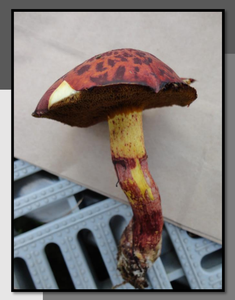
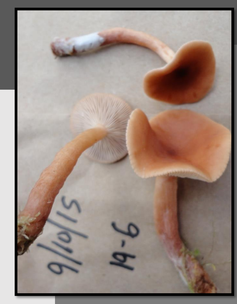
Isotopic Analysis of Ectomycorrhizal Sporocarps Indicates Organic Nitrogen Uptake at SPRUCE





Nathan R. Thorp[1], Dr. Erik A. Hobbie[1], Dr. Kirsten Hofmockel,[2] and Dr. Paul Hanson[3]

[1]Earth Systems Research Center, University of New Hampshire, Durham, NH, [2]Pacific Northwest Laboratories, Richmond, WA [3]Oak Ridge National Laboratory, Oak Ridge, Tennessee

Background

- Peatlands store 1/3 of the world's soil carbon and the fate of this stored carbon under predicted global warming trends and enhanced atmospheric CO_2 concentrations is unknown.
- Nitrogen (N) controls many aspects of ecosystem function and productivity and is therefore tightly linked to carbon cycling. Organic N is an important component of the peatland N budget, but because of difficulties in estimating organic N uptake *in-situ*, rates of organic N uptake remain unclear.
- Here we use an innovative approach to estimate organic N consumption by analyzing ectomycorrhizal sporocarp C and N isotope patterns to estimate responses to elevated CO_2 and warming at the DOE SPRUCE experiment in Northern Minnesota.
- The majority of vascular plants at the SPRUCE bog have symbiotic relationships with fungi. Thus, changes in organic N uptake in response to increased CO_2 and warming may reflect nutrient demands of plants and microbes and their impacts on C cycling.

Hypotheses

- Incorporation of organic N in the form of amino acids into fungal protein results in differential isotopic patterns between the carbon of stipe versus cap versus gill tissues of ectomycorrhizal sporocarps (Figure 1).
- Warming treatments will result in increased N uptake which will be reflected by higher $\delta^{15}N$ and N concentrations of sporocarp tissues.
- Differences between $\delta^{13}C$ of stipes and gills will be greater in sporocarps from warming plots than for those in unheated chambers (Figure 2).

Methods

Sporocarp tissue samples were separated by type (i.e. stipe, cap, and gills) and analyzed for stable isotopes at University of New Hampshire. Future radiocarbon analyses will be done at Lawrence Livermore National Laboratory. Protein content of tissues will be assessed characterized using tissue-specific %N, FTIR and elemental stoichiometry.

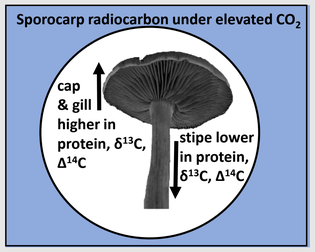


Figure 1. Sporocarp tissue-specific $\delta^{13}C$ and / or $\Delta^{14}C$ patterns

Figure 2. Infrastructure at SPRUCE Climate Change Experiment in Northern Minnesota. Treatments include warming and elevated CO_2 fertilization

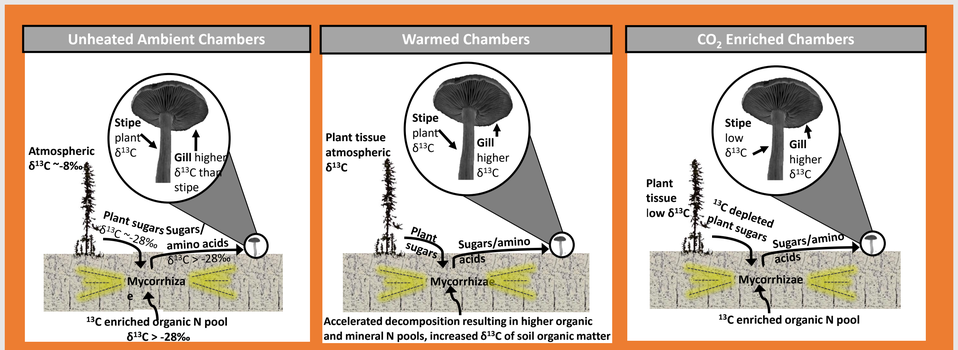


Figure 3. Conceptual diagram of $\delta^{13}C$ distribution in tissues of ectomycorrhizal fungi in unheated ambient versus elevated temperature and CO_2 chambers. Plant sugars will be lower in $\delta^{13}C$ compared to atmospheric $\delta^{13}C$ due to isotopic fractionation against ^{13}C during photosynthesis. Sporocarp structural compounds will be similar to plant $\delta^{13}C$. Gill and cap tissues incorporating soil derived amino acids into fungal protein will have higher $\delta^{13}C$ than stipes. Elevated CO_2 chambers will result in negative $\delta^{13}C$ shifts for all tissues.

Results

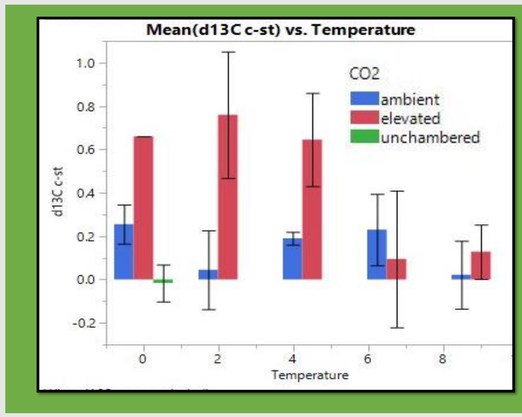


Figure 4. Mean difference (‰) between $\delta^{13}C$ of cap and $\delta^{13}C$ of stipe (d13C c-st) from *Lactarius spp.* ectomycorrhizal sporocarps collected in September 2016 from SPRUCE plots in unchambered (green bars), ambient (blue bars), and elevated (red bars) CO_2 chambers. Bars are means ± standard error.

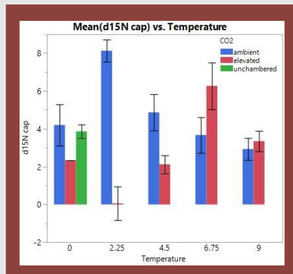


Figure 5. Mean $\delta^{15}N$ of *Lactarius* sporocarp caps collected in 2016 from SPRUCE plots across the heat treatments in unchambered, ambient and elevated CO_2 chambers. Bars represent means ± standard error.

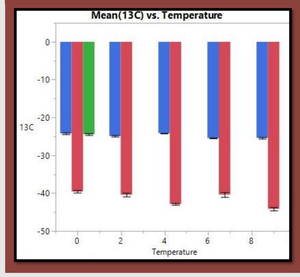


Figure 6. Evidence of plant uptake of fossil fuel-derived CO_2. Mean $\delta^{13}C$ (13C) of *Lactarius* sporocarps collected in 2016 from SPRUCE plots across heat treatments in unchambered (green bars), ambient (bue bars) and elevated (red bars) CO_2 plots. Bars represent means ± standard error.

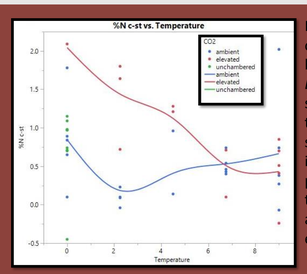


Figure 7. Regression of differences between %N *Lactarius* caps and stipes (%N c-st) and temperature of sporocarps collected in 2016 from SPRUCE plots across heat treatments in ambient and elevated plots.

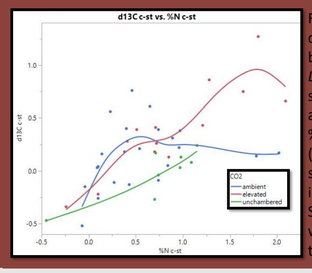


Figure 8. Regression of differences between $\delta^{13}C$ of *Lactarius* caps and stipes (d13C c-st) and differences in %N of cap and stipe (%N c-st) of sporocarps collected in 2016 from SPRUCE plots across warming treatments.

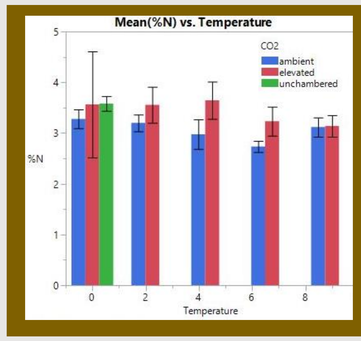


Figure 9. Mean %N of *Lactarius spp.* ectomycorrhizal sporocarps collected in 2016 from ambient (blue), elevated CO_2 (red) and control (green) SPRUCE plots. Peat and air temperatures were increased by 0, 2.25, 4.5, 6.75, or 9 °C over ambient. Bars represent means ± standard error.

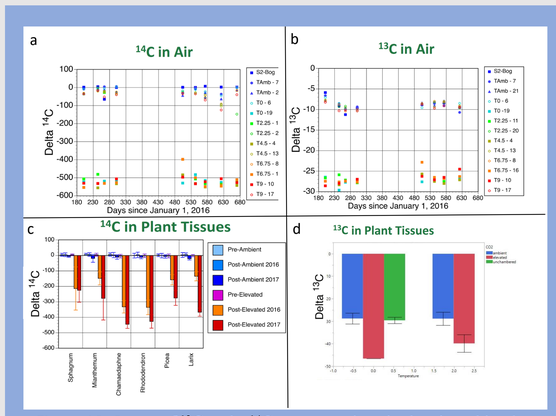


Figure 10. Current $\delta^{13}C$ and $\Delta^{14}C$ concentrations in the air and in plant tissues from SPRUCE experiment (a-c from Hanson et al., unpublished).

Discussion

- In elevated CO_2 treatments, differences between $\delta^{13}C$ of stipes and caps were lower in the warmest plots (Figure 4), indicating a reduced proportion of organic N uptake and potential greater rates of N cycling with warmer temperatures.
- Radiocarbon analysis will compliment these findings by increasing the magnitude of isotopic shifts between protein rich caps and protein poor stipes of sporocarp tissues.

Acknowledgments

This material is supported in part by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research. Oak Ridge National Laboratory Department of Energy under contract DE-AC05-00OR22725. DOE grant ER65430 to Iowa State University also supported this work. We thank John Latimer and Shin Ugawa for assistance during fieldwork and thank Peter Kennedy and Chris Fernandez for supplying additional fungal specimens.