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Flux Chamber and Metagenomic Studies Provide Insights into Biogeochemical Mechanisms of Reactive Nitrogen Cycling in Soils of Mixed Hardwood Forests

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In terrestrial ecosystems, nitrogen (N) cycle processes play a crucial role in regulating the overall abundance of oxidized inorganic nitrogen and are responsible for initiating the subsequent loss of soil N via volatilization and leaching. Rates of nitrification and denitrification, pool sizes of nitrite and nitrate (NO_2^-+ NO_3^-), and oxygen availability have been shown to be major determining factors in soil emissions of nitrogenous gases such as nitric oxide (NO) and nitrous oxide (N_2O). We investigated these factors in the context of two different mixed hardwood stand-types typically found throughout the Midwestern USA. Stand-type differentiation was based on whether plots were either dominated by trees that associate with arbuscular mycorrhizal fungi (AM) or ectomycorrhizal fungi (ECM). Metagenomic analyses revealed significant differences in the estimated copy numbers of N cycle genes, with AM soils possessing significantly greater copy numbers relative to ECM soil. Furthermore, the largest fluxes of N_2O and NO were observed under anaerobic conditions from AM soil. Additionally, AM soils possessed significantly larger pools of NO_2^- + NO_3^- and more transcript copies of key nitrification and denitrification genes. We also find that when ECM soil is spiked with NO_2^-, N_2O production and denitrification transcript numbers rapidly increase. Together, these results indicate that anaerobic conditions in AM soil result in a significant loss of oxidized aqueous nitrogen via volatilization, and nitrogenous gas production in ECM soil is inherently limited by small pool sizes of NO_2^- + NO_3^-. At the ecosystem level, AM tree species have been encroaching rapidly into ECM-dominated forests throughout the Midwest (U.S.A). This change in tree species composition may significantly reorganize the soil microbial community leading to an increase the amount of nitrogen oxides being emitted from these ecosystems.