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Long-term nitrogen fertilization alters nitrogen isotopes and concentrations in ectomycorrhizal fungi, hosts, and soil in pine forests

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To assess how nitrogen (N) availability affected functioning of ectomycorrhizal fungi and interactions among ectomycorrhizal fungi and plants, we measured %N and δ^{15}N in soils, foliage, and nine ectomycorrhizal fungal taxa in six-year (Rosinedalsheden) and 40-year (Norrliden) N addition experiments in *Pinus sylvestris* stands in northern Sweden. The %N of the F horizon correlated strongly with sporocarp %N, reflected nitrogen addition history, and served as a useful proxy for N availability. Both sporocarp %N and soil %N increased with fertilization, implying that nitrogen uptake per unit fungal growth and protein content of sporocarps increased with N fertilization. In addition, foliar %N correlated strongly and positively with foliar δ^{15}N, with both increasing with N additions. Our prior growth chamber studies indicated that this positive relationship is related to declines in carbon allocation to ectomycorrhizal fungi at high N availabilities. Thus, we suggest that δ^{15}N in ectomycorrhizal *Pinus* can be used as a proxy for carbon allocation patterns to ectomycorrhizal fungi and a useful indicator of the extent of alteration of plant-fungal interactions across N availability gradients.

Patterns in fungal and soil δ^{15}N across the two sites suggested that N acquisition was primarily from the H horizon for *Cortinarius traganus* and *Russula aeruginea*, from the S horizon for *Lactarius rufus* and *Paxillus involutus*, and from the F horizon for the other five taxa. Higher ^{15}N enrichments in *Cortinarius semisanguineus*, *Suillus variegatus*, and *Paxillus involutus* relative to source N with increased N availability suggested enhanced transfer of N to plants (higher transfer ratios), whereas other taxa did not change transfer patterns.