Temperature and Air Quality: Effects In Tree Health and Arthropod Abundance

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Introduction

Urban trees and forests are crucial for regulating surface temperature, improving air quality, and providing habitat for diverse arthropod communities.

For red maples (*Acer rubrum, ACRU*) to thrive, air temperature can be as low as -40°C (Dansereau et al. 1957) especially since the trees are more prominent in parts of Eastern U.S and Northern Canadian regions–much colder regions compared to the rest of the world. The standard diameter at breast height (DBH) for ACRU is 5-20 centimeters (cm), while for paper birch trees (*Betula papyrifera, B. spp*) DBH hovers around 20 cm and an air temperature of at least -15° C (Safford et al. 1990). B. spp is native to Northern North America. While both species have comparable DBH ranges, mature ACRU trees generally accomplish larger diameters than mature B. spp. Optimal air quality, as defined by the U.S. Air Quality Index (AQI), falls within the range of 0 to 50.

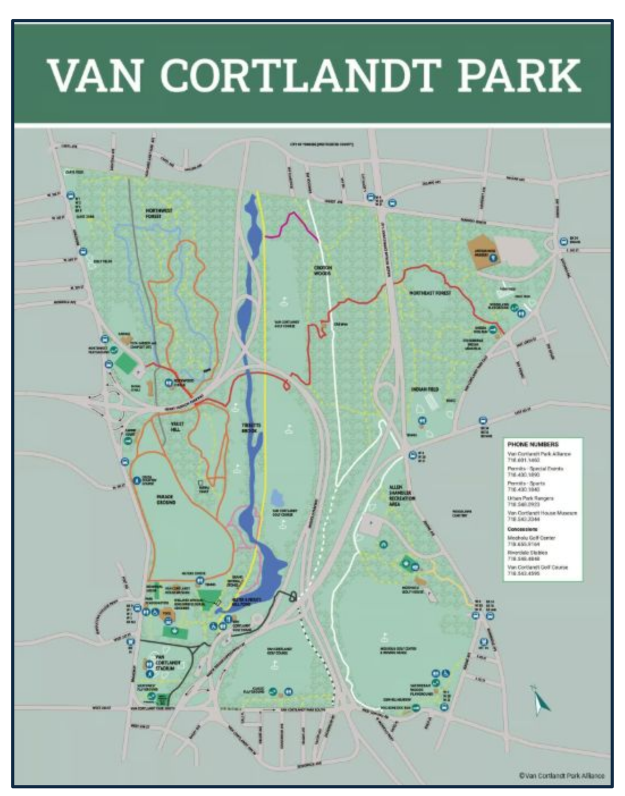
Arthropods, such as ants (*Formicidae*), beetles (*Coleoptera*), and spiders (*Araneae*), are among the most abundant and diverse organisms associated with trees; these insects use trees as habitat, feeding and breeding sites. Their presence and abundance alone can serve as environmental indicators for ecological health (Sollai et al. 2024). However, urban environments are increasingly affected by pollution and climate change, both of which may reduce the health and resilience of trees and arthropod populations.

Air quality and temperature are also important factors when determining arthropod trends. Increasing average temperatures have led to arthropods being negatively affected, and food webs have become disrupted. Many animals that rely on insects had less food to eat, and their population had decreased over decades (Lister et al. 2018). This study examines how variations in air temperature and quality influence arthropod abundance (specifically Diptera and Araneae) and evaluates structural health patterns in red maple and paper birch trees in Van Cortlandt Park from 2015 to 2018

Methodology

The study site used was Van Cortlandt Park (VCP), a significant green space situated in the Northwest Bronx. The park is home to a broad spectrum of organisms, including plants, insects, animals, and fungi. The two tree species used were Red Maples (ACRU) and Paper Birches (B. spp), with them being native to New York State and are considered heat-sensitive trees; the trees used were within a two-mile radius of the park's center.

1. Variables recorded include time (years/months), tree condition, DBH, arthropod abundances, temperature, and air quality.
2. We use open source datasets to find data that supported the research questions:
    a. iNaturalist used for spider and fly abundance data
    b. NYC Open Source Data for gathering Tree Health data and air quality within New York
    c. NOAA used for temperature analysis.
3. For tree-related data, the collection ranged from 2015 to 2018.
4. For arthropod-related data, the collection ranged from 2017 to 2023
5. We used Google Sheets & Structured Query Languages (SQL) to conduct queries and further filter information within CSV files.
6. For statistical analysis and visualization: we used Python with Pandas for data structuring and the creation of data-frames
7. Then used Python libraries such as Seaborn and Matplotlib for graph generation.



Abstract

This study investigates how air quality and temperature influence arthropod abundance and tree health in Van Cortlandt Park, Bronx, NY. The focus is on two common arthropod groups: flies and spiders, and two heat-sensitive tree species: red maple and paper birch trees. Environmental and biological data were obtained from open-source platforms, including iNaturalist, NYC OpenData, and NOAA, and analyzed using Python and SQL. Arthropod abundance remained stable between 2017 and 2021, peaked in 2021–2022, and declined by 2023, though no strong correlation was observed with air quality or temperature trends. Most red maples were in "Good" or "Fair" condition, with a wide and healthy range of DBH values, while paper birch trees were sparsely represented and showed limited variability. Overall, the findings suggest that tree health remain stable under current environmental conditions, while fluctuations in arthropod populations may be influenced by additional ecological or observational factors.

Research Questions & Hypotheses

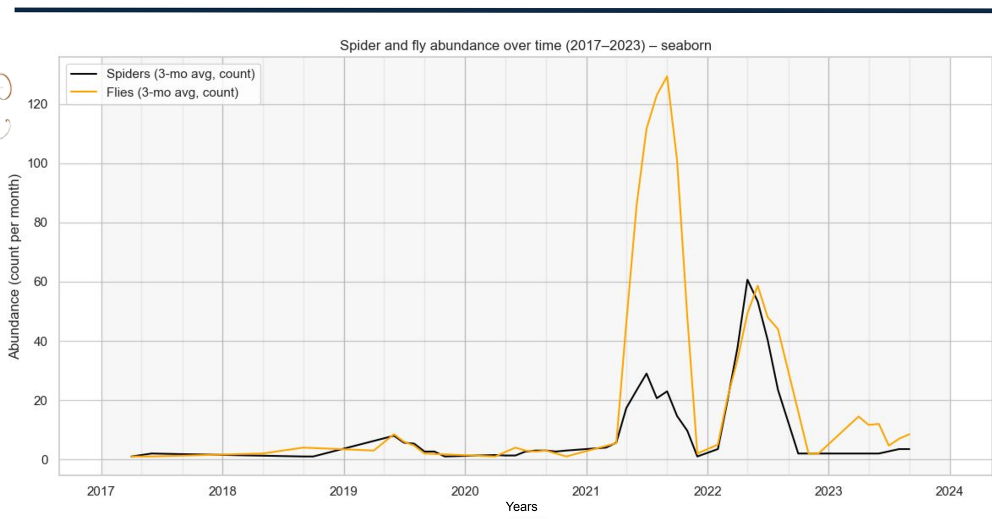
Question 1: How do health conditions, structural status, and risk rating differ between paper birch and red maple trees in Van Cortlandt Park?

- **Hypothesis 1**: Red maple trees will appear to have more variety in overall condition than paper birch trees due to the paper birch species having a smaller population.
- **Hypothesis 2**: Trunk diameter (DBH) will primarily be in a normal range for each tree species due to the fact the air quality and temperature have been constant over time (2015-2018).

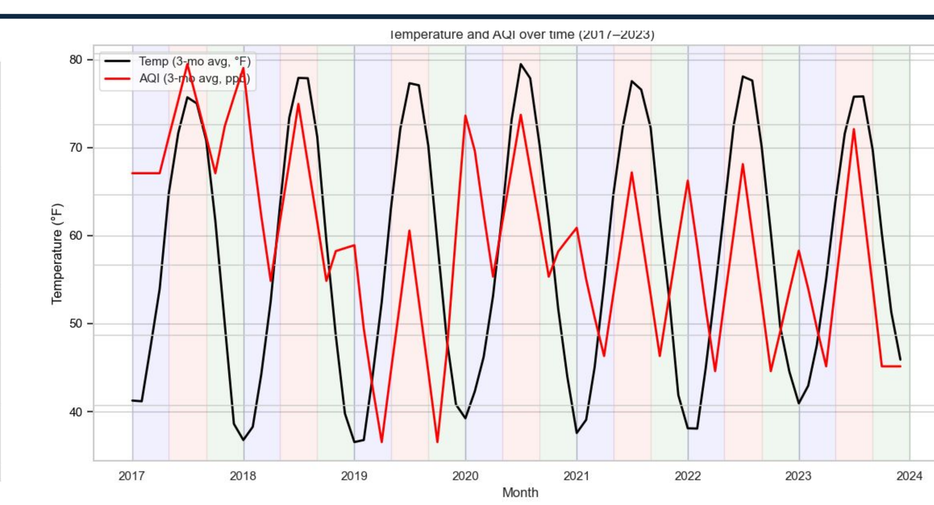
Question 2: How have changes in temperature and air quality over time affected abundance trends of fly and spider groups in forested ecosystems?

- **Hypothesis 1**: Significant changes in temperature over time would affect the population trends of fly and spider groups.
- **Hypothesis 2**: The abundance trends of fly and spider groups would be affected due to changes in air quality over time.

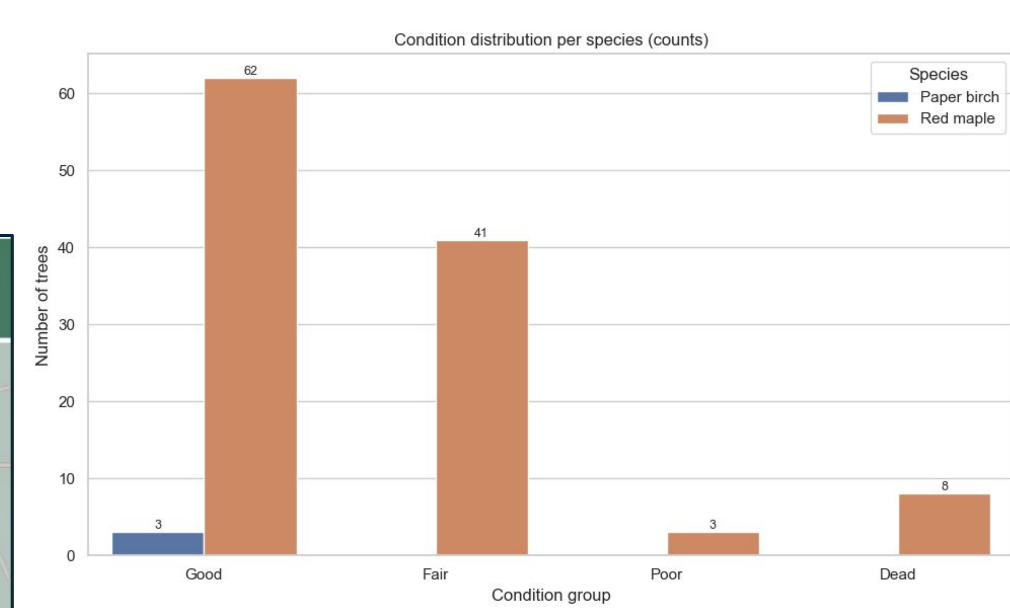
Results & Figures



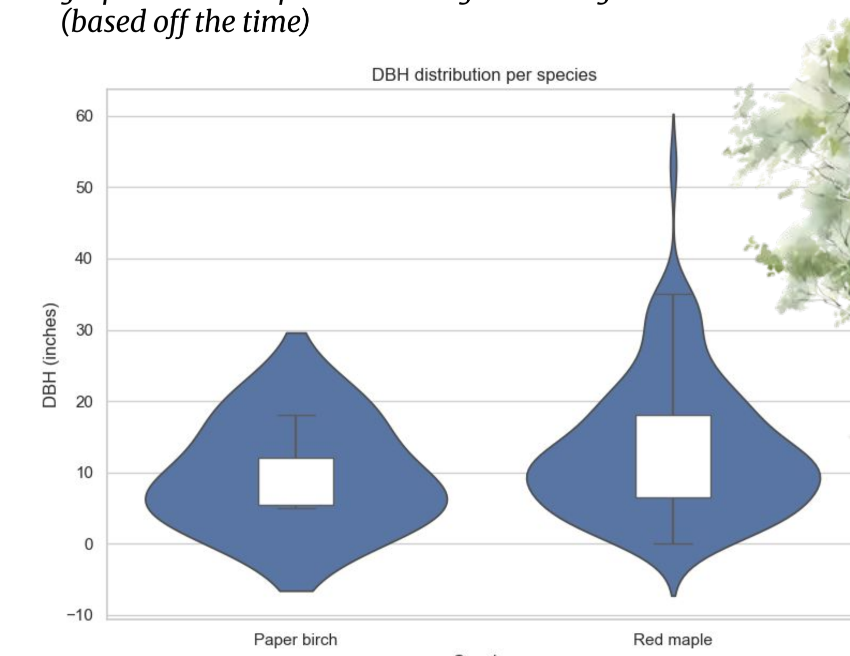
(*Figure 1*): *Spider & Fly abundance tracking by the years (three-month-AVG; matched with AQI and temperature averages)*



(***Figure 2***): *Air Quality Index tre... om 2017 to 2023; two y-axes graph where temperature ratings are being recorded within NYC (based off the time)*



(***Figure 3***)*: count distribution of all trees located within Van Cortlandt Park*



Betula papyrifera

(***Figure 4***)*: Box & Whiskers plot: This boxplot details the Diameter at Breast Height for the ACRU and B. Spp in Van Cortlandt Park. It is measured in inches.*

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Results and Analyses

A total of 114 red maple (Acer rubrum) and 3 paper birch (Betula papyrifera) trees were assessed. Of the red maples, 90.4% (n = 103) were in "Good" or "Fair" condition, while 100% of the B. Spp trees were adequate. The range of the DBH for the ACRU population is 12.7 to 1800 centimeters. The range of the DBH for the B. Spp trees is 12.7 to 900 centimeters.

Fly and spider presence remained consistent from 2017-2020. There was an increase in flies and spider abundance from 2021-2022. Flies had 120 observations during 2021-2022, while the spider count was 25. Both fly and spider abundance dropped immensely after. The 2022-2023 years had an immense drop in abundance but was higher than before 2020. During 2022-2023, the observations of flies was 59 and the spider's was 60.

The temperature fluctuations stay within a normal range without any notable anomaly events. According to the AQI index, the overall air quality has been satisfactory with a range of 13 to 19.

Discussion

The red maple population in Van Cortlandt Park was generally in good condition, with most trees exhibiting favorable health ratings and a wider range of DBH measurements. This supports the hypothesis that red maples show greater variability in condition, likely due to their larger sample size in VCP and higher resilience to environmental stress factors. Paper birch trees were sparsely represented (n = 3), preventing any meaningful comparisons. This aligns with prior findings that B. spp is more vulnerable to heat and disease, which may explain its limited presence in New York City's urban forest (Sumida et al., 2015)

The analysis supports a positive relationship between AQI and tree health, as trees tend to thrive when the AQI is below 50 as seen in VCP (National Park Service et al. 2022). The temperature has not been warm enough to affect ACRU abundance, although prolonged urban heat may contribute to B. spp decline, which is consistent with their preference for cooler climate.

There wasn't a significant change in fly and spider abundances until 2021 through 2023. Temperature and air quality did not seem to influence arthropod abundances at all, going against the original hypothesis. The data suggested that these groups may possess ecological resilience or behavioral adaptations, with how the arthropod species endured. During the summer and winters, they tend to fluctuate towards warmer shelter for survival and stationing near food sources, allowing both groups to flourish (Miller, 2024; Plunkett's pest control et al. 2023).

Several limitations should be noted: The reliance on iNaturalist data introduces potential observer bias, and the small sample size for B. spp restricts comparative analysis. Future research should incorporate better sampling methods and multi-year ecological monitoring to better understand long-term patterns.

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