The Effect of Human Population Density on Moss Microcommunity Diversity

Introduction

Pollution is one of the most pressing threats to the environment and global ecosystem, affecting not only visible fauna and flora, but microorganisms as well. Anthropogenic pollution is particularly harmful, and its full consequences are still being investigated. The health of a plant's surface microbes is an important indicator of the plant's overall condition; therefore, studying the factors that influence microbial biodiversity on plants is a valuable approach for understanding elements that may damage plant life (Berg et al 2019).

While the effects of anthropogenic pollution on microbiome diversity in various land plants have been widely studied, there is limited research on how such pollution impacts microbiome diversity in moss (Darrall 1989). Although moss is well known as a bioindicator species, commonly used to detect the presence and concentration of pollutants, there is currently no research examining how the very pollution moss identifies affects the biodiversity of organisms living within the moss itself (Radziemska et al 2019).

This study aims to address this gap in the research by examining the relationship between anthropogenic pollution, measured indirectly through human population density, and microbial biodiversity in moss samples. Human population density was chosen as a proxy for pollution because anthropogenic pollution originates from human activity, and population density captures a broad range of pollution-related factors rather than relying solely on direct measures of specific pollutants. Moss samples were collected from areas with varying population densities, determined using a statistical atlas, and analyzed to assess how human population density correlates with moss microcommunity diversity.

We predict that areas with higher human population densities have greater levels of pollution, which in turn negatively affect microorganisms. We hypothesize this because air pollutants can inhibit photosynthesis and reduce available resources, while microplastics can alter the environment and make it less hospitable for microbial communities (Radziemska et al 2019)(Darrall 1989).

Although there is abundant evidence that urbanization reduces microbiome biodiversity, and urbanization is, by definition, caused by human presence, no direct evidence links human population density itself to microbial biodiversity. This research therefore addresses an important lacuna in existing literature.

Methods and Materials

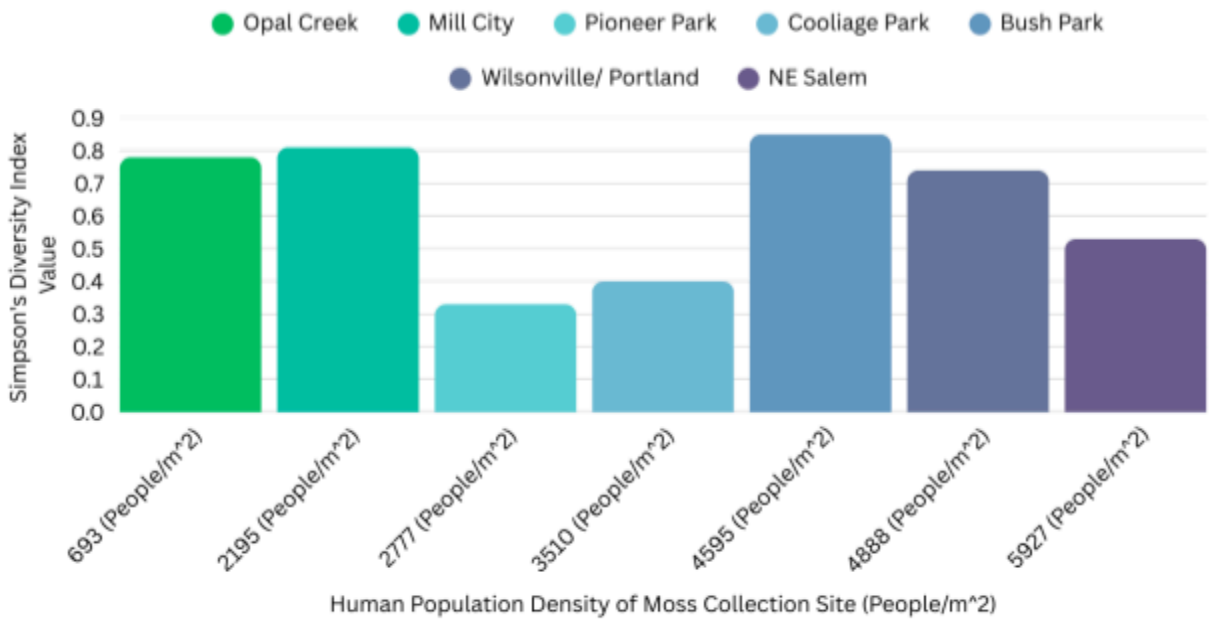
To investigate the effects of human population density on moss microbial diversity, two samples were collected from multiple locations representing a range of population densities. After collection, the samples were dried for two days. On the day of data collection, each moss sample was rehydrated in water for six hours before inspection.

To measure microbial diversity, two methods of microscopic inspection were used. First, water from each hydrated moss sample was squeezed into a petri dish. The dishes were scanned under a microscope, and all observable species were documented. Each petri dish was then examined for 15 minutes, and every organism belonging to each identified species was counted.

The second method involved creating three wet-mount slides from each petri dish sample. Each slide was observed under the microscope for five minutes, and the species present were tallied. These procedures were performed for all moss samples.

Results

Figure 1: Diversity of Microorganism Populations in Moss Across Sites with Varying Human Population Density



Multiple moss samples were collected from areas with varying levels of human population density. After collection, the samples were dried for two days, then rehydrated and examined to assess microorganism diversity. The value of diversity was then calculated by the Simpson's Diversity Index, and the higher index values indicate greater microbial diversity.

As shown in Figure 1, the highest diversity value (0.85) was observed in the sample from Bush Park, a site with a relatively high population density of 4,595 people/m². In contrast, the sample from Pioneer Park—our third-lowest density site (2,777 people/m²)—had the lowest diversity value (0.33). Surprisingly, the sample from Opal Creek, the site with the lowest population density (693 people/m²), exhibited a relatively high diversity value (0.78). Meanwhile, the sample from NE Salem, the site with the highest population density (5,927 people/m²), displayed a moderately low diversity value of 0.53. On the other hand, Mill City, the location with the second-lowest population density (2,195 people/m²), had the second-highest diversity value (0.81). Coolidge Park (3,510 people/m²), which falls near the middle of the density range, showed the second-lowest diversity value. Finally, Wilsonville/Portland, the site with the second-highest population density (4,888 people/m²), exhibited a relatively high diversity value of 0.74.

Overall, the data suggest that human population density alone does not have a direct correlation with microbial diversity in moss. Instead, the trends suggest that moss microbial diversity may depend on multiple variables, including environmental conditions, weather patterns, and the types of organisms present at each location.

Discussion

The original hypothesis predicted that higher human population density and its associated pollution would negatively impact moss biodiversity. Prior studies have shown a correlation between pollution and its negative effects on human biology and the process of photosynthesis in plants (Schell & Denham 2003)(Durrani et al 2004). However, the collected data does not support this assumption. No clear relationship was found between human population density and moss microbial diversity. When considering the data alongside the study's methodology and limitations, several sources of error become apparent that may influence the conclusion.

Sample collection occurred over multiple days, under different conditions, and across varying environments, including public parks and private backyards. These inconsistencies introduce additional variables, such as differences in foot traffic, microclimates, and drying or rehydration conditions that could affect results. Samples collected from private backyards, for

example, may not accurately represent pollution levels associated with broader population density.

During the laboratory analysis, inconsistencies also occurred. Some equipment was not properly cleaned, species may not have been counted using uniform criteria, and data sorting errors were resolved using memory rather than documented observations. Additionally, due to time constraints, replicate samples from each location could not be examined. This meant that a single sample often had to represent an entire site, reducing reliability and preventing confirmation of trends within each location.

The hypothesis was based on evidence showing that pollution impacts plant physiological processes such as photosynthesis, respiration, and carbon allocation (Darrall 1989). Urban environments tend to produce more pollution, which can stress local ecosystems. This reasoning suggests that more urbanized areas would exhibit reduced biodiversity. Microplastics, which can block light penetration and gas exchange, further disrupt photosynthesis and contribute additional environmental stress (Sawangproh Weerachon 2024). While this logic is supported in plant physiology research, the results of this experiment did not align with these expectations. This discrepancy may stem from the hypothesis not accounting for the many additional factors that influence moss microcommunities beyond anthropogenic pollution alone, especially in areas with higher human population density. In reality, the ecological dynamics affecting moss diversity are broader and more complex than our original, narrowly focused hypothesis allowed.

Limitations also included the inability to compare population density to actual human activity at each sampling site. A site may have a high population density overall, but low foot traffic in the exact sampling area. Additionally, unknown environmental factors, which would range in severity, could be recent rainfall or weather patterns, to wildfires, influencing moss communities without our awareness. Without controlled environmental conditions, such variables limit the accuracy of the findings.

Overall, the collected data does not support a relationship between population density and moss microbial diversity. The findings instead suggest that other environmental factors may play a larger role than initially expected. While this study provides a preliminary look at moss microcommunities, the possible incorrect hypothesis, limitations, and errors highlight the need for future research with standardized procedures, multiple samples per site, and the inclusion of additional environmental variables to better understand how pollution affects moss biodiversity.

References

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