Lichen Influence on Microbial Activity in Pinelands Soils

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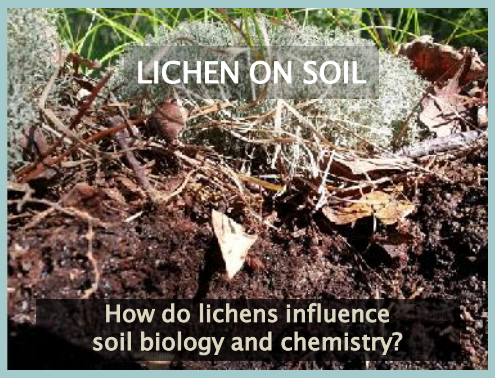


INTRODUCTION

There is a trove of research about how plants influence soils. But lichens (entities made of a fungus with embedded photosynthesizing organisms and a variety of associated bacteria) also live on soils, and only a few studies hint at what they do there.

In the NJ Pinelands (as in the Arctic and in some deserts), lichens form dense mats that cover the ground. So their presence may influence soil nutrient cycling, soil communities and soil decomposition processes.

Sedia et al. (2006) found that lichens grow in low nutrient conditions where microbial communities were actively producing enzymes to acquire nutrients they could not otherwise find. My study asks whether the lichens created those difficult conditions.


Common Pinelands lichens: *Cladonia subtenuis*, *C. cristatella gr.*, *C. chlorophaea gr.*, *C. submitis*)

HYPOTHESIS

LICHEN
- Slow growing, water absorption from air
- Secondary metabolite production
- Retention of rainwater N & P

LITTER
- High phenolics, slimy texture
- N and P in complex organic compounds

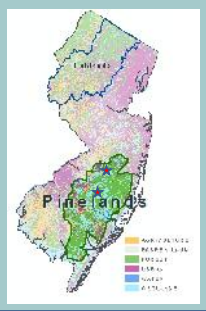
SOIL PROPERTIES
- Slow decomposition, moist soils
- Low nutrient mineralization rate
- Low nutrient availability in soil

SOIL PROCESSES
- Microbes with little access to inorganic N and P and sugars produce degradative enzymes to break down complex organic compounds

After Wardle et al, 2004

STUDY SITES

Lichen-dominated patches in Brendan Byrne State Forest & Wharton State Forest (Pinelands Reserve, NJ)



STUDY DESIGN

I created a transplant grid with 4 ground covers (lichens, pine needles, oak leaves, and bare ground) in January 2013.
I then took periodic samples to 5cm deep of the soil, which I analyzed for soil moisture, soil chemistry, and soil enzyme activity

1. RESULTS: SOIL PROPERTIES

Soil Moisture: Lichens only influenced soil moisture at Brendan Byrne forest, where the soils were drier and had less organic matter content (4% organic matter vs. 9% organic matter on average). Data in Figure 1represent soil moisture calculated by mass loss after drying to constant mass at 70°C.

Soil Phosphorus: Lichens influenced available soil phosphorus when levels were high. Data in Figure 2 represent soil PO_4^{2-} concentrations extracted from soils and measured using colorimetry as described in Sedia et al. (2006).

Soil Nitrogen: I did not find significant effects of lichens on soil ammonium (Figure 3), nitrate/nitrate, or microbial biomass (data not shown). Data in Figure 3 represent NH_4^+ concentrations extracted from soils and measured using colorimetry as described in Grey et al. (2012).

Fig1. Aboveground lichens increase water content of dry soils

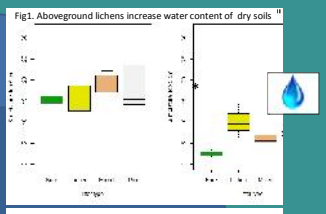


Fig2. Aboveground lichens decrease PO_4^{2-} in some soils

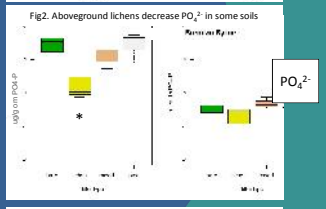
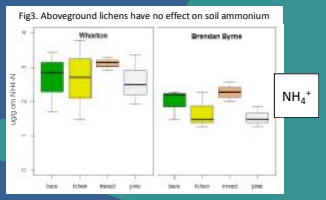


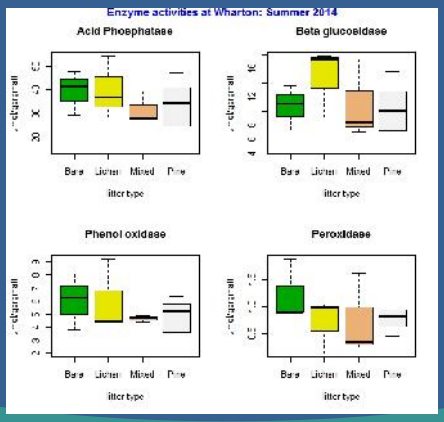
Fig3. Aboveground lichens have no effect on soil ammonium

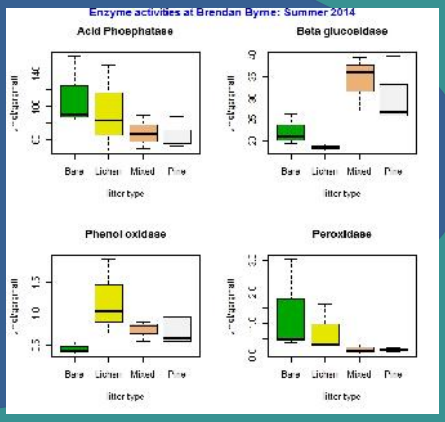


RESULTS: MICROBIAL ACTIVITY

To study microbial activity, I incubated soil samples with various color-changing substrates. When the enzymes broke down the substrates, I could analyze the activity of each enzyme by the degree of color change in the sample, using procedures described in Geng et al. 2012.

- **Acid Phosphatase** is an enzyme that liberates phosphate from organic material. In soils with little available inorganic PO_4^{2-}, I expected increased activity of acid phosphatase, and in Brendan Byrne (the more nutrient-poor forest) there were higher activity levels but no difference in activity with aboveground cover.
- **Beta-glucosidase** is an enzyme involved in liberation of glucose from cellulose. Its activity was higher under lichens at Wharton, but significantly lower in bare and lichen-covered sites at Brendan Byrne.
- **Phenol oxidase** is an enzyme involved in lignin degradation. There was no significant difference in activity of this enzyme under lichens.
- **Peroxidase** degrades recalcitrant compounds, some of which are excreted by lichens. I expected peroxidase activity to be higher under lichens, but it was not.





CONCLUSIONS and FUTURE STUDIES

Lichens can influence soils in a few subtle ways:
- They contribute to maintenance of soil moisture in dry soils.
- They deplete soils of plant available phosphorus, but not when soil phosphate levels are already very low, and not to an extent that forces soil microbes to produce acid phosphatase to access phosphorus from organic compounds. Lichens appear to have no effect on soil nitrogen.
- In some conditions, they provide alternative C sources for soil microbes, so they don't need to access the C from cellulose (leading to a decrease in β -glucosidase activity). I will need to verify this finding, as bare ground had a similar effect as lichens at Brendan Byrne forest, while at Wharton, soils were C-source poor, so microbes non-significantly increased production of β-glucosidase .

My future data will tell me whether the importance of lichens changes with season, and how they influence decomposition overall.

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