Ectomycorrhizal Fungal Community Change over a Nitrogen Deposition Gradient in Oak Woodlands

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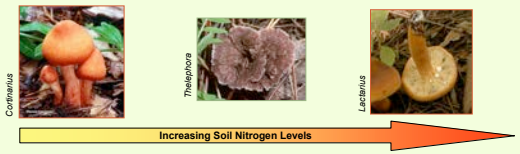
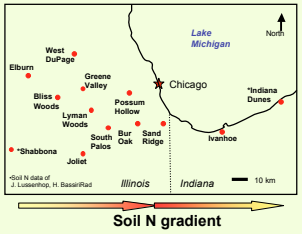
Introduction

- Human sources of nitrogen (N) now rival or exceed the natural inputs of N into many terrestrial ecosystems.
- Anthropogenic N enrichment leads to a cascade of effects, most notably an increasing availability of soil N as nitrate (NO_3), soil acidification, and alterations in plant community productivity and species diversity.
- A clear negative relationship also exists between soil NO_3 content and ectomycorrhizal (EM) mushroom production and diversity, and EM species richness on the roots.
- A key question for plant community function is whether any shifts in EM species composition might correspond to change in mycorrhizal functioning. For example *Cortinarius* species specialize in nutrient uptake under low-N conditions, whereas *Thelephora* functions under high N availability, and *Lactarius* species take up phosphorus (P) in high N or acidic soils.
- *We hypothesized that as soil N availability increased, EM community composition would shift from fungal species that function in low-N conditions towards those species that persist in high N soils.*

Hypothesized scenario



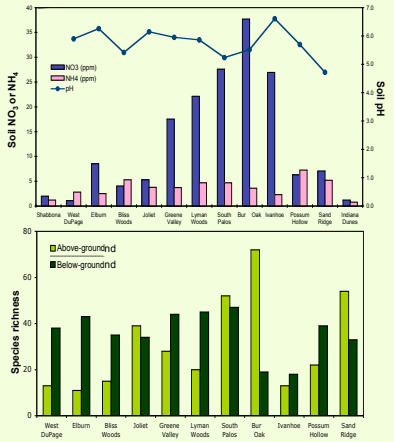


Soil N gradient

Methods

- We surveyed EM communities in 11 oak-maple woodlands in Chicago. These woodlands occur within an anthropogenic N deposition gradient, and are exposed to 5- 16 kg N ha^{-1} per annum that originates from auto emissions and industry as NO_x.
- *Sampling*: sites were sampled every three weeks throughout the growing season in 2003. Soil cores were collected from under 15 randomly selected oak trees at each site and sampling time.
- *Soils* were analyzed for available NO_3 and NH_4 by colorimetric analyses, and pH.
- *Above-ground EM community*: epigeous (mushrooms) and hypogeous (truffles) fruiting bodies were collected, identified to species level, and their abundance recorded in each site.
- *Below-ground EM community*: root samples were washed and typed, based on the color and texture of root tips. DNA was extracted from each morphotype and amplified by PCR (primers ITS1f, ITS4). The amplified ITS-PCR products were digested with two restriction endonucleases (*AluI*, *HinfI*) and fragment patterns were matched against those from known fungal species.

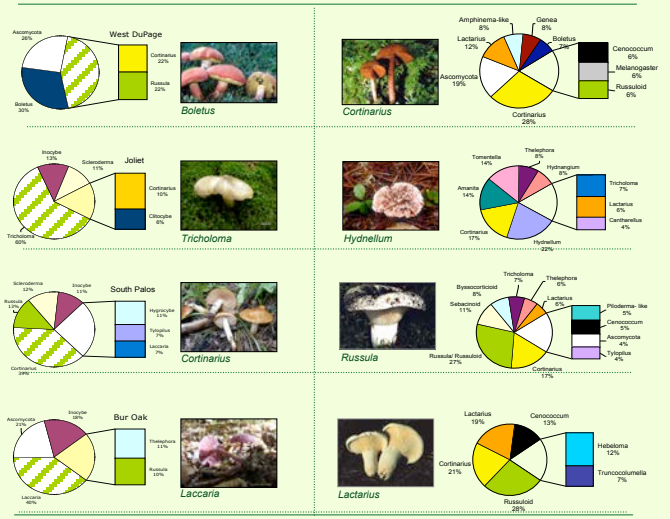
Results



- We confirmed a west-to-east soil N gradient: soil N increased from 3 ppm at Shabbona to 41 ppm at Bur Oak, and then decreased to 3 ppm at the Indiana Dunes. Most N occurred as NO_3.
- Soil pH ranged from 4.7 to 6.6, and was significantly correlated with soil NO_3 levels (r = -0.717, P< 0.05), but not NH_4 (r= -0183. P> 0.05).
- These patterns are consistent with anthropogenic N enrichment (as NO_3) followed by acidification.
- In the above-ground community, species richness increased with increasing input of soil N, especially between Elburn and Bur Oak (P< 0.05).
- Below-ground, there was no relationship between soil N and either species richness or % root tips colonized. At all sites, between 75 to 85% of the oak root tips were colonized by EM.

Results

EM community composition



- We found little concordance between the above- and below-ground mycorrhizal communities in oak woodlands; similar observations have been made previously in other mycorrhizal communities (e.g., Gardes and Bruns 1995).
- Above-ground, the fungal community composition varied greatly among sites. West DuPage (low N) was dominated by N-sensitive *Boletus,* intermediate N sites by *Tricholoma* and *Cortinarius,* and Bur Oak (high N) by nitrophilic *Laccaria*.
- Below-ground, however, there was a shift from a *Cortinarius*-dominated community (West DuPage, low N) to one mainly comprised of *Russula*, *Lactarius* and Russuloid taxa in the higher N soils (South Palos, Bur Oak).

Discussion and Synthesis

The fungal community patterns observed in this study suggest that atmospheric N deposition in oak woodlands may:

- Increase the above-ground species richness as well as the abundance of the nitrophilic *Laccaria*. For such nitrophilic fungi, a high proportion of host carbon is usually allocated towards reproductive, rather than vegetative, structures.
- Alter below-ground community composition. The shift from a *Cortinarius*-dominated (low N soil) to *Russula* and *Lactarius*-dominated community (high N) supports the expectation that different fungal species will dominate in soils with different levels of N. This interpretation is also supported by Lilleskov et al. (2002), who reported an abundance of the Russulaceae in the root community of conifers in high N soils.

Given that each fungal species has a unique functional trait, such changes in EM community composition with N enrichment could have significant consequences for plant community function.

References

Gardes, M., and Bruns, T. 1995. *Canadian Journal of Botany* **74**: 1572- 1583.

Lilleskov, E., Fahey, T., Horton, T., and Lovett, G. 2002. *Ecology* **83**: 104- 115.

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