How can lichens facilitate the revegetation of mine tailings?

College of Biological Sciences, University of Minnesota Driven to Discover℠

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Context

- 350 x 10^9 tons of mine waste generated annually.[1]
- Mine tailings experience high soil temperatures, low soil moisture, and nitrogen deficiency that make it difficult for plants to establish.[2]
- Lichens grow abundantly on abandoned mine tailings.[3] Do they have a role in restoring this landscape?

Hypotheses

Lichens facilitate the revegetation of mine tailings by…

1) Increasing soil moisture

2) Reducing heat stress

3) Increasing nitrogen availability.

Methods: *Greenhouse Experiment*

- Jack pine seedlings grown in soil and tailings, and a *Stereocaulon* lichen "mulch" addition treatment →
- **Testing Hypothesis 1:** All seedlings undergo a 48h drought treatment, then soil and seedling water content was measured.

Methods: *Field Experiment*

- Site: Abandoned 50-yr old mine tailings at Hill Annex Mine state park, MN, US, with abundant lichens and naturally regenerating jack pine. Selected 84 saplings for experiment.
- Treatment established: lichen removal and lichen addition (Fig. 5, top panel)
- **Testing Hypothesis 2:** Soil temperature measured at each sapling during hottest part of the day.
- **Testing Hypothesis 3:** Buried ion exchange resin bags under each sapling for 15 weeks, then determined concentrations of captured nitrate and ammonium.

Results: *Greenhouse Experiment*

1) Lichens increase soil moisture of mine tailings

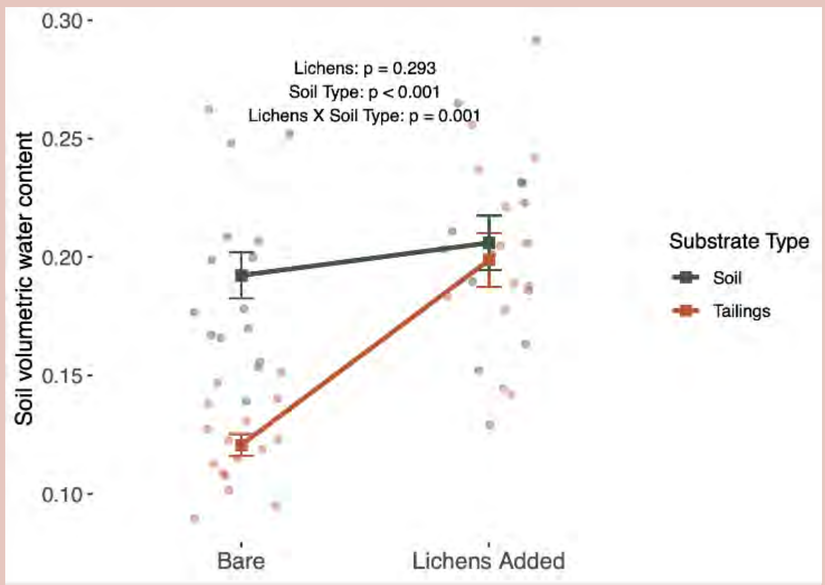

Figure 1. Linear model of soil moisture as a function of lichens with an interaction with soil type. Lichen addition improved water content and retention of mine tailings.

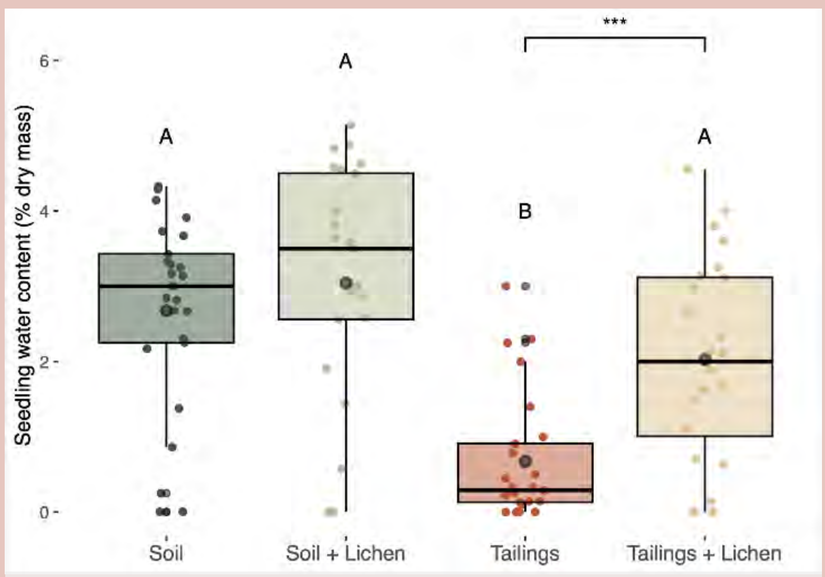

Figure 2. Seedling water content increases with the addition of lichens when grown on tailings after drought treatment (KW: p = 0.0036).

Results: *Field Experiment*

2) Lichens buffer soil temperature of mine tailings

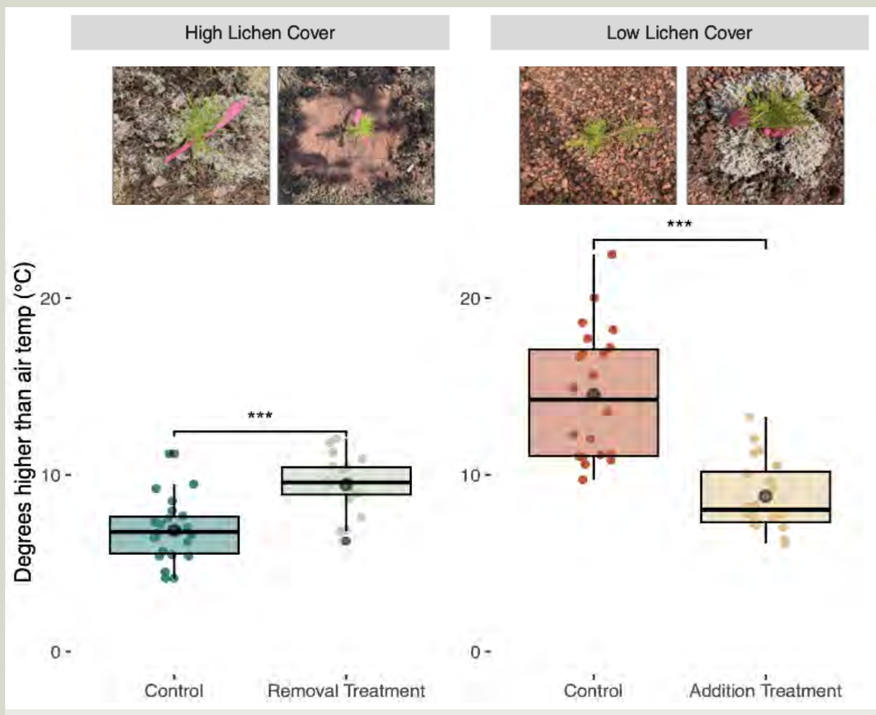

Figure 3. Relative soil temp. on midday, 15/7/23. Lichen removal increased soil temp. (X^2=16, p<0.0001), lichen addition decreased soil temp. (X^2=21, p<0.0001).

3) Lichens intercept nitrogen deposition

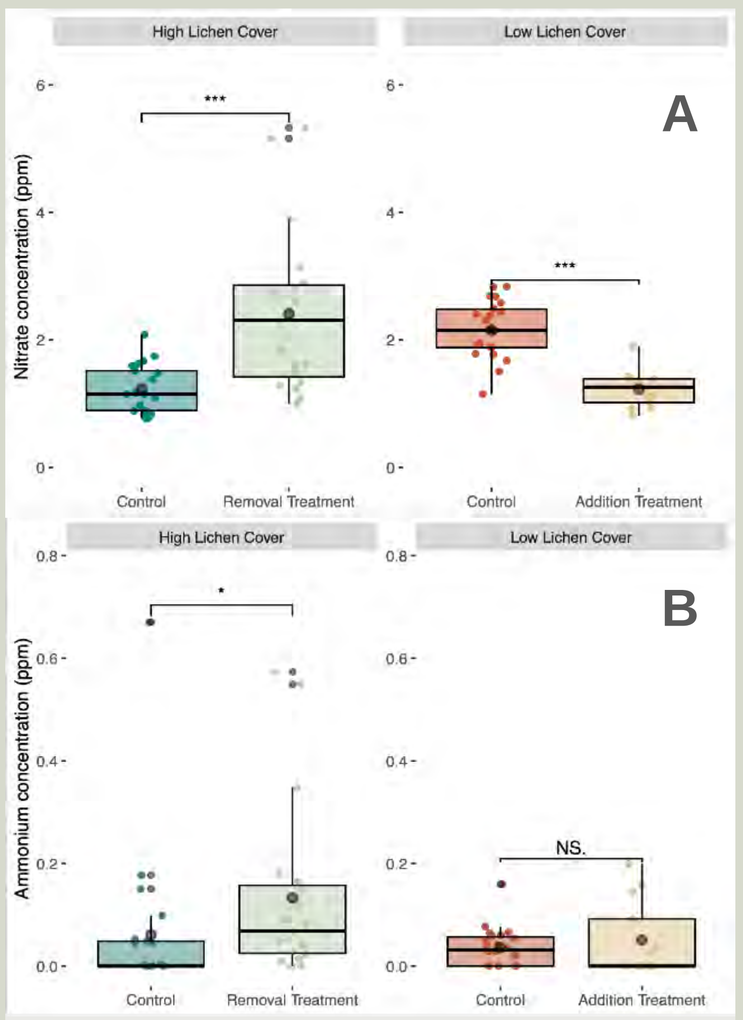

Figure 4. Availability of nitrate (A) and ammonium (B) on mine tailings across treatments. Lichen removal significantly increased nitrate (X^2= 13, p = 0.0003), and ammonium (X^2 = 6.4, p = 0.01168). Lichen addition significantly reduced nitrate (X^2 = 19, p p<0.0001).

Conclusion

Establishing among lichens can help jack pine survive on mine tailings that are prone to drought and heat stress. Though lichens don't immediately increase nitrogen availability, their interception of nitrogen prevents its rapid leaching. Lichens play a significant role in the amelioration of harsh physical conditions of this disrupted ecosystem.

Further directions: How can we incorporate lichens and other biocrust-forming organisms, that are often overlooked, into existing mining restoration practices?

References: 1) Letcher and Valero. (2019). *Academic Press.* 2) Cross, Stevens, et al., (2021). *Plant and Soil.* 3) Osyczka and Rola.(2013). *Open Life Sciences.*

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