Mycorrhizal Networks Inhibit Decomposition in Boreal Bogs

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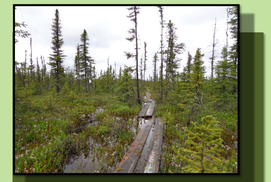


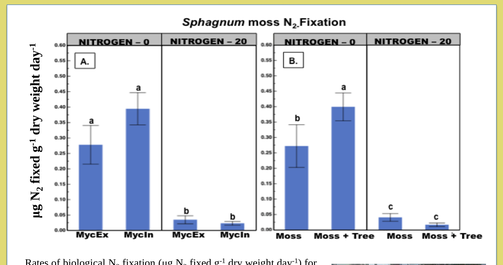
Introduction

- Nitrogen (N) deposition has resulted in the loss of mycorrhizal fungi in diverse sites around the globe.
- Nitrogen (N) enrichment inhibits mycorrhiza formation with fungi specialized in N acquisition, leading to a decline of the symbiosis[1]. The loss of mycorrhizae in peatlands may result in higher rates of decomposition due to the reduction in competition with saprotrophic microbes[2,3,4].
- In order to assess potential repercussions of mycorrhizal decline due to N deposition, I experimentally excluded the networks of mycorrhizal fungi while simultaneously adding N in two pristine boreal bogs in Alberta Canada that differ in age, as determined by the most recent fire.
- *Picea mariana* seedlings were planted in native peat cores and grown *in-situ* from June 2012 through September 2013. Mycorrhizal colonization responses to N fertilization were assessed for peat cores excluded from, and peat cores exposed to, the in-growth of the mycorrhizal network.
- The potential for mycorrhizal fungi to inhibit saprotrophic decomposition, commonly known as the "Gadgil effect," was assessed in this mycorrhizal exclusion experiment in terms of mass loss from peat incubated *in-situ* for two seasons with variable connection to the native bog mycorrhizal network.

Methods

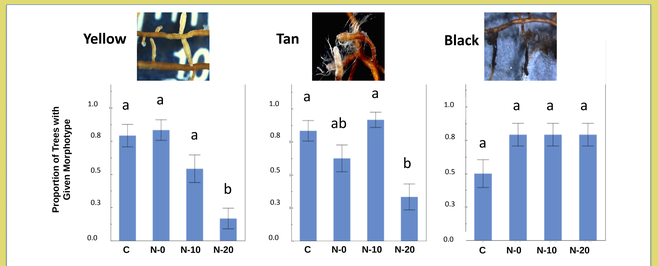
- PVC tubes were wrapped in 1µm nylon filter fabric or window screening to exclude (MycEx) or allow in-growth (MycIn) of the mycorrhizal network
- Each MycIn and MycEx tube (n=5) contained a litter bag at the 10-20 cm depth.
- Litter bags consisted of native *Sphagnum* peat (+ vascular roots) obtained from each bog at the same 10-20 cm depth.
- Homogenized litter was oven-dried to constant mass at 60 ºC, approximately 5 g (pre-weighed dry peat) was then placed into nylon mesh bags.
- Litter bags were incubated in-situ in both the Utikuma (burnt bog) and the Mariana (mature) bog beginning July 2012 and recovered in October of 2012 and September of 2013.
- Nitrogen was added at two rates (0 and 20 kg N $ha^{-1}yr^{-1}$).
- Mycorrhizal colonization was assessed by ectomycorrhizal morphotype according to Agerer[5] (2006).
- Moss associated diazotrophic N_2 fixation was estimated using acetylene reduction assay.

Biological Nitrogen Fixation



Rates of biological N_2 fixation (µg N_2 fixed g^{-1} dry weight day^{-1}) for moss cores from mycorrhizal exclusion (MycEx) and mycorrhizal network in-growth (MycIn) plots (n=5) estimated with acetylene reduction assay at the end of 2 years *in-situ* incubation. Bars that do not share a letter are significantly different bsed on Tukey's HSD a posteriori test after full factorial ANOVA with MycEx/MycIn, nitrogen (N) addition and tree presence as factors. There was an interaction (A.) for N treatment x MycEx/MycIn (p=0.0414) and an interaction (B.) for N treatment x tree presence (p=0.0216).

Morphotype Diversity

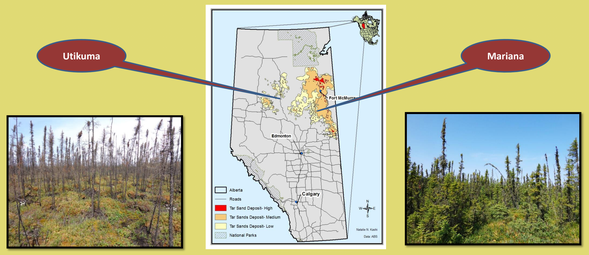


Proportion of trees with the given morphotype[5] (n = 4) from Utikuma nitrogen addition plots. Bars represent mean ± standard error. Bars that do not share a letter are significantly different based on Tukey's HSD a posteriori test after a one way ANOVA. Nitrogen was added at four rates (0 (water only), 10, and 20 kg N ha^{-1} yr^{-1} and control (C). There was no significant effect of nitrogen treatment for "black" type ($p = 0.055$). There were significant effects for "yellow" and "tan" ($p < 0.0001$)

Conclusions

- Results support the hypothesis that mycorrhizal fungi play an important role in both C and N cycling in boreal bogs.
- Increased decomposition resulting from the complete loss of ErM and EcM functionality in peatlands could have a substantial effect on greenhouse gas emissions from these vast stores of organic soils.
- Mycorrhizal fungi are sensitive to N inputs and I show that certain types will decline given high rates of N deposition.
- The nature of the relationship between mycorrhizal fungi and moss associated diazotrophs is still unknown,[6,7] but we do show stimulation of biological N_2-fixation activities due to presence of *P. mariana* seedlings. Further research should be done to determine the nature of this relationship.

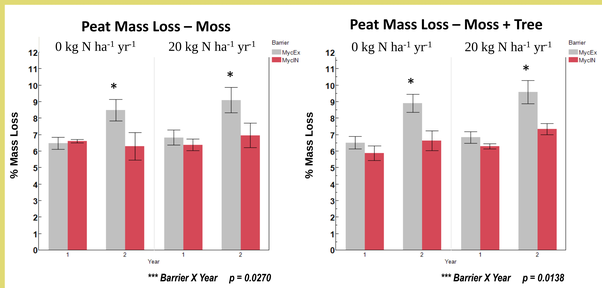
Study Sites



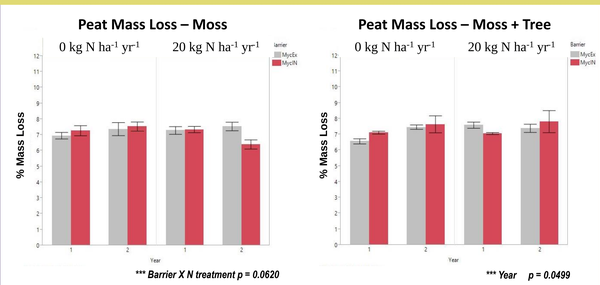
Study sites are pristine bogs located in Alberta, Canada; one near Mariana Lake (55° 57′ N, 112° 1′ W) the other near Utikuma Lake (55° 59' N, 115° 11' W). Mean annual precipitation in Alberta is less than 450 mm. Plots (five replicates, each 3 X 2 m) were set up in the summer of 2012. Sites vary in age, Mariana Lake site, approximately 60-100 years since fire and a Utikuma Lake recently burned was established one year post-fire. Both sites have background deposition of 1.1 to 2.6 kg N ha^{-1} yr^{-1} (Vile and Wieder, *unpublished data*).

Decomposition (% Mass Loss) from Peat in Mycorrhizal Network Exclusion / Nitrogen Addition

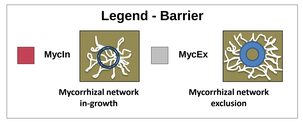
Utikuma Burnt Bog



Mariana Mature Bog



Bars represent % mass loss over 1 and 2 seasons for peat litter (n=5) collected at 10-20 cm depth (including roots) from each of two sites varying in age since fire and fertilized at two levels of N addition (0 and 20 kg N ha^{-1} yr^{-1}). Litter bags were housed in mycorrhizal exclusion (MycEx) and mycorrhizal network in-growth (MycIn) tubes and set out for 1 and 2 years *in-situ* incubation. Error bars are standard error. Bars that do have an asterisk are significantly different from those that do not based on Tukey's HSD a posteriori test after factorial ANOVA with MycEx/MycIn, nitrogen (N) addition and year as factors. Tubes with trees and tubes with only moss were analyzed separately. Interactions are indicated above.



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