Porosity and Prosperity: Tree Diversity and Function in Urban Ecosystems

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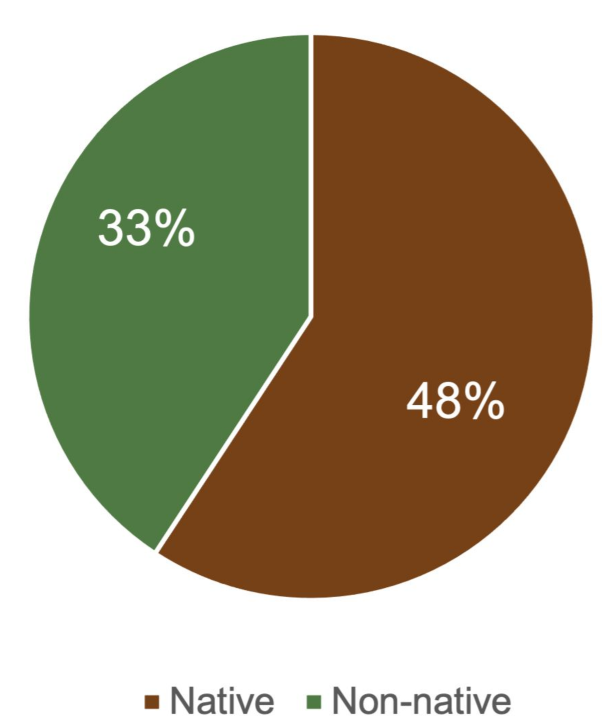
Introduction

Trees provide substantial ecosystem services in cities, where urban challenges like impervious surfaces, pollution, and the urban-heat island effect increasingly require healthy urban forests to mitigate excessive ecological or anthropogenic harm.[1] To monitor the health of trees in urban environments, students conducted field research assessing the tree crown health and pest activity between native and non-native tree throughout the Bronx Zoo.[2]

This summer, research aimed to assess whether native tree species displayed poorer health and higher pest activity compared to non-native species. Using open-source data, 3-month follow up studies were conducted expanding on this research, looking at two other facets of urban forest composition and their ecological impacts. Specifically, how tree species diversity and functional traits (e.g., wood porosity) influence their capacity to combat environmental challenges.

Key Takeaways

Data collected during the summer suggests a greater prevalence of native trees compared to non-native trees across the Bronx Zoo.[2] Building on this observation, students conducting fall research on tree diversity hypothesized that this distribution pattern would persist throughout the Bronx. The collected data was contributed to the Healthy Trees, Healthy Cities database as part of a community science initiative.



$$H' = -\sum_{i=1}^{S} pi \ln pi$$

Fig 1: Formula to calculate the Shannon Diversity Index. Calculations use relative abundance of each species, assessing richness and evenness to characterize species diversity within a community. A higher index value indicates higher biodiversity.

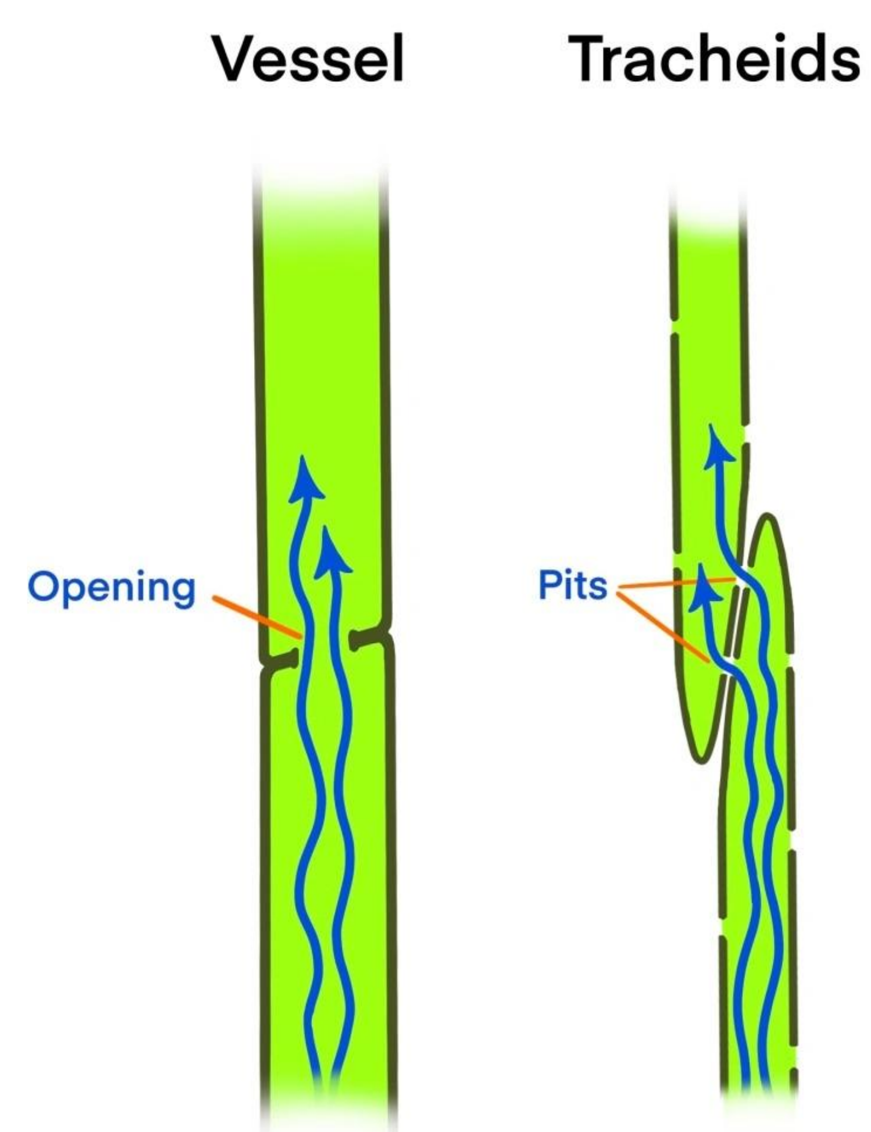


Fig 2: Vessels transport water more efficiently and are found primarily in angiosperms or diffuse-porous trees. Ring-porous trees, or gymnosperms, lack vessels.[3]

Diversitrees: An Evaluation of Tree Diversity and Non-Native Tree Abundance in Urban Parks of NYC and Boston

Nathalia Flores, Tahsan Latif

Questions: How does Shannon Diversity measure between urban parks in NYC and Boston? Do non-native trees share a greater relative abundance compared to native trees in Boston or in NY?
Hypotheses: Measures of Shannon Diversity Index will be greater in NY urban parks compared to urban parks in Boston. Relative abundance of non-native trees will be higher compared to native trees in the urban parks of Boston.

Synthesis

Coalescing summer and fall research, these projects highlight the critical role of green spaces in mitigating environmental risks. By examining tree diversity and their functional grouping based on wood porosity (e.g., diffuse-porous vs. ring-porous species) across different urban contexts, these studies underscore how tree composition can influence ecosystem services such as flood mitigation. These findings also offer insights into how to improve current forest management practices to support a well-balanced and healthy tree population as to encourage greater stability and productivity in urban forests.

Rooting for Porosity: Examining the Relationship between Diffuse-Porous Tree Abundance and Flood Risk in Bronx Neighborhoods

Eli Cato, Ashley Joran

Question: How does the relative abundance of diffuse porous trees correlate with the flood risk of neighborhoods in the Bronx?

Hypothesis: Neighborhoods in New York City with a lower risk of flooding will have a higher abundance of diffuse porous trees compared to neighborhoods with high risks of flooding.

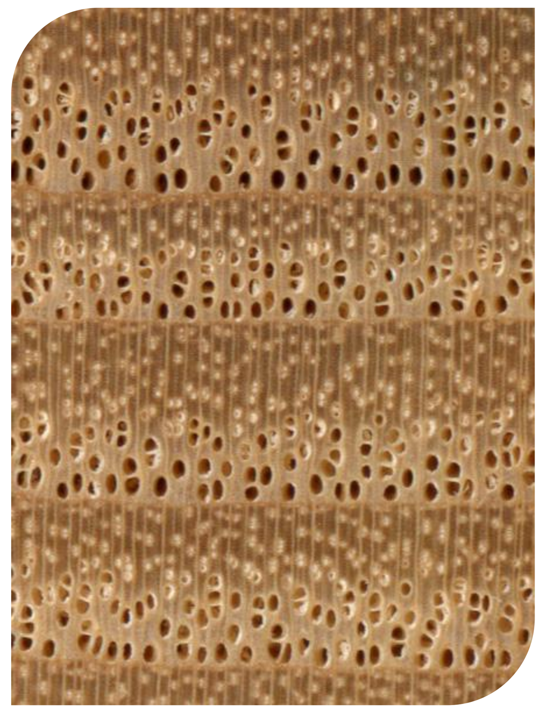


Fig 3: European Ash, a ring-porous species. Earlywood vessel size is greater than latewood, creating distinct annual growth rings.[4]

Fig 4: Afzelia, a diffuse-porous species. Vessel size remain relatively constant and dispersed throughout the bands with no clear arrangement.[4]

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"Was schert es eine alte Eiche, wenn sich ein Wildschwein in ihr scheuert?"

"It's no skin off an old oak's back if a wild boar wants to use its bark as a scratching post."

Rooting for Porosity: Examining the Relationship between Diffuse-porous Tree Abundance and Flood Risk in Bronx Neighborhoods

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Introduction

Trees are essential to sustaining urban environments, benefiting humans and nature alike. Trees partake in a process known as transpiration, using hollow tubes called xylem to move water up through their trunks and to their crown.[1] This absorption and release of water vapor is especially helpful for urban environments that are mostly paved over with non-porous materials like concrete. Such impervious surfaces require transpiration to better mitigate stormwater runoff.[2] Researchers looking into the effect of transpiration on flood risk in urban areas often look at tree canopies since canopy interception loss from leaves catching rainwater plays a crucial role in forest evaporation rates.[3] However, functional traits tend to be overlooked in models evaluating the water capacity and transpiration rates of various tree species.[4] This knowledge gap motivated research looking at the relationship between the tree wood porosity and flood risk.

This study looks at the relationship between the relative abundance of diffuse-porous trees and the flood risk of Bronx neighborhoods. We hypothesized that neighborhoods with more diffuse-porous trees would have lower flood risk indices than those with less diffuse-porous trees. We utilized open-source data sets, like the NYC Street Tree Census and the Wood Database to get information on the trees in Bronx neighborhoods, as well as First Street to find the flood risks of each neighborhood.

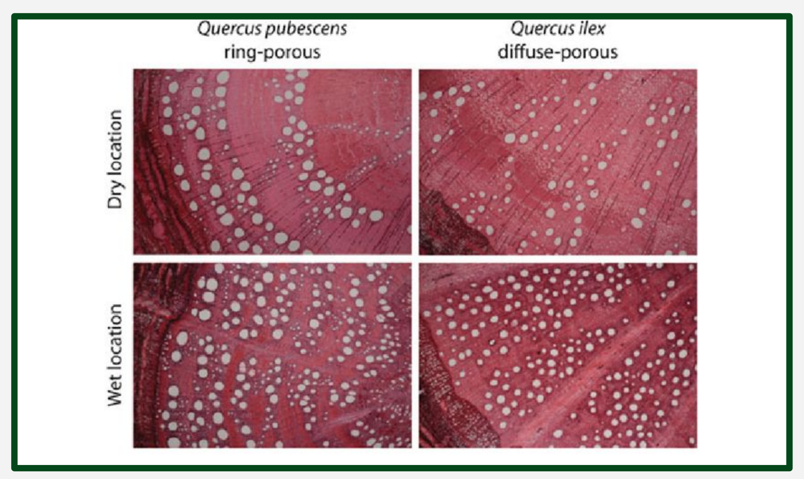

Fig 1: A comparison between the transverse sections of the ring-porous *Quercus pubescens* (downy oak) and the diffuse-porous *Quercus ilex* (holm oak) to show the difference in abundance, location, and size of pores.[4]

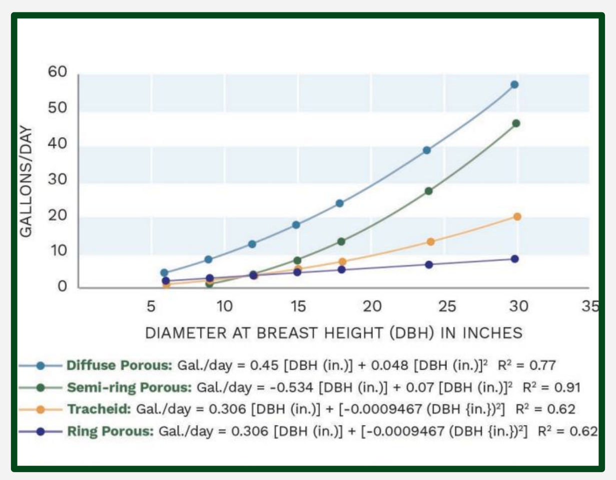

Fig. 2: Diffuse-porous trees diffuse more gallons of water per day on average at any DBH compared to semi-ring porous, ring-porous and tracheid. Source: U.S. Department of Agriculture (2020).[5]

Methodology

NYC Street Tree Census was used to gather raw data on the population of trees in each Bronx neighborhood, accounting for the total number of trees as well as the top five most common species per neighborhood.[6] We then referred to the Wood Database to determine whether each species was diffuse-porous, calculating the relative abundance by dividing the species count by the total population.[7] Additionally, we determined the flood risk for each neighborhood using flood risk modeling from First Street Solution.[8] Finally, we ran a regression analysis on excel and visualized the data through a scatter plot to show the relationship between tree abundance, wood porosity, and flood risk.

Abstract

Trees benefit urban environments by partaking in transpiration that helps mitigate stormwater flooding. We used open-source data to investigate the correlation between the relative abundance of diffuse-porous trees and the flood risk of all 37 neighborhoods in the Bronx. Open-source data was collected from the NYC Street Tree Census, First Street, and the Wood Database. The five most prevalent tree species across each neighborhood were recorded. The relative abundance of diffuse-porous species was then compared to the flood risk of each neighborhood. There was little correlation between the abundance of diffuse-porous trees and flood risk. Our results suggest that wood porosity does not affect flood risk as much as other flood mitigation methods, such as drainage systems or canopy coverage.

Research Question & Hypothesis

Question: How does the relative abundance of diffuse porous trees correlate with the flood risk of neighborhoods in the Bronx?

Hypothesis: Neighborhoods in New York City with a lower risk of flooding will have a higher abundance of diffuse porous trees compared to neighborhoods with high risks of flooding.

Results & Figures

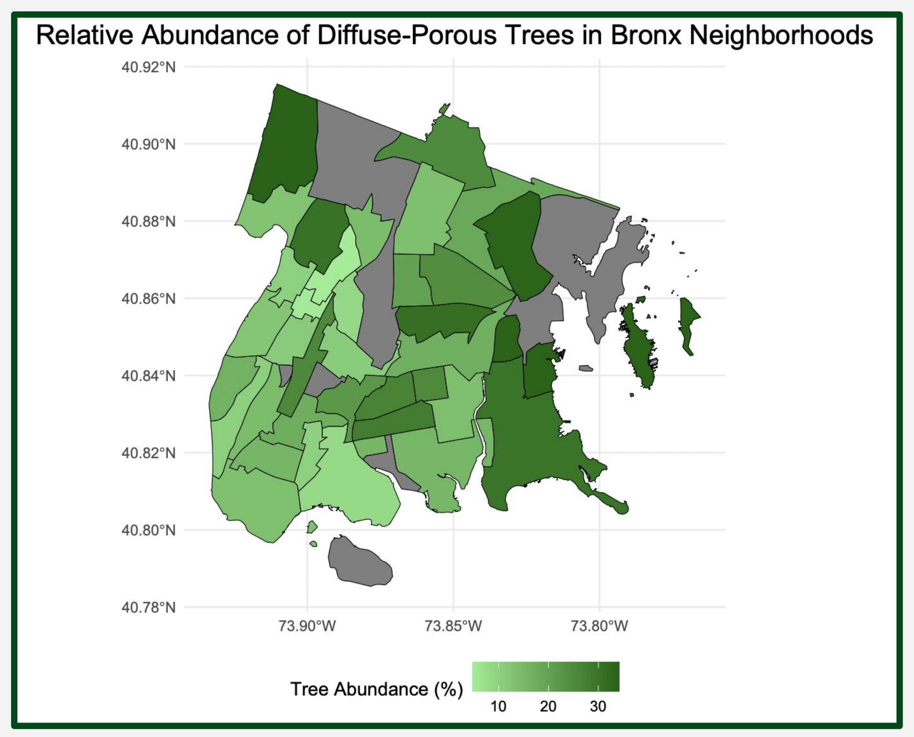

Fig. 3: Map showing the relative abundance of diffuse-porous trees in Bronx neighborhoods. Lower relative abundance is represented with lighter shades of green while higher levels are darker.

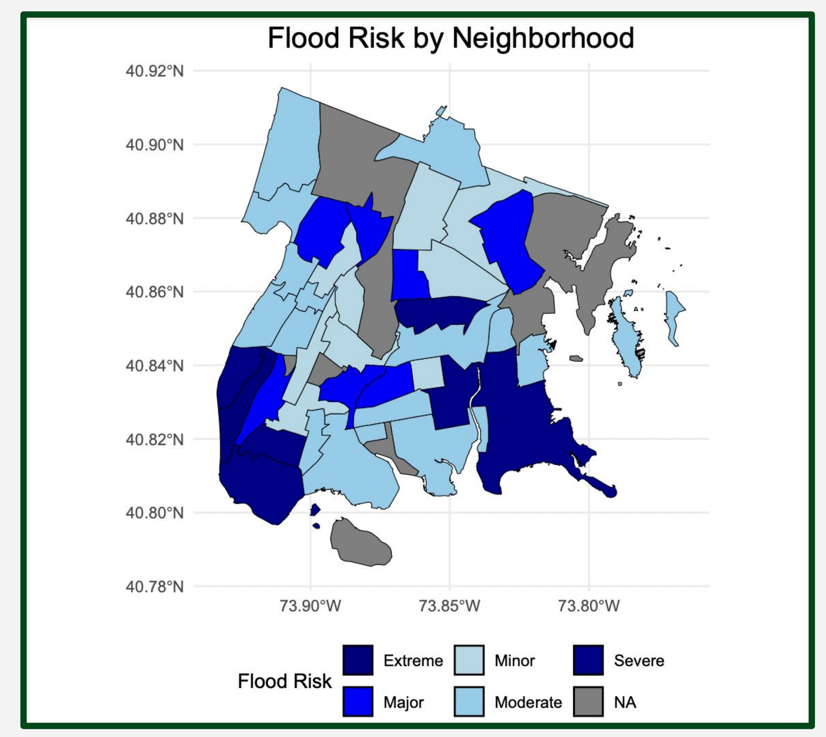

Fig. 4: Map showing the flood risks of Bronx neighborhoods, with the lightest blue indicating minor risk and the darkest blue indicating severe risk.

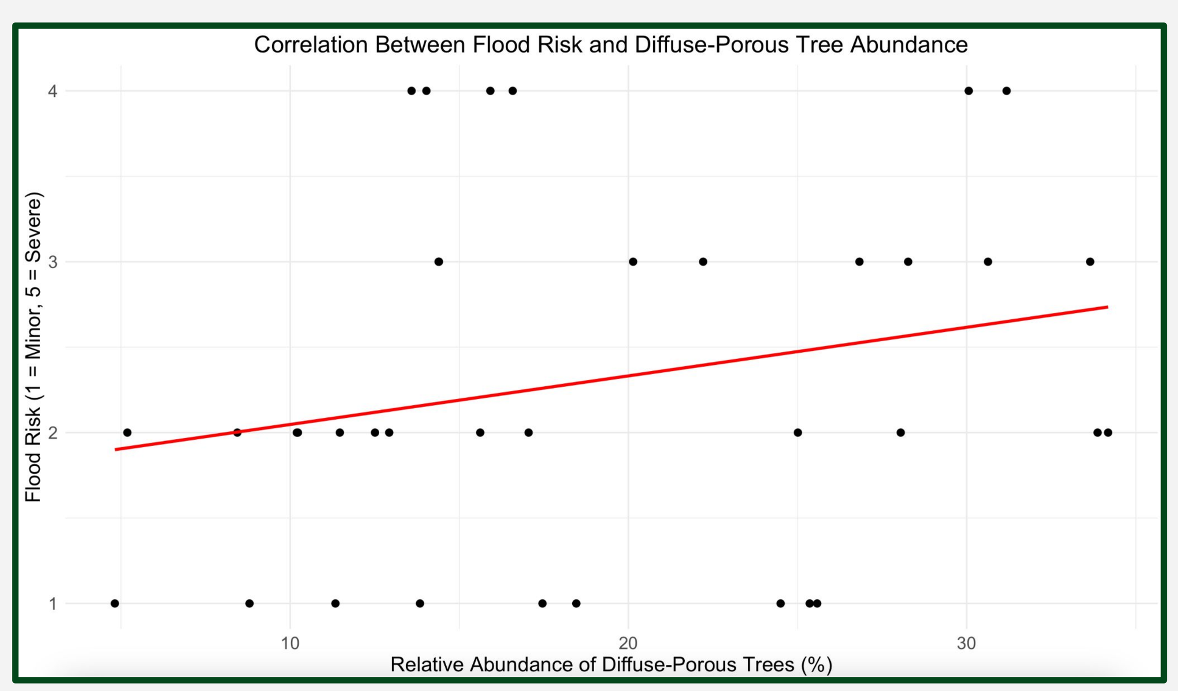

Fig. 5: The scatter plot demonstrates large variance in the relative abundance of diffuse-porous trees across different levels of flood risk. There is no evidence of a significant relationship between these two variables ($p = 0.384$).

Discussion & Conclusion

According to our results, the abundance of diffuse-porous trees is not a primary factor in mitigating flood risk. However, these results may be due to factors that were not considered in our study design, such as the spatial distribution of diffuse-porous trees within each neighborhood. Trees that are more clustered may capture greater amounts of stormwater within that specific area compared to trees that are more spread out. Furthermore, the data taken from the NYC Street Tree Census was conducted in 2015, which may not accurately represent current tree populations. Additionally, the flood risk recorded for certain neighborhoods relied on data available for zip codes within those neighborhoods and may not have been representative of the flood risk for the entire neighborhood.

According to the USDA, diffuse-porous trees are often planted in areas that have a large amount of precipitation to mitigate flood risk.[5] Considering that the total annual precipitation in NYC has been increasing over the past decade, alleviating damage caused by stormwater runoff requires urban foresters to focus on all possible factors, including wood porosity, leaf surface coverage, and the presence of sewage drains in cities.[9] Future research that looks into the relationship between these various instruments for flood mitigation will evidently work toward a more holistic and accurate model of the transpiration process among trees. In turn, this improves understanding of urban forest systems and green stormwater infrastructure.

Acknowledgements

We would like to thank the Wildlife Conservation Society as well as the Pinkerton Foundation. A special thanks to Max Falkenberg, Dr. Lowell Iporac, and Emily Torres for their guidance and support throughout our research.

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Diversitrees: An Evaluation of Tree Diversity and Non-Native Tree Abundance in Urban Parks of NYC and Boston

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Introduction

Tree diversity is essential when it comes to maintaining stable environments and ecosystems. In urban cities, increased tree diversity leads to a greater number of ecosystem services provided.[1] Non-native trees also provide similar services to native trees, but bring the added detriment of outcompeting native species.[2]

Biodiversity is measured using the Shannon Weiner Diversity Index, with a higher value indicating a more diverse community.[3] Previous studies conducted indicate that cities with higher average winter temperatures are positively correlated with higher street tree diversity as warmer temperatures contribute to increased forest productivity.[4] Similarly, smaller cities tend to have greater percentages of non-native trees in urban parks when compared to larger cities due to preferences in land management practices.[5]

In this study, the Shannon Diversity Index value and relative abundance of non-native trees in urban parks of Boston and New York City were evaluated. Thus, it was hypothesized that NYC will have a greater Shannon Diversity Index value and lower percentage of non-native trees in urban parks due to its greater size and warmer average temperatures when compared to Boston.

Methodology

Using the Healthy Trees, Healthy Cities database, five urban parks were selected in Chelsea, Boston and Bronx, New York. Parks in Boston were selected depending on if they had at least 30 trees recorded. New York City parks were selected if they had, at max, a difference of 10 trees recorded and similar acreage to the Boston parks. The sites were categorized into groups based on acreage, and data was cleaned of redundant and unclear observations (e.g., stumps). Then the Shannon Diversity Index and relative abundance of non-native trees was calculated for each park.

Group	Parks	Acres
A	B Winnisimmet Park	0.47
	NY Nelson Playground	0.61
B	B Quigley Park	0.55
	NY Washington Park	0.62
C	B Washington Park	1.7
	NY Mapes Park	1.6
D	B Carter Park	3.06
	NY Fort Independent Playground	3.02
E	B Voke Park	3.2
	NY Watson Gleason Playground	3.3

Fig 1: Park Grouping Chart

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Fig 2: Formula for Shannon Diversity Index

Abstract

Biodiversity in urban tree selection enables greater resistance to disease and provides more ecological services. This project focuses on assessing the diversity of trees in urban parks in NYC and Boston, which is important to improving horticultural practices in urban settings. In this study, the Shannon Diversity Index was used to measure the biodiversity of urban parks in NYC and Boston. Additionally, the ratio between native and non-native trees in each park was measured. Parks in Boston were selected depending on data availability in a database called Healthy Trees Healthy Cities, while NYC parks were selected to have a similar area (in acres) to the chosen Boston parks. The results indicate that Boston parks had a higher Shannon Diversity Index value to their NYC counterparts. However, NYC parks had a lower percentage of non-native trees. This research supported our hypothesis that Boston parks would have more non-native trees but failed to support our hypothesis that NYC would have higher Shannon Diversity Index values. Our results are in accordance with previous research that smaller cities would have more non-native trees.

Research Questions & Hypotheses

Question 1: How does Shannon Diversity measure between urban parks in New York City and Boston?
Hypothesis 1: Measures of Shannon Diversity Index will be greater in New York urban parks compared to urban parks in Boston.
Question 2: Do non-native trees share a greater relative abundance compared to native trees in Boston or in New York?
Hypothesis 2: Relative abundance of non-native trees will be higher compared to native trees in the urban parks of Boston?

Results & Figures

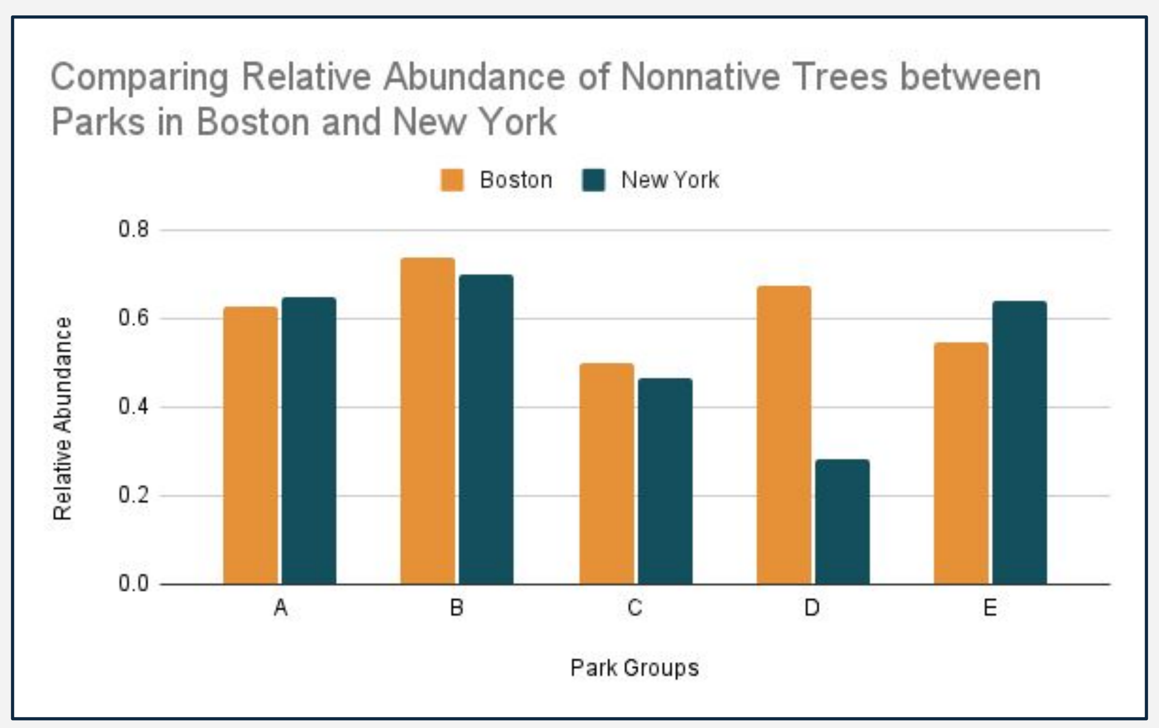

Fig 3: Relative abundance of non-native trees is greater in Boston parks compared to New York City parks.

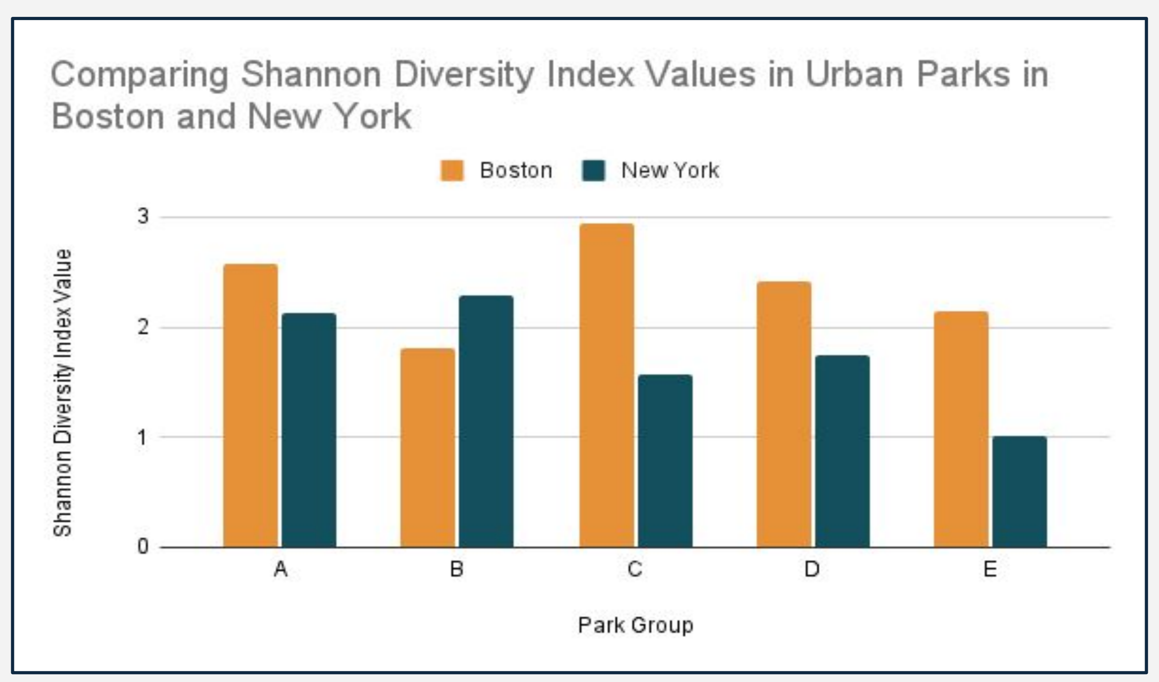

Fig 4: Shannon Diversity Index values are greater in Boston parks compared to New York City parks

Discussion & Conclusion

Contrary to our hypothesis, the results found that New York City parks often reported lower Shannon Diversity Index values compared to parks in Boston. However, parks in Boston had a higher relative abundance of non-native trees compared to New York City parks, supporting our hypothesis. Consequently, our findings supported previous research that smaller cities in the Northeast have higher abundance of non-native trees [4] and failed to support research that cities with warmer average winter temperatures have increased tree diversity.[3] One explanation for our results could be that the parks in Boston have a higher relative abundance of non-native trees due to more elm hybrids, which were listed as non-native due to being composed of American and European/Asian species, being present in Boston parks.

Some limitations with the study include the scarcity of tree data in Boston compared to New York City and the lack of confirmation for tree data, as HTHC data is conducted based on community science efforts. Further research can be conducted evaluating urban parks across the East Coast and the impact that weather patterns have on tree diversity. Research can also be conducted comparing tree diversity in urban and rural parks throughout New York state. The findings of this study are significant as they can lead to ecologically informed horticultural practices in New York, Boston, and surrounding cities.

Acknowledgements

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