A Comparison of Moss Biodiversity Between Areas of Different Atmospheric Pollution in Westchester County, NY

By: Marley Jennings[1], Aine O'Sullivan[1], Abigail Troup[1], and Michela Visco[1]
Dr. Oxana Litvine[1], Mrs. Rebecca Beaton[1]

[1] The Ursuline School, 1354 North Ave, New Rochelle, NY 10804

Cold Spring Harbor Laboratory DNA Learning Center

Funded by the Thompson Family Foundation

Abstract

Moss is a nonvascular spore-bearing species which plays an essential role in the environment. Mosses are absorbent and they help regulate water levels and maintain the moisture in the soil. Moss also serves as a bioindicator of air pollution in the atmosphere. Using moss as a bioindicator, we can compare the effect air pollution has on the biodiversity of moss. We hypothesized that the area with high levels of atmospheric pollution would contain less moss biodiversity. Our goal was to compare the biodiversity of moss species between areas with high levels of atmospheric pollution and those with low levels of atmospheric pollution. We initially identified our samples using iNaturalist and paper field guide. Then, using processes such as DNA extraction, PCR, Gel Electrophoresis, and DNA sequencing we were able to DNA barcode our samples, giving us more accurate results. Overall, we found that there was more biodiversity in areas of low atmospheric pollution versus high atmospheric pollution. This leads us to conclude that air quality has a significant impact on important plant species in our environment.

Introduction

- Moss is a small nonvascular spore-bearing plant.
- There are 12,000 identified species of moss worldwide and over 200 species in Westchester County.
- Moss plays a vital role in ecosystem functions such as water regulation, soil erosion control, and providing a habitat for other plants.
- Moss can serve as a bioindicator of air pollution due to its ability to absorb nutrients and pollutants from the atmosphere.
- Moss biodiversity was expected to be higher in a protected area (Rockefeller State Park Preserve) and lower in an area with direct proximity to air pollution (Bronx River Parkway).
- Samples were collected from Rockefeller State Park Preserve (low pollution site) and Bronx River Parkway (high pollution site).
- iNaturalist, the Common Mosses of the Northeast and Appalachians field guide, and DNA barcoding were used to identify the moss species.
- The study aimed to compare the biodiversity of mosses collected in the two sampling sites.

Materials & Methods

- A total of 30 moss samples were collected in April 2023, 15 from Rockefeller State Park Preserve and 15 from the Bronx River Parkway Area.
- Moss samples were initially identified using iNaturalist and a paper field guide, and microscopic observation.
- DNA barcoding confirmed the species of the moss samples.
- The rbcL primer was used to amplify DNA via PCR .
- The presence of DNA was confirmed using Gel Electrophoresis
- The samples were sent to Genewitz for sequencing.
- DNA analysis and organization were carried out using the DNAsubway.org website and BLAST.
- Results from iNaturalist, Field Guide, DNA Subway, and BLAST were compared to determine the moss species.

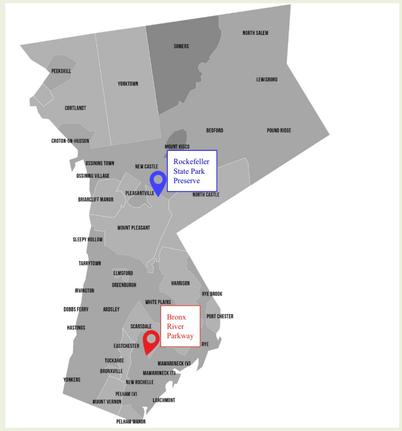


Figure 1. Map of sample collection area. Rockefeller State Park Preserve, 41.1084° N, 73.8368° W. Bronx River Parkway, 40.8618° N, -73.8717° W.

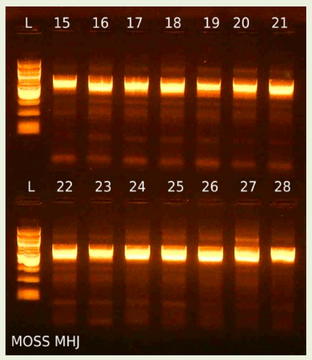
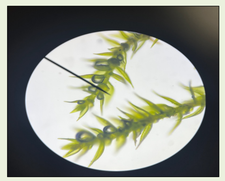


Figure 2. Gel results for several moss samples post rbcL gene amplification.



Figures 3 & 4. Moss microscopy examples.

Results

Of the 15 samples collected at Rockefeller State Park Preserve (Figure 1), there were 13 different species found according to iNaturalist (see Table 1). However, according to the field guide, there were 14 different moss species of the 15 (see table 1). Lastly, according to DNA sequencing and BLAST, one sample with an unreadable sequence and 13 different species were identified (see Table 1). Of the 15 samples collected in the Bronx River Parkway area (Figure 1), iNaturalist found that there were 10 different species of moss (see Table 2). However, according to the field guide, there were 11 species among these 15 specimens (see table 2). Finally, according to DNA sequencing and BLAST, there were 6 different species of moss out of the 15 collected (See Table 2).

Out of 30 moss samples, all 30 successfully yielded DNA sequences. However, one of those samples was of poor quality and did not yield readable DNA. The results of biodiversity from our Rockefeller State Park Preserve samples were 13 different species, as shown in Table 3. The results of biodiversity from our Bronx River Parkway samples were 6 different species, as shown in Table 3.

Tables & Figures

Table 1. Moss species found in Rockefeller State Park Preserve and Bronx River Parkway areas.

Rockefeller State Park Preserve	Bronx River Parkway
1.Climacium dendroides	*1.Hypnum lindbergii*
2.Plagiothecium nemorale	*2.Plagiomnium cuspidatum*
3.Orthotrichum consobrinum	*3.Prunella vulgaris*
4.Plagiomnium cuspidatum	*4.Hygroamblystegium varium*
5.Dicranum scoparium	*5.Brachythecium rutabulum*
6.Brachythecium plumosum	*6.Brachythecium oxycladon*
7.Pylaisiadelpha yokohamae	
8.Hygroamblystegium varium	
9.Atrichum undulatum	
10.Orthotrichum anomalum	
11.Callicladium haldanianum	
12.Thuidium delicatulum	
13.Amblystegium serpens	

Table 2. Summary of number of moss species found in Rockefeller State Park Preserve and Bronx River Parkway area.

Moss Collection Location	Rockefeller State Park Preserve Biodiversity	Bronx River Parkway Biodiversity
Number of Species	13 species	6 species

Discussion

- Samples from Rockefeller State Park Preserve (RSPP) had higher biodiversity than those from Bronx River Parkway (BRP) samples. RSPP samples included 13 different species out of 14 total samples. BRP samples included 6 different species out of 15 total samples.
- Four methods were used to identify species: iNaturalist, field guide, DNA barcoding with DNA subway, and direct analysis with BLAST. Rarely did all four methods yield the same results, with only one case out of 29 analyzed showing complete agreement. Microscopic features played a significant role in moss identification, which iNaturalist struggled with.
- DNA subway and direct BLAST analysis yielded identical results 17 times and similar results (within the same genus) 9 times. In three cases, DNA subway and BLAST yielded very different results, and the reason for this discrepancy is still being determined.
- Species identification was based on the results of DNA subway and direct BLAST analysis, considering nearby species distribution in case of slightly or very different results.
- Moss biodiversity was higher in the protected natural reserve (RSPP) than near the busy parkway (BRP).
- Species found near BRP are likely more tolerant of harsh atmospheric conditions. Atmospheric pollution has a significant impact on moss species.
- Limitations of the study include the challenge of identifying moss based on physical features and the potentially small sample size at BRP.
- Future studies can explore expanding the sample size, measuring biodiversity in different areas with varying atmospheric conditions, and investigating plant biodiversity beyond moss in the same areas.

References

BLAST (Basic Logical Alignment Search Tool) BLAST: Basic Local Alignment Search Tool (nih.gov)

Discovery Communication. (n.d.). Primary and Secondary Succession.

Britannica, T. Editors of Encyclopaedia (2023, April 14). moss. Encyclopedia Britannica. https://www.britannica.com/plant/moss-plant

Click + Learn with DNALC Media - CSHL DNA Learning Center. (n.d.). DNA Learning Center. Retrieved May 25, 2023, from https://dnabarcodingt01.org/resources/

NYC Environmental Protection website (n.d.). Transportation Emissions. Transportation Emissions - DEP. https://www.nyc.gov/site/dep/environment/transportation-emissions.page#:~:text=Emissions%20from%20transportation%2C%20primarily%20cars,of%20the%20nitrogen%20oxide%20emissions.

McKnight, K. B., Perdrizet, W. J., Ward, K. M., & Rohrer, J. R. (2013). Common Mosses of the Northeast and Appalachians. Princeton University Press.

Qin X, Zhu Y, Yu J, Xian X, Liu C, Yang Y, Tao N. (2018 Nov 6). Chemical Sensing in Real Time with Plants Using a Webcam. Anal Chem.

Sands, Y. (2017, Nov. 2). Moss Study Helps Identify Pollution Hotspots.

Using moss as a bioindicator of air pollution. (2016, April 8). Environmental News Network. Retrieved January 30, 2023, from https://www.enn.com/articles/49463-using-moss-as-a-bioindicator-of-air-pollution

Rockefeller State Park Preserve (n.d.) State Parks. Parks, Recreation and Historic Preservation. Retrieved May 25, 2023, from https://parks.ny.gov/parks/rockefeller/details.aspx

Urban Barcode Project Guidelines. (n.d.). DNA Barcoding 101. Retrieved May 26, 2023, from https://dnabarcodingt01.org/files/ubp/UBP_Guidelines.pdf

Acknowledgments

We thank The DNA Learning Center for collaborating with us on this project. We would also like to thank Cold Spring Harbor Laboratory and The Ursuline School for helping with funding for this experiment. We thank our mentors, Mrs. Rebecca Beaton, and Dr. Oxana Litvine.