Effect of Prescribed Fire on Soil Quality in the Long Island Central Pine Barrens

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Abstract

Understanding fires impact on soil health is crucial to understanding the impact of fire on the health of an ecosystem. Samples were analyzed for three factors that contribute to soil health: micro- and macro- fauna, chemical properties, and root biomass. Samples were taken from plots with different fire management labelled as frequent, infrequent, and control. Micro- and macro- fauna were more abundant in frequently burned sites, while diversity and evenness were higher in control sites. Infrequently burned sites had the lowest overall abundance, but had greater diversity and evenness then frequently burned sites. The pH levels were lowest in the frequently burned plots, but only slightly with little difference between all the plots. The potassium levels were consistently high among all the plots, while the phosphorus levels fluctuated greatly between plots with no consistent trend. The nitrogenous results were inconclusive due to the faulty tests. The root biomass was highest in soil sampled from control areas, followed by frequently burned areas, with the infrequently burned areas having the lowest root biomass.

Methods

- We used a soil corer to obtain samples.
- To measure the root biomass, roots were separated using a sieve and rinsed to remove additional soil.
  - Then the roots were dried in a 60° oven for 48 hours.
  - A later revised procedure included walking in a straight line into the sampling plot with a tape measure, and using the soil corer to extract a sample at 10m, 20m, and 30m.
- To measure pH and PNK concentration in the soil, the Akasha® soil test kit was used
  - pH was measured by adding 1g of soil and one capsule of methyl red and bromothymol blue along with 5mL of water and checking the color of the solution.
  - PNK was tested using a premade mixture of 5 parts water to 1 part soil that was let to settle. The capsules provided by Akasha® were then mixed in and checked for color after 10 minutes.
- To analyze samples for micro- and macro-fauna 50 grams of soil were taken from Layer B of each sample and subsampled 10 grams at a time. An optical microscope was used to look for and identify any living organisms.
- Any organisms found were identified to the lowest taxonomic level.

Root Biomass Results

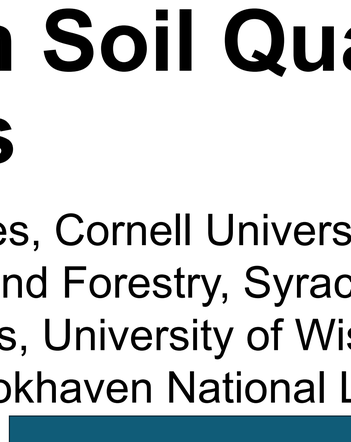
Treatment	Average dry weight of roots
Control	2.15
Infrequent	3.209090909
Frequent	3.06875
Total	2.862162162

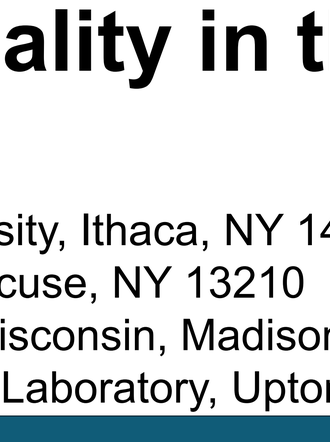
Figure 1:
Table showing the differences in the average root biomass between the different treatment groups.

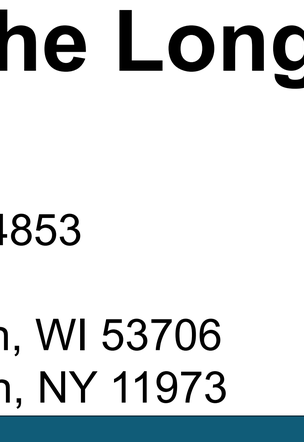
Micro- and Macro- Fauna Results

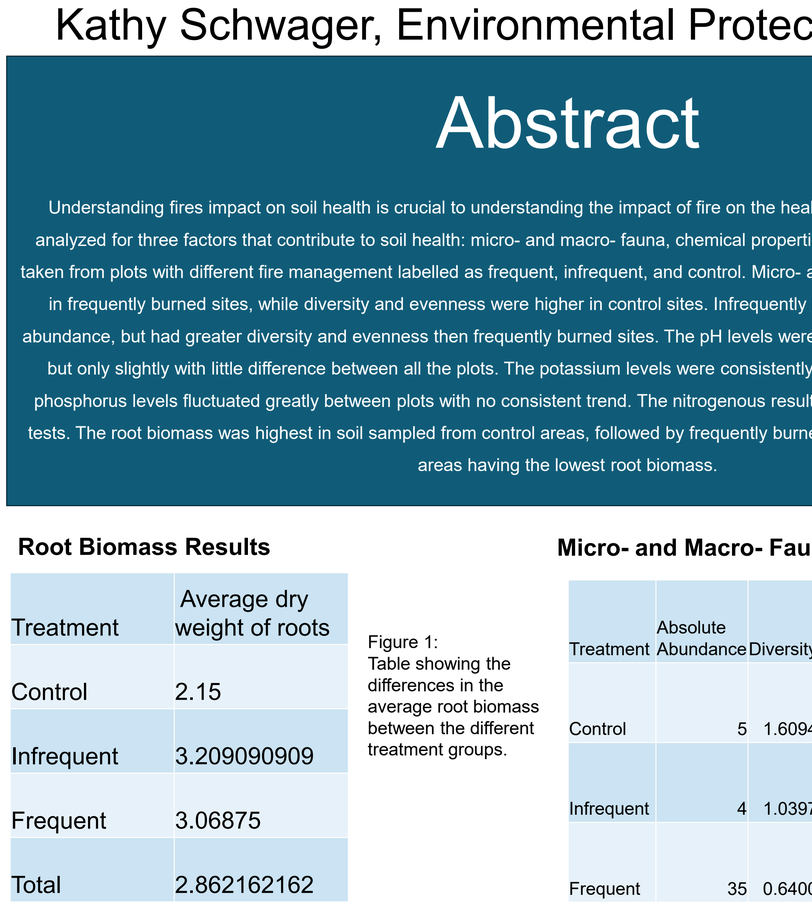
Treatment	Absolute Abundance	Diversity	Evenness
Control	5	1.609438	1
Infrequent	4	1.039721	0.75
Frequent	35	0.640036	0.180021

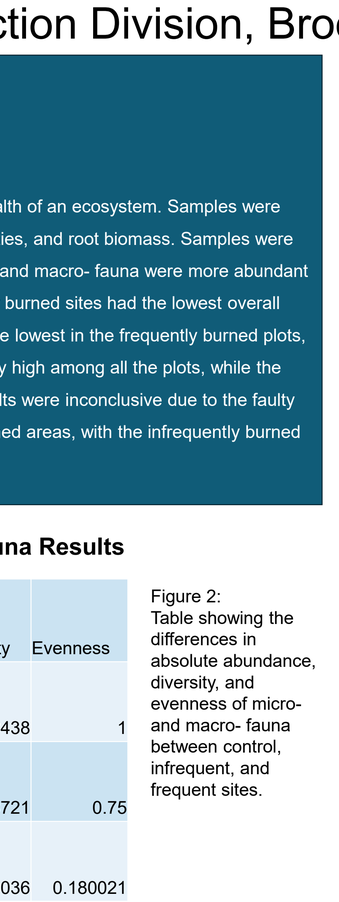
Figure 2:
Table showing the differences in absolute abundance, diversity, and evenness of micro- and macro- fauna between control, infrequent, and frequent sites.











Results

- A Kruskal Wallis test was used to determine the significance of the results, with the website "Statistics Kingdom." In total, 37 samples were collected, with one sample being one soil core. I compared my results first in three separate categories; control, infrequent and frequent fire. I got a p-value of 0.2269, which is insignificant. There was marginal significance between the control and infrequent values, with a p-value of 0.08533.
  - The plots were also separated into two categories, plots that have not experienced fire (control) and plots that have experienced fire (infrequent and frequent). A Mann Whitney U test was performed on these categories and a p-value of 13.85 was obtained, indicating marginal significance
- Micro- and macro- fauna were more abundant in frequently burned sites, while diversity and evenness were higher in control sites. Infrequently burned sites had the lowest overall abundance, but had greater diversity and evenness then frequently burned sites. A Kruskal-Wallis test was used to calculate statistical significance between diversity, evenness, and abundance. Neither diversity or evenness were statistically significant, each having a p value of .368. Abundance between the sites was also not statistically significant with a p-value of .438.
- The pH, phosphorus, and potassium values were sorted by plot type and averaged for comparison. The nitrogenous test proved faulty; thus, the results were not analyzed. A Kruskal Wallis test was used to determine the significance of the three tests due to the lack of normality of the data. The p-values found for the pH, phosphorus, and potassium tests were 0.2283, 0.0162, and 0.1173, respectively. This means that the pH and the potassium results are likely not significant whilst the phosphorus results may be significant.

pH, Phosphorus and Potassium Results

Treatment	pH Average	P Average	K Average
Control	6.0	3.25	3.75
Infrequent	6.0	2	3.5
Frequent	5.65	2.1	4

Figure 3:
Table showing the average pH, phosphorus, and potassium levels of each type of treatment plot.

Introduction

- While prescribed fires' effects on vegetation is quite apparent and heavily studied, it's as important to assess soil health when seeking to understand fire's effect on ecosystems.
- Long Island Central Pine Barrens ecosystems require fire to exist on the landscape, without which there is a conversion to a closed canopy forest (Jordan et al. 2003)
- Mesophication occurs in the absence of fire, the replacement of fire adapted and resistant plants with shade adapted and fire susceptible plants (Nowacki 2008).
- To better understand the relationship between the pine barrens and the effects of fire frequency on soil properties, our team set out to measure a variety of soil qualities in a spectrum of sites ranging from frequently burned to not burned in thirty years
- Pine Barrens soil is typically nutrient poor, sandy and acidic (Jordan et al. 2003; Shah et al. 2011).
- Quigley et al suggests that poor soil quality may be conducive to maintaining the sparse canopy characteristic of the Pine Barrens (2020).
- In the 2025 Long Island Forest Health and Wildlife Risk Reduction Field Trip held on Long Island, it was apparent that the Long Island Pine Barrens is its own unique biome that thrives off of processes and factors, such as fire, that may seem counterintuitive to ecosystem health in the public perception.
- pH is known as the master soil variable due to its large range of effects on numerous soil functions, including enzyme activity, organic material precipitation, and biodegradation (Neina et al. 2019)
- Phosphorus, nitrogen, and potassium (PNK) are known to work as colimiting factors on terrestrial plant growth and development (Fang et al, 2024)
- Testing pH and PNK levels of the soil at different sites will illuminate the relationship between fire and said chemical properties along with the soil health they provide
- The presence of microfauna and macrofauna indicate the soil's ability to both sustain life and decompose organic matter, making it an important measure of soil health (Dervash et al., 2018)

Discussion

- The chemical tests gave mostly nonsignificant results, providing evidence against there being a link between fire frequency and pH or potassium levels. There was significance in the phosphorus results, specifically between control and frequent plots. This potentially describes an inverse relationship between fire frequency and phosphorus presence. This relationship, however, should be further studied due to the small data set potentially skewing the results.
- Though there were differences between absolute abundance, diversity, and evenness none of the values were statistically significant, suggesting that there is no link between fire frequency and micro- and macro- fauna populations. Organisms that were present were consistent with knowledge of recolonization after fire in an ecosystem, with macrofauna being most abundant in frequently burned sites.
- In a study conducted by Siefert in 2005 in the Long Island Central Pine Barrens, increased canopy cover was found to negatively correlate with the total understory cover. Frequently burned plots often have a lower total canopy cover, which would probably coincide with a higher understory cover. The higher density of understory vegetation in the frequently burned plots could explain the observed greater root biomass.

Sources of Error

- Procedures for collecting soil samples changed throughout the study, which may have impacted the results.
- The Akasha® soil test kit was heavily flawed and likely skewed results. The nitrogen test never produced usable results, and the phosphorus test required more frequent shakings to show color than the other tests.
- The testing was also likely subject to human error due to the subjectivity of color richness being used to determine chemical amounts. This means that test tubes of similar color can be misidentified as different results depending on the amount of sunlight or eye strain of tester.
- Because the test was unable to work for one of the chemicals and was highly subject to error, the significance of the posted results should be viewed with scrutiny
- The root washing procedure may not have extracted all of the dirt, especially as later samples had three soil cores combined, more soil may have been left in the roots during the rinsing process.
- In future studies, a better root washer should be used. Additionally, the soil samples should be collected in the same procedure.
- Additionally, Ericaceae plants that are one of the dominant understory species in the Pine Barrens have stems underground, which may have been included in the root biomass measure (Gilvarg).
- Techniques for preparing microscopy samples changed throughout the study, which may have impacted what data could be gathered.
- Sample sizes for microscopy were small, impacting the data that could be collected.
- Time frame for the study was short which could impact what species were seen as well as the frequency and absolute abundance as some species are more prevalent during certain seasons.

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