the total trees as moderate diversity, and non-Norway maples dominating over half of the total tree species as high diversity. To measure severity of black tar spot on our tree of interest each member of our group viewed the tree from a different angle for 1 minute then changed positions and observed for another minute. If we differed in our severity rating we discussed and settled on a rating with which we all agreed. A tree with no observed black tar spots was categorized as “No presence”, a tree with a few scattered spots on either the treetop or the bottom of the crown was categorized as “Low” severity, a tree with many tar spots on either the treetop or the bottom of the crown as categorized as “Moderate” severity, and a tree with many tar spots located all over the tree crown was categorized as “Severe”.

Statistical analysis. Due to zeros in our data we do not have a normally distributed data, which lead us to use the nonparametric Mann Whitney U test to compare the fungus severity with the habitat type. We also performed a Mann Whitney U test to test the significance of severity and diversity.

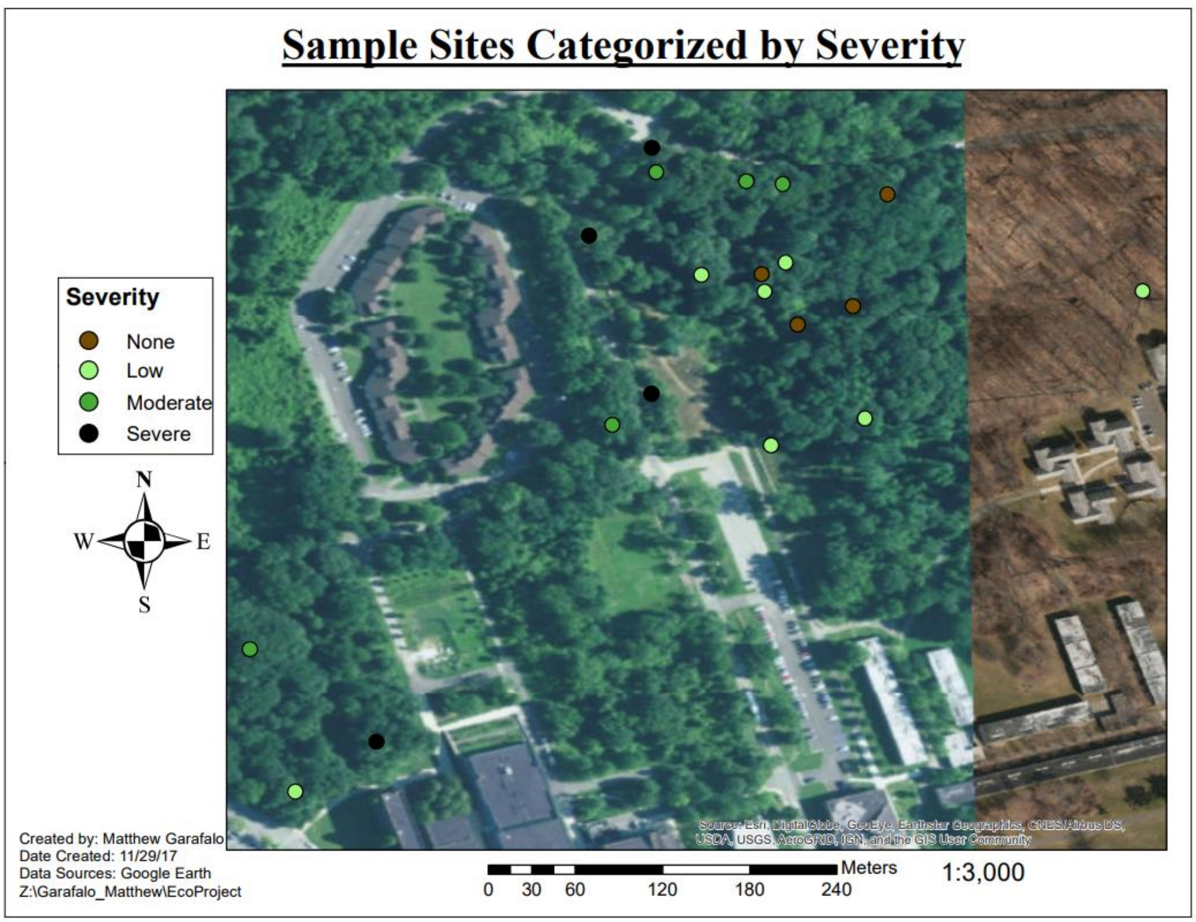

Figure 1: Our 20 sample sites shown on SUNY Purchase College Campus.

RESULTS

While conducting the experiment it was clear the edge habitat sites had a higher severity than interior sites. Our data supports that a higher mean severity in edge habitat sites of 2.2 differs significantly than a mean severity of 0.7 in interior habitat sites ($p < .05$, Table 1). The mean severity did not differ significantly for diversity levels of *A. platanoides* ($p > 0.05$).

Figure 2 and 3 show that on average tar spot was more prevalent in areas of some diversity as opposed to those areas of *A. platanoides* only. Figure 3 shows that low diversity has the highest average of severity. Figure 2 shows higher average presence and severity of tar spot on edge habitants.

Table 2 represents the distribution of severity between edge and interior habitats of our 20 sample sites. Low severity sites were the most abundant with 7 sites, followed by moderate severity with 5 sites, while no presence and severe had 4 sites. It should be noted that no presence of tar spot was only observed in interior habitats and severe presence occurred only in edge habitats.

Table 1: Average severity between edge and interior habitats between edge and interior habitats.

Average of Severity	
Edge	2.2
Interior	0.7

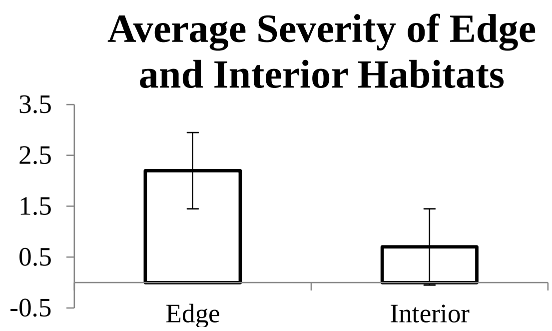

Figure 2: A visual of Table 1 with error bars representing the standard deviation of the data.

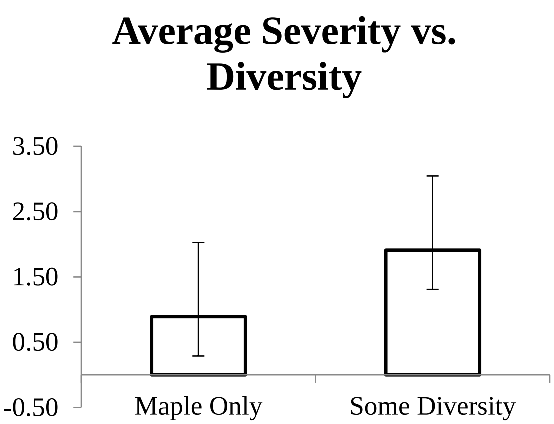

Figure 3: This graph shows the average severity with two groups: *A. platanoides* only and some tree diversity. There are also error bars representing the standard deviation.

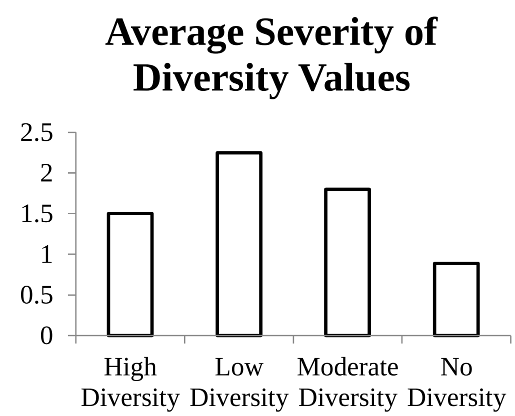

Figure 4: This graph is similar to Figure 3 but shows the average severity for all levels of diversity.

Table 2: Distribution of severity

Count of Severity	Number of trees
Low	**7**
Edge	2
Interior	5
Moderate	**5**
Edge	4
Interior	1
No Presence	**4**
Interior	4
Severe	**4**
Edge	4
Total Number of Sites	**20**

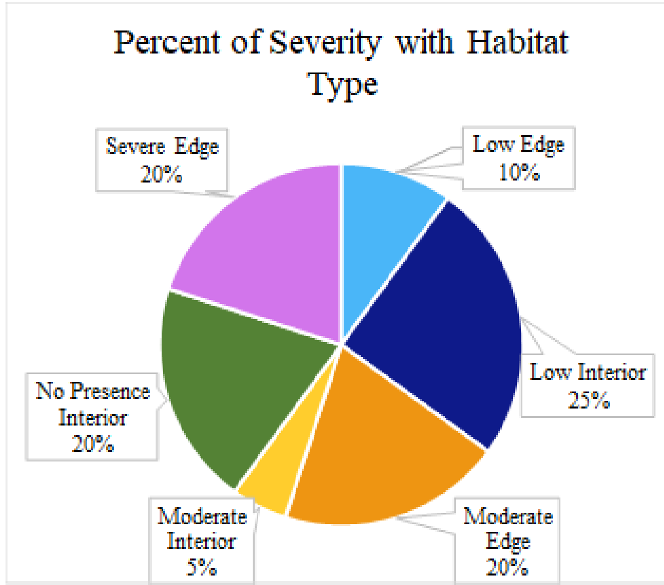

Figure 5: Percent distribution for all of our sample sites. Low severity in interior habitats had the largest percentage followed by moderate severity in edge habitats, no presence in interior habitat, and severe presence of tar spot; low severity in interior; and finally moderate severity in the interior.

DISCUSSION

Our results showed that the severity of tar spot was higher in trees that resided in edge habitat rather than interior forest habitat, thus supporting our hypothesis. This was most likely due to the fact that most of our edge habitat sites consisted predominantly of *A. platanoides*, thus leading to an increase in *R. acerinum* spore-containing leaves. Other considerations could be that leaf litter has a lower rate of decomposition in edge habitat (Riutta et al. 2012), leading to a higher concentration of infectious leaf litter. On average, sample sites with lower diversity had the highest severity of infection, more so than sites that only contained *A. platanoides*. This discrepancy could be explained by the method in which we used to determine tree diversity. There was a gradual decrease in severity as diversity increased, a finding that was in line with our hypothesis. More accurate identification of tree species and more sampling sites could allow for different results.

The presence and abundance of tar spot in maples has been used as a bioindicator of elevated atmospheric SO_2 and NO_2 concentrations. Multiple studies have shown that tar spot severity is lower at sites with high SO_2 and NO_2 concentrations (Gosling et. al 2016). According to Leith and Fowler (1988), distribution of tar spot is primarily controlled by the presence of overwintered *R. acerinum* infected leaves. Observations from a study conducted by Van Der Kolk et. al (2010), led authors to conclude that maple leaves infected with *R. acerinum,* possibly caused equine acquired multiple acyl-CoA dehydrogenase deficiency (MADD), an enzyme deficiency that typically results in the death of horses.

From our results, we can conclude that tar spot has an increased presence in edge habitats, which could be due to the fact that *A. platanoides* were initially planted as an edge habitat, border, and ornamental tree species. However, due to insufficient data at this time, the study was not able to show significantly whether or not the abundance of *A. platanoides* on the SUNY Purchase campus has any effect on tar spot disease severity or dispersal rate. *A. platanoides* have a decreased dispersal rate in dense intact forest and the spread of tar spot disease affects the growth rate of sapling *A. platanoides* (Lapointe, 2010& Martin, 2006). Statistical analysis models, human development and landscape augmenting can lead to increased invasions of woody plant non-native species (Allen et. al. 2013).

In order to further clarify our findings, future researchers would need to increase sample size and refine the methods used in data collection by referencing sufficient literature prior to data collection. Our expectation that *A. platanoides* abundance would correlate to tar spot disease abundance was incorrect. This was probably due to the fact that habitat type has a greater influence on the dispersal of the invasive Norway itself in addition to the spread of the pathogen.

As shown by Lapointe and Brisson (2011) tar spot disease does in fact influence the growth rate and photosynthetic production rate of the *A. platanoides*. If future studies took into account *A. platanoides* sapling abundance and health, the gathered data could show increased consistency between finds on campus and those of researchers further north of Purchase.

CONCLUSIONS

The findings of our study proved our original hypothesis of increased tar spot in more *A. platanoides* dense areas to be falsifiable. Rather, our data showed that our second hypothesis about prevalence in edge habitat to be non-falsifiable. The implications of the study are important for future researchers on the Purchase campus, as increasing sample sizes over the years will give the opportunity for more statistical analyses and increased significance in differentiating factors. The tar spot pathogen, as a co-invasive, is the Norway maple's only natural enemy in North America; perhaps, more studies into the effects of these species cohabitation can lead to a better understanding of how to manage invasives.

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A BUG'S LIFE: DIVERSITY AND ABUNDANCE OF INSECTS ON PURCHASE COLLEGE CAMPUS

By Daniel Demopoulos, Georgie Humphries, and Isabella Wrobel

ABSTRACT

In this study, we surveyed 3 different areas of low shrubs, low shrubs and tall trees, and just tall trees to look at how each environment facilitates insect habitats. We used a stick and kite method (knock-down method) to shake bushes and trees, as well as a dragging sheet method (Sheet Method) to capture insects and place them in ethanol. We hypothesized that the mixed environment would have the highest abundance and diversity and that there would not be a large difference between low shrubs and tall trees for either variable. Our results showed that while a mixed environment of tall trees and low shrubs had the highest abundance of insects, low shrubs had a higher diversity of insects.

Keywords. Abundance, Diversity, Environment, Habitat, Insects

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INTRODUCTION

Insect species diversity are primarily determined by their environment and how well they adapt to it over time. Their unique characteristics are determined through a process called natural selection which determines their phenotypic traits that increase their chances for survival over a long period of time. Their abundance can depend on the vegetation density and richness, predation exposure, and climatic conditions. If all their needs are met, then their species will flourish and thrive.

It is important to learn and understand what insects inhabit certain locations because it can influence the balance of our surrounding environment. Especially if there is a keystone species that can influence trophic levels. For example, there was a study to determine if arthropod species diversity was influenced by plant species diversity and functionality. Their results demonstrated their hypothesis to be proven true. Arthropod species diversity was correlated with the diversity in plants. (Siemann 1997) Another research was conducted to determine if bark beetle species would spread to northern parts of the US where conifer trees are most present because of climate change. By using available population models and climate forecasts, they concluded that bark beetles could spread to northern regions as the climate warms. (Bentz 2010) If certain species are considered an important attribute to an environment than conservation efforts put into place to safeguard these species from extinction or dispersal.

Purchase College has approximately 550 acres of land occupied by academic buildings, student housings and scenic trails that house a wide variety of animal and plant species. But what kind of inspect species does it have? And what is their abundance? The purpose of our experiment was to determine the diversity and abundance of the insects here on Purchase college. We were curious to discover what species inhabited the campus. Our hypothesis was that there will be more diversity in areas that had mixed diversity of plants and very low abundance and diversity in areas with low shrubs and tall trees.

METHODS

To conduct this experiment, we had to determine three separate locations with specified different habitats within a close three-mile radius. Habitat is a possibly natal preference induction in insects, (Davis 2004) which implies that species found in each field site may be unique/prefer that site. Our first field site identified as "Location 1" was located outside of the entrance to the Neu Village at Purchase College Campus. This site consisted of tall trees and minimal low shrubbery, making it our first specific habitat. Our second field site or "Location 2" was located behind the Admissions Building at Purchase College Campus. The site we chose consisted of both tall trees and low shrubbery making it a specific habitat with the mix of both tall trees and low shrubbery that we were searching for. Our final field site or "Location 3" was located across the street from Location 2 and a little way uphill. This site consisted of strictly low shrubbery. These three locations gave us three separate habitats (tall trees, low shrubbery, Mix of both tall trees and low shrubbery) with generally low human foot traffic. Locations 1-3 were close enough in proximately that its soil and general weather were approximately the same. The weather the day of testing was 64 degrees Fahrenheit, with highs of 67 degrees and lows of 54 degrees, and overcast.

To study the diversity and abundance of these insect species in these 3 locations we needed to collect and count these specimens. To gather insects, we used methods similar to studies that rounded up and collected footman moths (Eilema Lurideola) to average their abundance in Rothamsted (Creighton 1938) and studies that used natural examination techniques (Savopoulou-Soultani 2012). The Sheet-Method and the Knockdown-Method were used for specimen collection. The Sheet-Method consisted of a white queen-sized sheet with handles made of duct tape for dragging. The sheet was dragged across the ground in a straight line for 10 meters twice for each location, then the sheet would immediately be inspected for insects, such insects on the sheet were collected and put into small vials of ethanol (Brand unknown) and counted to record abundance. To avoid unnecessary deaths of some of the insects, we avoided killing excess like many studies who used light traps (Frith 1979), and did not put easily identifiable insects such as standard black ants into ethanol for later identification. The Knock-down method consisted of a white sheet about 4ftx4ft held open by two wood sticks to make a square. While holding this square underneath a shrub/tree, another wood stick would be used to rustle or bang on said shrub/tree and catches the falling insects. This is repeated twice at each location, and just like the Sheet-Method we immediately counted and collected the insects immediately. In total, each location had four collection attempts with both methods. The collected insects were taken back for counting and species identification. Each location was statistically recorded by how many insects there were and what species occurred within that collected population. These rates were then analyzed into tables/figures to be compared to each other in terms of the diversity and abundance of each location and its respective habitat.

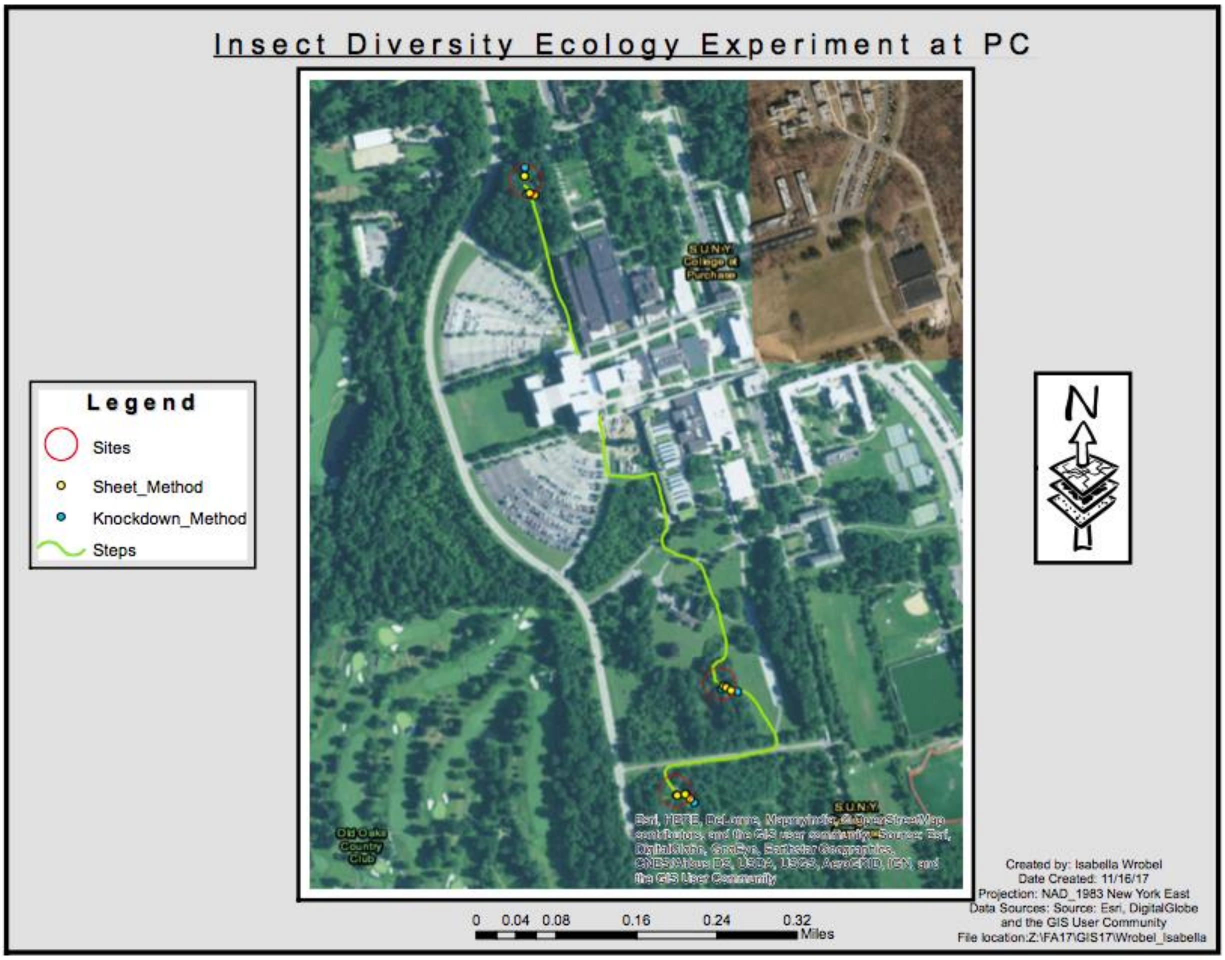


Figure 1: Map of Purchase College campus and the Locations respectively

RESULTS

We concluded that the three tested location habitats (High trees, low shrubbery, and combination of both) had distinct and varying abundance and species diversity in terms of insects. Location 1 consisted of high trees and had the lowest abundance and diversity of the three locations, with only 7 specimens collected and a total of 3 species of insect. These species found were 3 standard black ants, 3 tan sac spiders, and a single true cricket, (Figure 2). Location 2 consisting of a combination of both high trees and low shrubs did have the highest abundance with 17 specimens collected, but did not have the highest diversity with only 5 different species of insect. These species were 5 standard black ants, 8 tan sac spiders, a single daddy long leg, a single earwig, and 2 fruit flies, (Figure 3). Location 3 consisting of low shrubs had an abundance of 11 specimens collected, but the highest diversity with 7 different species of insect. These species were a single standard black ant, a single standard fly, 2 green leaf bugs, 3 grasshoppers, 3 red ants, and two different species of beetle totaling to 3 beetles, (Figure 4). Figures 2-4 demonstrate these findings with the x-axis containing the species found on each location and the y axis containing the abundance of each of these species found. Figure 1 demonstrates all the species (x-axis) and their abundance (y-axis) combined in conjunction to each location by differentiating location by different shades of grey. From this graph, we can see that the only species located on all three locations was the standard black ant, with tan sac spiders occurring in two of the three locations.

Table 1: The number of specimens of each insect species that occurred at each of the three locations

Species of Insect	Location 1	Location 2	Location 3
Standard black ant	3	5	1
Tan Sac Spider	3	8	0
True Cricket	1	0	0
Daddy Long Legs	0	1	0
Earwig	0	1	0
Fruit Fly	0	2	0
Standard Fly	0	0	1
Green Leaf Bug	0	0	1
Grasshopper	0	0	2
Red Ant	0	0	3
Beetles	0	0	3

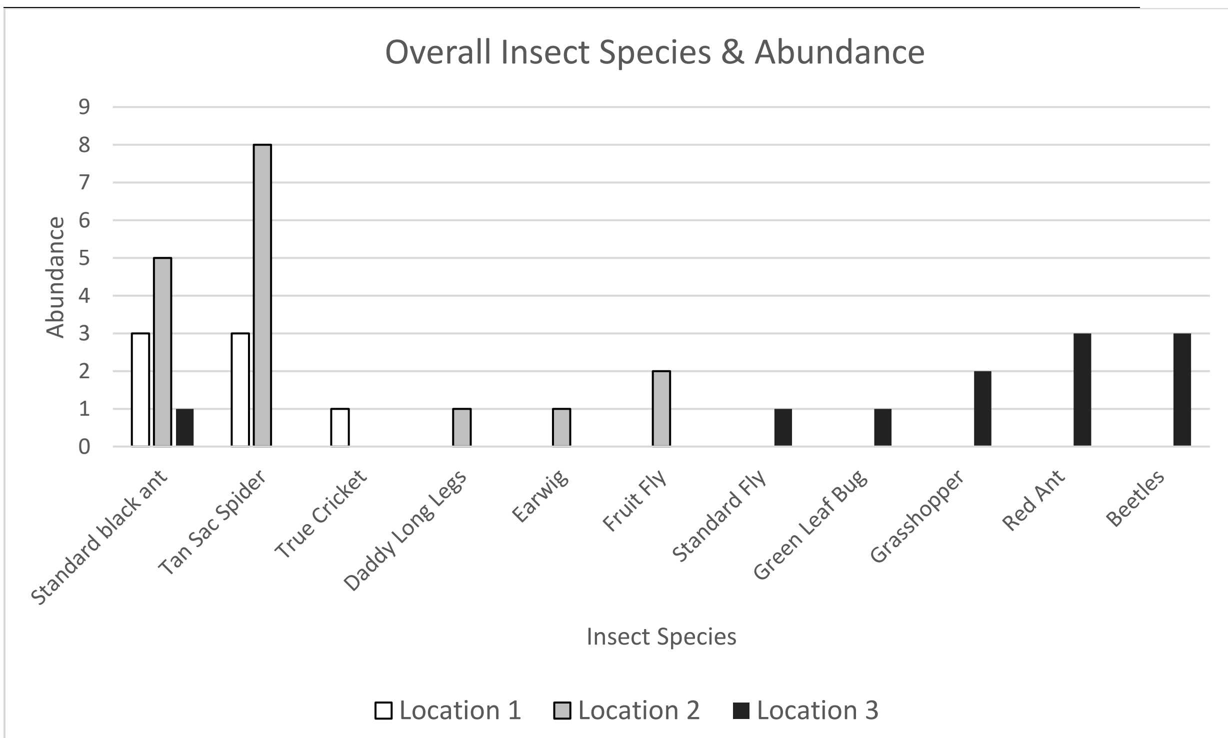
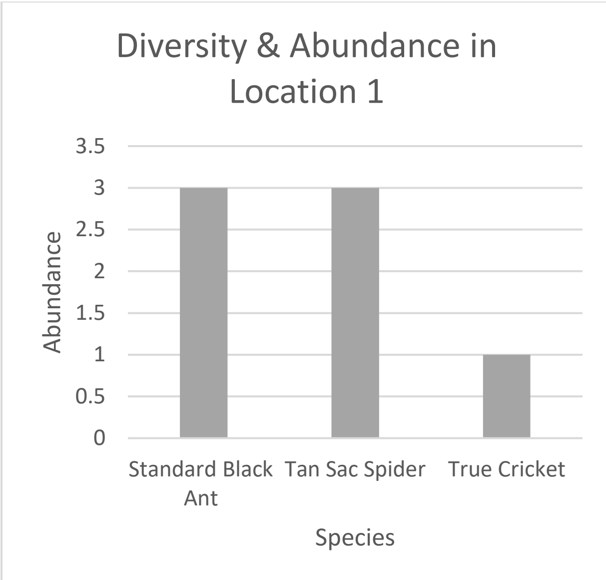
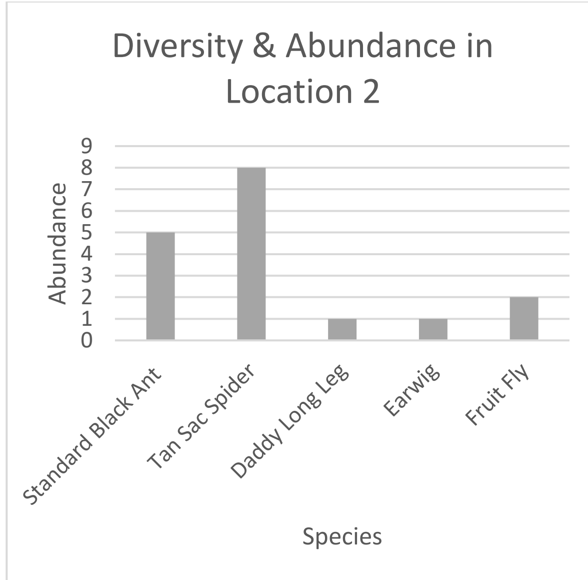
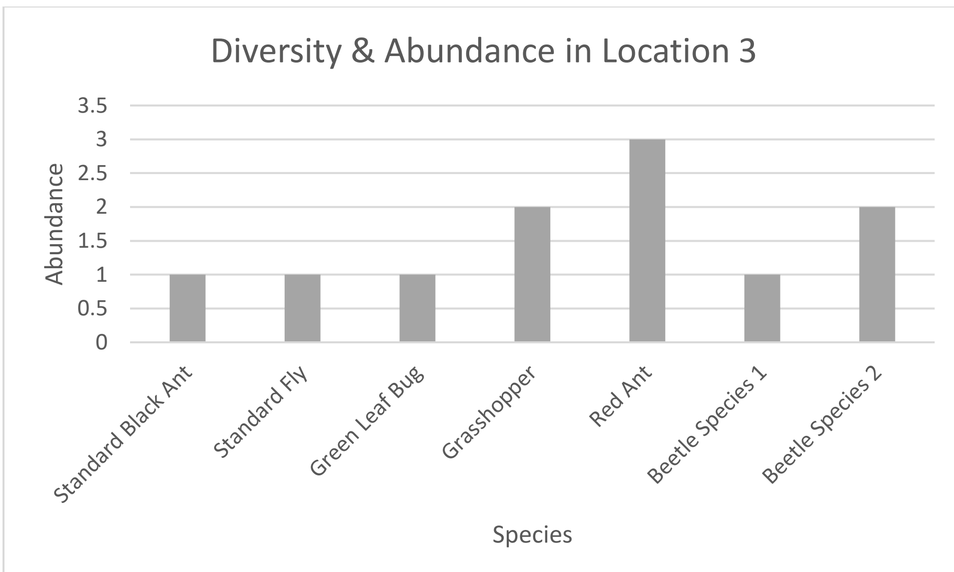


Figure 2: The number of specimens of each insect species that occurred at each of the three locations in conjunction to each other







Figures 3-5: Species found in each location and their abundance

DISCUSSION

One pattern found was that while there was a higher abundance of insects in the mixed habitat of tall trees and short shrubs, there was more diversity in the short shrubs. One explanation could be that location 2 had different types of plants that had less niches than location 3 which only had low shrubs. An alternate explanation could be that there was outside influence, such as people walking through location 2 before we got there that scared off the insects there and caused there to be less insects when we got there. Another significant pattern found was that location 2 had the highest abundance of insects. This finding was expected because location had a variety of low shrubs and tall trees, as opposed to just tall trees in location 1 and just low shrubs in location 3. A higher variety of niches means that there will be a higher carrying capacity of life in that area. Tall trees also had an unexpectedly low diversity. There were spiders, ants and one cricket found. This could be due to the tree not being healthy or having defenses against insects. The spiders might have also eaten or driven away the other insects. We also found that insects tend to live close together, often multiple species occupying a single bush. This shows that the distribution of insects is quite small, considering how many can live within the same plant. (Taylor 1984) Even spiders coexisted with prey insects like ants and beetles, which was not expected. This finding is the opposite of what was found by Flecker et al. who found that large insects, over 8 mm, were much more abundant when there were not predators within the vicinity. (Flecker et al. 1984)

One issue with our methods was that we could not replicate the plant species for each location, meaning that there was unaccounted for variation, which influenced both abundance and distribution. While we studied the same plant life on campus, in a small area, the environment was not controlled, meaning there was some differences in the environments besides the height of the plants, such as predators, distance from water, pesticide usage and more. We also could not control other people walking through the area we were observing.

L.R. Taylor studied the distribution between different insect species to see what their ideal niche is and how far away they like to live from each other. He found that to study insects properly, they need to be in a contained environment to prevent outside factors from influencing the data. However, when he tried to contain them in an enclosure, the natural distribution was thrown off. He concluded that insect distribution is better left to being a theoretical study than a practical one. This relates to our study because it discusses the challenges of studying insects in the field versus in a closed environment. Getting significant results with outside factors having an effect is just as hard as maintaining a natural distribution in a laboratory.

A separate study by Flecker, A.S. & D., Allen investigated the factors that play a role in insect distribution found that predation, substrates available, and spatial refugia all had effects on the distribution of insects. Substrates, the surface of the floor, that contained a lot of empty spaces were occupied more frequently than small, tightly packed ground surface. Predators had a significant effect on the abundance of large insects, which had much higher numbers when there were no predators around. Spatial refugia and substrate type still had a larger effect though, said to be caused by an affinity for surface area and trapped detritus. This relates to our own study in that we also found a high abundance of insects clumped together in bushes and grass. In contrast to the lotic insects, we found large insects and predators such as spiders coexisting within the same bush or tree.

We could have recorded better results by having more days of field testing to lower the chance of outliers, influences from weather, influences from temperature. Another way we could have gotten more accurate results would have been to record data use two different examples of each habitat so that there would have been a lower chance of variation between habitats. A third way to ensure more accurate results would have been to use more methods of catching insects such as a net.

In the future, we could use our data to observe the abundance and diversity of lotic and lentic insects. Understanding how insects in the woods could help us study how insects behave in the water and how parallels could be drawn between water quality and forest quality and how that impacts the insects and the animals that interact with them. Another direction we could explore would be to measure the abundance and diversity between seasons every year and measure if climate change is affecting how long insects are living at Purchase College. (Ulrichs et al. 2008) Furthermore, since climate change is such a quickly growing field, we could also observe where the insects are moving if their current habitat becomes too different or inhospitable due to changes in climate. If certain keystone insects move to a different location, it could create a trophic cascade, in a positive or negative way. (Régnière et al. 2012)

Our study shows that Purchase College has a tentatively low number of insects on campus. That’s bad because insects are near the base of the food chain, so if they are not thriving, then it is safe to assume that the animals that depend on insects as food are also not thriving. It could also be a sign that the plant life is dying as winter gets closer, which would also explain the low number of insects found. During the fall, it's probable that animals are eating as many insects as they can before the winter comes when food sources are harder to find.

CONCLUSIONS

After collecting the data, preparing our samples, and quantifying our findings. We have found in total 35 insects and 15 identifiable species out of the total of insects captured. Our hypothesis was supported by the abundance and diverse species that we collected in areas of low shrubs with diverse plant species

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THE EFFECTS OF RUNOFF ON BLIND BROOK AND ITS POTENTIAL IMPACT ON THE LONG ISLAND SOUND

Brian Doherty, Samantha Robinson, Alexa Youre-Moses

ABSTRACT

Eutrophication of the Long Island Sound has become a major environmental issue in recent years. Eutrophication of the Sound is caused, mostly, by runoff that contains nitrogen left by human activity. Input of nitrogen into marine and freshwater ecosystems is only increasing as human populations grow. A runoff water quality study of Blind Brook in Harrison, New York shows that nitrogen is in greater abundance after rainfall. The results of this study did not show that nitrogen levels are in greater concentrations after large industrial areas such as town, airports or major roadways.

Keywords: Blind Brook, eutrophication, Long Island Sound, runoff, water quality

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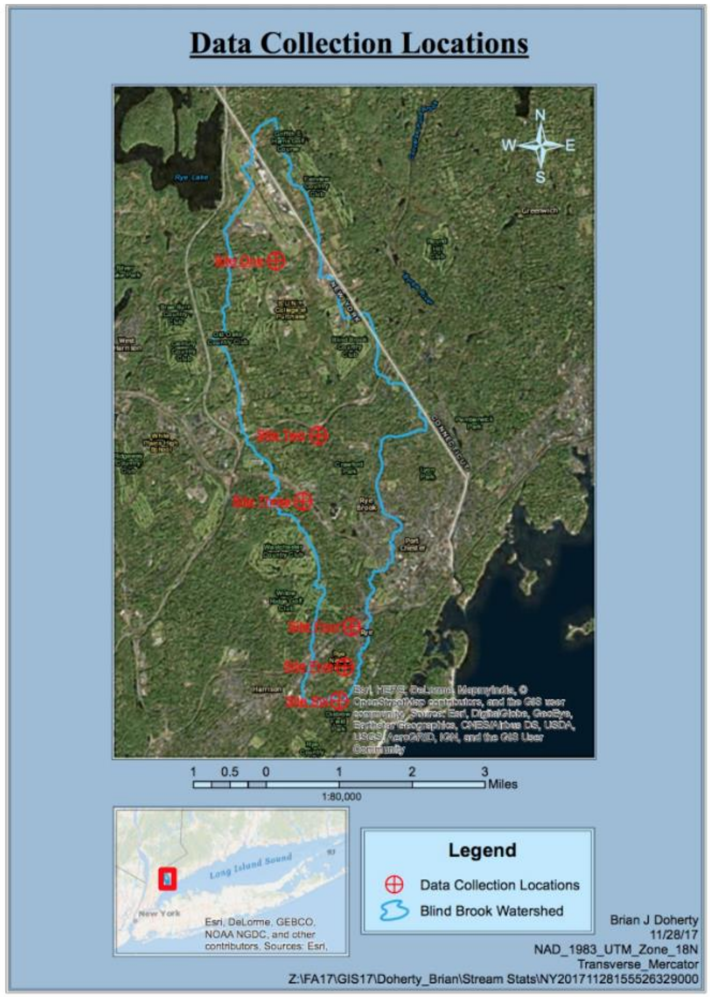
INTRODUCTION

All life on Earth depends on clean water for survival. This vital molecule has been on Earth for millions of years, untouched and unpolluted. Since the start of the Industrial Revolution, water quality has drastically decreased. Industrialization and the increase of human activity has had major impacts on water supplies and natural ecosystems. Industrialization has decreased pH levels, resulting in acid rain, and increased the levels of nitrogen being deposited into natural bodies of water. This has lead to many downstream problems. An increase in nutrients, such as sulfates and nitrates, results in many sublethal and lethal effects on the organisms living in these ecosystems. Research has proven that excessive levels of nutrients can decrease biodiversity by making the ecosystem less habitable for species that are unable to adapt (Sun et al. 2017).

The Long Island Sound is an estuary, which mixes the saltwater from the Atlantic Ocean and freshwater from nearby rivers. Within its 1,268 square miles, and with some parts being as deep as 299 feet, the Long Island Sound supports a wide range of species. With such a diverse ecosystem, it allows for different communities of organisms to live in unison. Unfortunately, the Long Island Sound has a long history of eutrophication, making it difficult for species to thrive as they once had. Research, that began in the early twentieth century, has shown that there has been a steady decline in water quality of the Long Island Sound due to contamination from anthropogenic sources (Parker et al. 1991). These sources include the weathering of buildings, renovation, demolition, fertilizer and pesticide use, city fires, and traffic. Runoff from roadways and rooftops has allowed for the transport of these contributors and pollutants. Pollutants vary depending on the source, and studies have shown that pollutants from road runoff tend to have a higher concentration of total suspended solids (TSS) and chemical oxygen demand (COD), whereas roof runoff holds higher concentrations of dissolved heavy metals, particularly zinc (Gnecco et al. 2005).

The Long Island Sound is a large basin, receiving water from neighboring states. With runoff coming from miles away, there is plenty of time for pollutants to be collected in large concentrations. Particle bound pollutants, such as nitrates, collect on top of impervious surfaces, which are then easily picked up by stormwater and transported into waterways (Morten Jartun et al. 2008). This collection of nitrogen has created a very serious problem for the Long Island Sound. As a result, the Western Long Island Sound has seen decreasing levels of dissolved oxygen within the last few decades due to eutrophication (Parker et al. 1991). Excess nitrogen stimulates the rapid and excessive growth of algae, outcompeting other plants that then die. Respiring bacteria decompose the dead biomass. With more dead biomass from aquatic plants, there is also a steady increase in bacteria, ultimately causing a decrease in available oxygen for other species. This lack of oxygen can, in extreme cases, lead to dead zones. Known as hypoxia, this lack of oxygen can also lead to a loss in biodiversity by creating less suitable habitats for species and increasing competition for oxygen. Surviving organisms are subjected to stresses that can cause extinction, such as “reduced growth and reproduction, physiologic stress, forced migration, reduction of suitable habitat, increased vulnerability to predation, and disruption of life cycles” (Vaquer-Sunyer et al. 2008).



Map 1: Blind Brook Watershed and Data Collection Locations

Recent research on the Western Long Island Sound has noted that hypoxia is a relatively new issue (O'shea et al. 2000). To conduct further research about the flow of excess nutrients into the Long Island Sound, data was collected from a local stream, called Blind Brook. Blind Brook runs from the Westchester County Airport, through several major runoff sites, such as the Hutchinson Parkway, straight into the Long Island Sound. It was predicted that elevated levels of nitrate would be detected after major roadways and industrial locations, such as airports or towns with high human activity. It was also predicted that there will be a gradual decrease in water quality further downstream.

METHODS

A total of six sites were chosen to be sampled. Choosing evenly distanced sites to sample proved to be difficult due to the fact that Blind Brook often runs through private property. The six sites were spread down the entire length of Blind Brook, starting at Westchester County Airport and ending at the beginning of the marshlands just West of Rye Playland. Data collection was conducted on three days: October 11th, October 25th, and October 29th of 2017. On each day of data collection, several tests were used at each site. A DIGITAL Professional Series, Pro DSS YSI Meter was used to collect the temperature, salinity, TDS, and pH of each site. Before collecting the YSI readings, the sensor sat fully submerged in the water for five minutes, allowing for a more accurate reading. The LaMotte Nitrate-Nitrite kit was used to collect the nitrate levels of each site: two nitrate samples were taken at each site in the field. A HACH Pocket Turbidimeter was also used at each site to collect turbidity levels: two samples were taken in the field. On each day of data collection, two samples of water were collected at each site and stored in a iced cooler for transport back to the lab, where we performed the HACH Dissolved Oxygen Test. These samples were stored in airtight glass bottles to prevent any contamination of oxygen that could alter our readings.

Table 1: Coordinates of Sample Sites

Site	Longitude, Latitude
Site 1	41.0560, -73.7044
Site 2	41.0212, -73.6940
Site 3	41.0082, -73.6938
Site 4	40.9832, -73.6861
Site 5	40.9753, -73.6879
Site 6	40.9686, -73.6895

RESULTS

When organizing the data for each day, the temperature, pH levels, nitrate levels, turbidity, and dissolved oxygen were taken into consideration.

Temperature Results

When reviewing the temperatures of the three collection days, it was found that the average temperature on day one was higher than the average temperatures of days two and three. Temperature on day one averaged out to 18.45°C , temperature on day two averaged out to 17.04°C, and temperature on day three averaged out to 16.53°C.

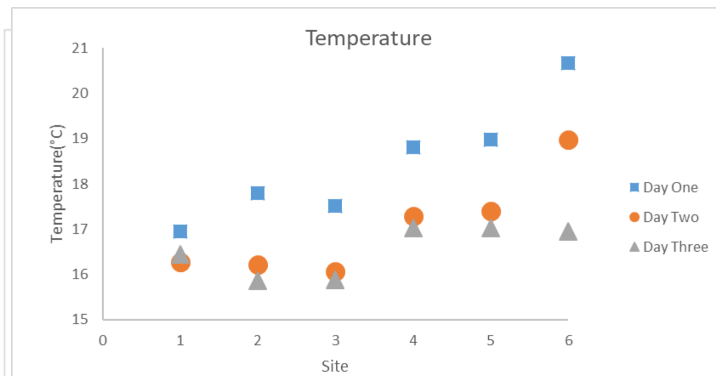


Figure 1: Temperature at each site for each day of sampling.

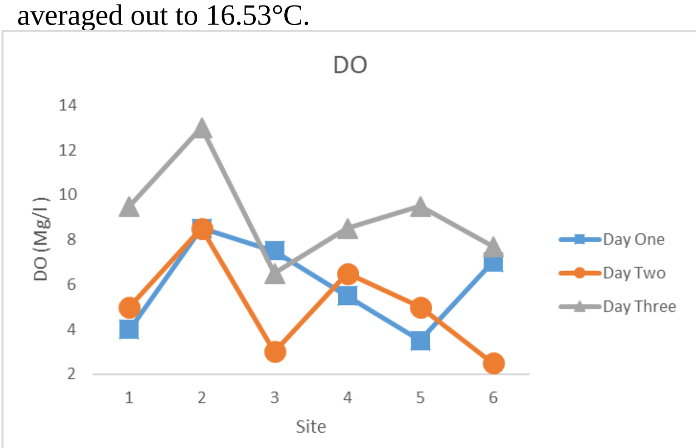


Figure 2: Dissolved oxygen at each site for each day of sampling.

Dissolved Oxygen Results

The average dissolved oxygen on day three was higher than the average dissolved oxygen of days one and two. Average dissolved oxygen of day one was 6 Mg/L, average dissolved oxygen of day two was 5 Mg/L, and average dissolved oxygen of day three was 9.1 Mg/L *pH Results*

The first two days of data collection consisted of an average pH value of 7.11. For day one, average pH value was 7.1 and on day two average pH was 7.12. Days one and two were dry sampling periods, and day three data was taken during a rainstorm which produced 1.68 inches of rain. Average pH of day three was 5.04. During a rainstorm, average pH was more acidic than during dry days.

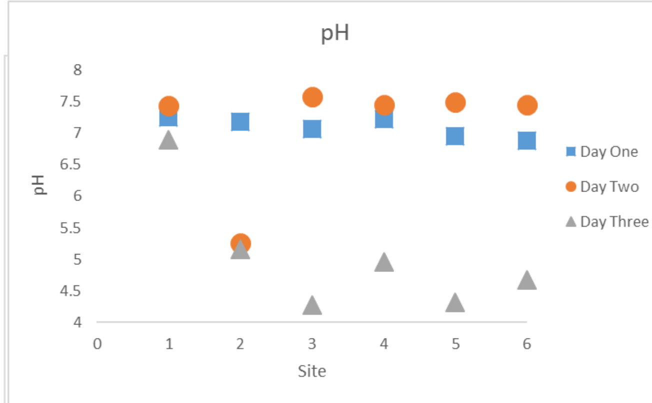


Figure 3: pH levels at each site for each day of sampling.

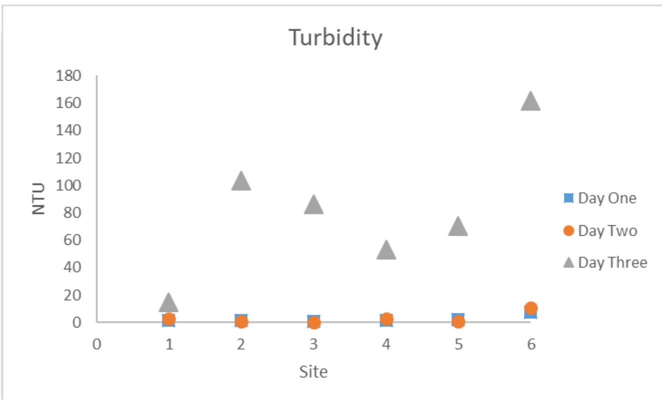


Figure 4: Turbidity at each site for each day of sampling.

Turbidity Results

Turbidity was found to be much higher on day three than on days one and two. On day three, the average turbidity was 81.7 NTU, with the highest value being 161.9 at site 6. In comparison, the turbidity on days one and two were 2.4 NTU and 3.1 NTU, respectively.

Nitrate Results

No levels of nitrate were detected during the first two days of data collection. On day three, a minute level of nitrate was detected, but no nitrate was detected at site one. Sites two through six each had a nitrate level of 1.

Table 2: Nitrate levels at each site based on day of data collection

Location	Day One	Day Two	Day Three
Site 1	0	0	0
Site 2	0	0	1
Site 3	0	0	1
Site 4	0	0	1
Site 5	0	0	1
Site 6	0	0	1

DISCUSSION

The results only partially support the hypothesis. It was hypothesized that elevated levels of nitrates would be detected after major runoff sites, and that water quality will decrease further downstream. While elevated nitrate levels were detected, they were miniscule, and they were only found during a storm event. The first flush, the initial surface runoff of a rainstorm when water pollution entering water bodies is most concentrated, is the only point in which elevated nitrate levels were observed.

Nitrate Discussion. Considerable concentrations of nitrate were not observed during the three days of data collection. The difference in nitrate levels between the three data collection days are most likely due to the increased amounts of runoff from heavy rainfall. The increased runoff allows for more contamination from anthropogenic sources. On day three, nitrate levels were higher downstream. This is likely due to the sources of runoff. For site one, which had no nitrate, the water was flowing directly from the Westchester County Airport. The other five sites were further downstream and closer to major roadways, which could affect the amounts of nitrate. Site one only gets runoff from the Westchester County Airport and above, at the river's source, but site two gets runoff from the Hutchinson Parkway as well as the water that has traveled downstream from site one. Sites further down continue to acquire runoff from various sources. Being closer to major roadways increases the chances that the runoff is contaminated. This is due to a high density of heavy human activity.

High nitrogen commercial products, such as fertilizer and de-icer, quickly become an environmental issue when used in excess. The use of fertilizers has a direct linear relationships with nitrogen overabundance. These products, that are sprinkled on lawns and icy roads, soak into the soil as well as get swept away by water and are deposited into water systems, both fresh and marine systems. It is expected that pollutants from the airport will increase during the winter, when the airport uses its de-icer. Rainfall and snowmelt runoff are the primary mechanism by which airport de-icer enters waterways, and it is shown that higher nitrate and ammonia concentrations coincided with ground frost and snow, suggesting that airport de-icer is a major cause of this (Turnbull et al. 1995). Additionally, it has been shown that pollutant concentrations are higher in winter, not just due to de-icer pollutants, but because snowmelt is an added method of runoff in the winter, and increases corrosion (Helmreich et al. 2010).

A major issue with inorganically produced nitrates, such as deicer, is the bypassing of the natural process of nitrogen fixation. Large scale nitrogen use increases the amount of fixed nitrogen in the environment by directly pumping fixed nitrogen into ecosystems rather than it being regulated by natural cycles. Humans have disrupted the nitrogen cycle by drastically increasing the amount of fixed nitrogen in ecosystems since the 1940's (Bernhard 2010). This excess of nitrogen that is deposited into water bodies, such as the Long Island Sound, becomes available for plants to use after the process of nitrogen fixation. Many microorganisms are capable of breaking apart the fixed nitrogen molecules that are released by humans. This process, known as nitrogen fixation, is necessary for all life on Earth. Unfortunately, an overabundance of nitrogen leads these aerobic microorganisms to constantly fix nitrate into a form plants can utilize. This increased amount of fixed nitrate then leads to an overabundance of marine plants that deplete the oxygen levels, creating harsh environments for marine species. (Taylor pers comm).

pH Discussion. Between the three days of data collection, an interesting relationship was found. On the first two days of sampling, pH was on average 7.09 on day one and 7.11 on day two. The pH on these two days was much higher than that of day three, which had an average pH of 5.04. The first two days of data collection were the dry days. This increase in acidity is most likely due to acid deposition in the form of acid rain. Acid rain "is comprised of sulfuric and nitric acids" and these chemicals "are largely emitted to the atmosphere by the burning of fossil fuels and by agriculture" (Driscoll et al. 2003). These chemicals are either dispersed into the atmosphere as gas or directly transferred into soils. The chemicals dispersed into the atmosphere are the beginnings of acid rain.

When water vapor begins condensing, these chemicals get trapped into the water particles that then are incorporated into rain. Once this acid rain reaches terrestrial and marine ecosystems, it "alters soils, stresses forest vegetation, acidifies lakes and streams, and harms fish and other aquatic life" (Driscoll et al. 2001). Fortunately, the discovery of chemicals that cause acid rain has led to political and societal changes over past decades; this was not always the case. Prior to the discovery of acid rain and its causes, society continued to push technology and business forward blind to the detriments of the by-products. Studies conducted in 1979 have found ice cores from pre industrial revolution have a pH ranging from 6 to 7.6, a healthy pH level for water (Likens 1979). When comparing the pH from these pre industrial revolution ice cores to post industrial revolution water sample, the post industrial revolution sample show a drastic increase in acidity with level of pH near 5. This is due to increased pollution of sulfates into the atmosphere from factories. This discovery reiterates the negative effects humans have had on the environment. We have created acid rain from sulfate pollution. Previously pristine waters have been drastically changed, and this increase in acidity is a direct effect of human activity.

Turbidity Discussion. Turbidity was exceptionally higher on the third day of data collection, when it rained heavily. This is likely because the rain increased streamflow, increasing the movement of sediments and introduced new ones. Site six, when compared to the other five sites on their respective days, has a fairly higher turbidity. This is due to site six being in a tidal estuary. Days one and two were sampled during times of lower tides while day three was taken at a higher tide. This also affected our salinity readings in that site six values were much greater.

Tide Cycle Times

10/11/17 High Tide: 3:54 AM, 4:08 PM

Low Tide:10:11 AM, 11:12 PM

10/25/17 High Tide: 3:25 AM, 3:28 PM

Low Tide: 9:23 AM,10:06 PM

10/29/17 High Tide: 6:56 AM, 7:12 PM

Low Tide: 12:52 AM, 1:12 PM

Temperature Discussion. The changes in temperature over the days are likely due to the weather for that day as well as the current water levels. On day one, the temperature was high 25°C and low 15.5°C , day two 19.4°C and 14.9°C, and day three 19.4°C and 15.5°C. The weather corresponds with the water temperature fairly well. Water levels also probably affected temperature, as the lower the water level, the slower it moves and the easier it is for it to warm. On day one, the water levels were quite low compared to days two and three, and the temperature was fairly higher.

DO Discussion. The results for dissolved oxygen show that on day three oxygen levels were higher than that of the first two days. This increase in dissolved oxygen is most likely due to rainfall. The rain that falls oxygenates the water bodies around it leading to increased oxygen in Blind Brook. The increased rainfall also increases the flow and churning of the water, also causing aeration. One oxygen reading on day three came back as extremely high, but this is most likely due oxygen contamination either during transport or testing in the lab.

Improvements For Future Studies. Although the results didn't show that there were excessive levels of nutrients in Blind Brook, there is still an issue that needs to be solved in the Long Island Sound. More research needs to be conducted to see the full effects of these excessive levels of nutrients on freshwater and marine ecosystems. Further studies on nitrate toxicity should also take other influences, such as salinity, pH, temperature and DO, into consideration when determining the full effects of nitrate on these ecosystems (Julio Camargo et al. 2003). The more research that is conducted about the effects of nitrate and human activity on the Long Island Sound will lead the path for policy change. Such changes can preserve ecosystems for years to come. Without the necessary policy changes, the Western Long Island Sound may become a dead zone, which would impact local ecosystems and the organisms that habitat these ecosystems and would devastate the local economy.

For future studies, it would be beneficial to take samples at different times of day and throughout the year. This study is best suited to be a long term study, so the full effects of seasonal differences and changes can be observed. More sample sites would be ideal, as this would lead to more accurate and indepth data.

CONCLUSION

This study has failed to support the hypothesis that Blind Brook is a major contributor of nitrate levels in the Long Island Sound. The results show that although Blind Brook does transport nitrate, these levels are not above a level of immediate concern. This study also shows a relationship between rainfall and overall water quality. During and immediately after it rains, pollutant concentrations in Blind Brook are significantly higher than usual, suggesting that pollutants make their way into the brook and quickly flow out into the Sound.

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EFFECTS OF URBANIZATION ON NORTHEASTERN MAMMAL SPECIES: DUMPSTERS AS A FOOD SOURCE FOR NOCTURNAL OMNIVORES

Genevieve G. Donovan and Patrick J. Harmon

ABSTRACT

The Purchase College Campus is home to a wide variety of species, all of which have adapted behaviors that developed over time with the increase of urbanization and habitat fragmentation in the Northeast United States. In particular, many species have not only learned to coexist with humans, but benefit from their presence as well, seeking anthropogenic food sources in garbage cans and dumpsters. In this article, we sought out 3 dumpster locations of which one might expect to find differing species and determined from these three locations the diversity of species as well as the individual count of animals that visited these sites. In six observation sessions spread out over the span of two weeks, we went out between the hours of 11:00 pm to 12:00 am and observed the sites, noting any animals that visited the dumpsters. Through this data collection, we found that 5 animals visited the Fort Awesome site, 10 visited The Hub site, and 6 visited The Olde site. The three observed species were the common raccoon (Procyon lotor), the striped skunk (Mephitis mephitis), and the Virginia opossum (Didelphis virginiana). We found that only raccoons and skunks visited For Awesome, all three species visited The Hub, and only skunks and opossums visited The Olde. After comparing this information, we concluded that more animals and a wider diversity of species gathered at The Hub due to the higher abundance of food available and the low levels of civilian traffic in the area.

Keywords: Biodiversity, Dumpsters, Habitat Fragmentation, Nocturnal Species, Omnivore Populations, Purchase College, Species Adaptation, Urbanization.

INTRODUCTION

Over the past few centuries, humans have advanced to a degree that allowed their global population to grow at an unprecedented rate. Advances in science and medicine enabled mankind to spread across the globe resulting in deleterious effects on the world's ecosystems. Compared to other habitat destruction directly manipulated by human interaction, the conversion of wildlife habitat into human settlements results in a permanent change (McKinney 2002). The Northeastern region of the United States in particular is the second most developed region in the country. This development comes at a cost as urbanization leads not only to direct habitat loss, but is also a precursor to the issues of habitat fragmentation.

Habitat fragmentation poses a huge threat to biodiversity and overall species health. The splitting of habitat connectivity into smaller, more isolated remnant-regions brings harm to all aspects of an ecosystem (Gibb et al. 2001). The equilibrium theory of island biogeography ties into this point as it proposes that a species living the mainland will be more successful than a species in an insular environment as it will have more open access to resources than an island can provide. The species richness of an insular environment relies heavily on the immigration and emigration of individuals from the mainland (MacArthur et al. 1963). The biodiversity patterns within fragmented urban environments show little interaction between individuals of these fragments therefore decreasing genetic diversity and overall population health (Gomes et al. 2011).

The Northeastern United States was once rich with a multiplicity of species that could potentially thrive in the varying environments of the region. When European colonists began exploiting the land for resources, they hunted the local wildlife, cleared forests, and displaced entire tribes of Native Americans (Ray 2000). This resulted in the extirpation of species such as cougars, wolves, and elk. Additionally, species that have been reduced significantly in the region include moose, lynx, and black bears (Merkle 2013). While this is the case for some, other species have adapted in response to human settlements. Specifically, some species including raccoons, skunks, opossums, coyotes, and bears have become adept at exploiting anthropogenic food sources. Most of these species are opportunistic generalists which can utilize food items left by humans in garbage dumps or other places like parking lots (DeStefano et al. 2003). Omnivorous and nocturnal lifestyles have proven successful to some species making it easier to acquire food by rummaging through dumpsters and trash cans at night, avoiding direct confrontation with humans while benefitting from their presence (Gehring 2003).

Purchase College was once rural, used mostly for farmland, before which it was a forest. Only in recent years has the land become a college campus (“Campus History to 1900”). This transition has resulted in the creation of many small, isolated forest habitats located around the campus’ center. The animals that occupy these forests have adapted due to human development, learning how to avoid contact, but benefit from the presence of humans. In suburban towns located near edge habitats or habitat fragments it is common for people to put cat food or bird seed outside of their house. In many cases however, this can draw unwanted attention in the form of striped skunks and common raccoons (Theimer et al. 2015). Another, unavoidable draw for these animals is the trash that people leave out before it is moved to a landfill. Many Northeastern mesopredator species have learned to scavenge for food from anthropogenic garbage sources (DeStefano et al. 2003).

The Purchase College campus is surrounded with small forest habitat fragments which are home to few mesopredator species observed in this study including, striped skunks, Virginia opossums, and common raccoons. This study sought to discover which dumpster out of three sites, Fort Awesome, The Hub, and The Olde, all of which differing in civilian traffic and trash composition, attracted the most animals and the greatest diversity of species. It was hypothesized that The Hub site would attract the greatest number and diversity of animals due to a perceived abundance of food in the area and the lack of human traffic between the edge of the habitat and the dumpster. It is important to know this information when approaching the complexities of conservation. While these species are viewed as pests, they are key to the ecosystems that they live and it is important for people to know why animals have gained certain behaviors in the presence of urbanization and habitat fragmentation when looking to the future.

METHODS

The entirety of the data collection was conducted through an observational study, requiring very few additional materials. Six observation sessions were spread out over a two-week period, from the 15th to the 29th of October 2017. The three sites had two, hour-long observation sessions over the two-week period, with one session at each site per week. The observation sessions lasted exactly 1 hour and were always conducted from 11:00 pm to 12:00 am. During a session, it was important to be situated in a location far enough away from the observation site as to not potentially frighten any nearby animals and deter them but also have clear visibility of the site. After recording our observations, we compared and developed graphs for our data using Microsoft Excel

Field Sites. The first site was the dumpster near the Olde apartment complex. This site appeared to have a lower concentration of food composition, however, it also has less human traffic possibly making it desirable. Site two was at a dumpster near Fort Awesome, here there was more estimated activity due to the dumpsters close proximity to a large living area and a Starbucks, the waste produced would add up to a steady supply of food for the animals. The Hub was the third and final site, due to the site being the dumpster for a dining area, it was estimated that there would be a wider variety of species due to an abundance of food waste supplied from the dumpster and the composter. This supply would almost certainly attract creatures looking for an easy meal (Prange 2004).

	Fort Awesome
	The Hub
	The Olde

Figure 1. Map of the Purchase College Campus marked with the locations of each field site.

Statistical Analysis. When recording and evaluating our data, we used Microsoft Excel, creating a table displaying the species that we found on each particular site during each observation session. To compare the collected data, we derived a bar graph which presents the differing abundance and diversity of animals based off of site location and week of each sighting.

Species Studied. The common raccoon (*Procyon lotor*) is a medium sized mammal characterized by its brownish-grey coloration and a patch of black fur surrounding both eyes forming a “mask”. They can reach up to thirty pounds, have large territories, and are known to be an aggressive species, capable of severely wounding humans and dogs (Owen et al 2017). They are a common site in suburban areas where they can utilize their high intelligence and manipulative hands to access food sources provided by humans (Prange et al 2004).

The striped skunk (*Mephitis mephitis*) is a small mammal of the *Mephitidae* family, which includes all other skunk species. Its black and white fur serves as warning coloration to ward off potential predators. It uses its anal scent glands to release a foul smelling gas when it feels threatened as an extra defense mechanism. Similar to raccoons it is commonplace to see them travelling through neighborhoods and backyards looking for food (Rudd et al).

The Virginia opossum (*Didelphis virginiana*) is the only marsupial native to the United States and like its Australian cousins it rears its young in a pouch. These cat-sized mammals are opportunistic omnivores that eat anything from seeds to bird eggs, making them highly adaptable in urban and suburban environments. However they require a natural water source to flourish (Fidino et al 2016). Despite their adaptability opossums are not considered an intelligent species and they do not have many defense mechanisms beyond playing dead. With a max lifespan of four years, opossums are enigmatic in their ability to compete with more well-adapted species like skunks and raccoons (Fidino et al 2016).

RESULTS

For the two weeks we studied, we only saw three species visit each site: the common raccoon (*Procyon lotor*), the striped skunk (*Mephitis mephitis*), and the Virginia opossum (*Didelphis virginiana*). At the Olde three skunks were spotted during week one and two skunks accompanied by a single opossum were spotted during week two. At Fort Awesome two raccoons were observed during week one, during the second week we observed one raccoon and two skunks. At the Hub we noted three raccoons, two skunks, and one opossum during the first week, during the second week we saw one raccoon, one skunk, and two opossums.

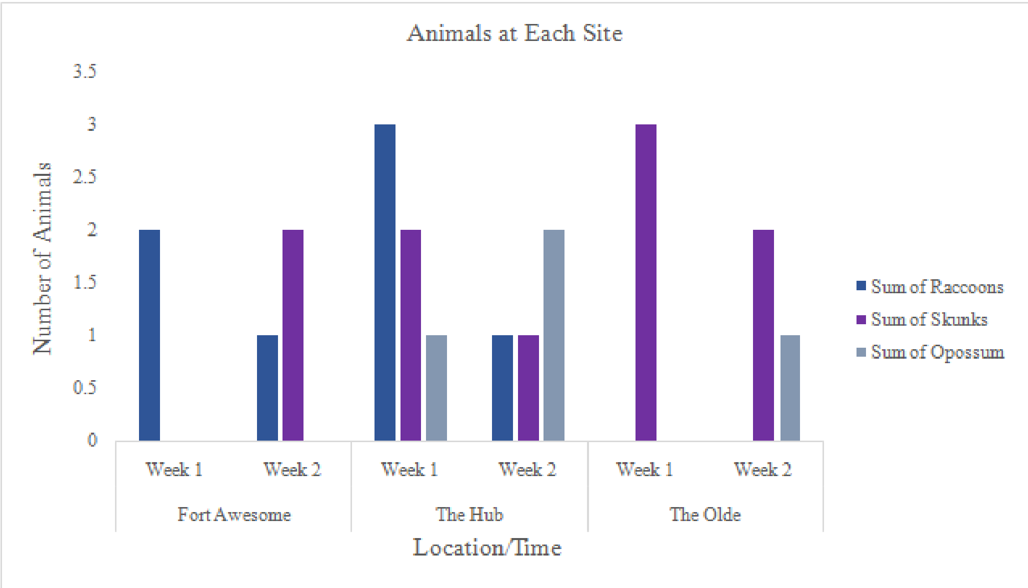

Figure 2: This graph shows the different species encountered and the number of individuals for each species that were observed during each week, at each location.

DISCUSSION

The purpose of this study was to determine the species diversity and abundance of nocturnal animals living in or near the Purchase College campus and what factors attract them to the school. Three study sites were chosen to best summarize the differing areas of the campus. These locations were based off of the amount of civilian traffic moving through the area and the possible food content that would likely be found in each area's respective dumpster (Prange et al. 2004). Based off of the data in *Figure 2*., the Hub appears to have both the highest number individuals and the most diversity out of the three sites. The Olde had the next highest individual count and both The Olde and Fort Awesome had only two observed species.

Overall, the two main factors that seemed to influence species diversity and abundance the most were the compositions of the dumpsters and the levels of civilian traffic moving through the area. Fort Awesome was located close the edge of a habitat, but between the animals and the dumpsters is a path that is frequently passed through by students living in Fort Awesome. While observing this site, the raccoons and skunks seemed to be very weary of this and crossed the path individually while the others waited for their turn to go at the edge of the forest. There were no opossums observed at this site, suggesting that perhaps this species is less comfortable being under stress in a highly human populated area (Fidino et al. 2016). Opossums were spotted at the other sites, which were situated in areas less visited by humans. At The Olde site, there were no observed skunks. This site is much closer to a forest edge habitat, but the composition of the garbage would have a lower proportion of food giving that the other two sites were located near dining commons. This suggest that while skunks may be more comfortable with humans, their diet may be more specialized requiring substances not found in this location (Gehring et al. 2003). All species were found at The Hub site. This site is further from the forest edge and located near a path, but during late hours it was observed that very few individuals pass through the area. Animals would make their way from the forest, down the grass next to the path and walk through the open gates to the dumpsters. The diversity of food supplied, the easy access, and the low numbers of humans make this spot the most appealing to these species. It was also noted that while species would go to the sites together, there was never more than one species at a dumpster at a time. This suggests that these species may try to avoid competing with each other by waiting for the dumpsters to be clear of competitors and to avoid confrontation (Crooks 2002).

From the data we have collected over the course of this study, it seems that more animals congregated by the Hub likely due to an abundance of food readily available to them. We also noticed how the fauna on campus differed based on location. For example, there were a higher number of skunks at the Olde while no raccoons were present in the area. This may have been due to the ability of skunks to drive competitors away with their warning coloration and defense mechanisms (Theimer et al. 2015). Opossums appear to be relatively scarce on campus when compared to skunks and raccoons. This is likely due to their perceived lower intelligence, solitary nature, lack of defenses, and specific requirements for water sources (Fidino et al. 2016). These reasons would likely make them more wary of the more aggressive and intelligent skunks and raccoons as to avoid directly competing with them.

Throughout this study several errors occurred during observations. One major factor that interrupted observations was the weather. When precipitation occurred it was difficult to make clear observations, coupled with the fact that many animals prefer to seek shelter during rain storms meant that they would not leave their burrows (DeStefano et al. 2003). Animals would sometimes not appear for an extended period of time possibly due to the presence of humans making them apprehensive.

Further research can be done to improve our overall understanding of the nocturnal populations living on and around the Purchase College campus. Given more time it would be helpful to run similar observational experiments at different times of the year to compare the activity during particular seasons. Equipment also plays a very important role in this research. Given the time and resources, cameras could be set up at every dumpster on campus. This additional information would not only give us a larger pool of data to work from, but it would also round out our conclusions and add a greater understanding of the nocturnal life on the Purchase College campus.

CONCLUSIONS

In our study we observed three dumpster sites on the Purchase College campus to determine what areas have the most diversity of nocturnal mammals and which areas attracted the most animals in general. Our results illustrate how urban environments have impacted animal behavior and how some have adapted to human society by exploiting anthropogenic food sources.

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