Fire presence affects patterns and controls on asymbiotic nitrogen fixation in seasonally flooded forests of southern Amazonia

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Key Points:

- Asymbiotic dinitrogen-N_2 fixation (ANF) was quantified for the first time in seasonally flooded forests at the Amazon–Cerrado transition.
- ANF rates in fire-disturbed forest soils (0–10 cm) were ~24% lower than in unburned soils.
- Our data indicate that interactions between soil C:N:P stoichiometry, fire history and ANF affect SF ecosystems in a predictable way.

Abstract

In this study, we focus on the biogeochemical consequences of fire on seasonally flooded (SF) forests of southern Brazilian Amazonia, where recent widespread rising tree mortality has been linked to changes in fire regimes. Recent studies have hypothesized that a quasi-permanent state-shift transition (from typical Amazon forests to open savannas) can occur when fire results in further depletion of already impoverished nutrient pools. Nitrogen (N) inputs via asymbiotic dinitrogen-N_2 fixation (ANF) could be important for

predicting the likelihood of post-fire forest recovery, but fire effects on ANF have yet to be quantified in this region. Here, we quantified ANF through combined field sampling and laboratory measurements using ^{15}N-labeled dinitrogen ($^{15}N_2$) incubations, and quantified 14 biogeochemical parameters in surface (0–10 cm) and subsurface (10–30 cm) soils from burned and unburned areas within five SF forest stands selected to represent a gradient of fire disturbance, from low (once in 13 years) to high (five times in 13 years) frequency. We find that ANF rates are ~24% lower in burned relative to unburned surface soils, with over 50% of the variance in ANF explained by soil carbon (C) to N ratio and phosphorus (P) availability. Our data indicate that interactions between soil C:N:P stoichiometry and fire presence affect ANF in a predictable way. Taken together, these findings show that changes in soil carbon and nutrients explain a decrease in ANF with potential for long-term decline in C sequestration from altered successional trajectories in forest ecosystems of southern Amazonia.

Keywords: Climate change, disturbance, drought, free-living diazotroph, stoichiometry, tropical soils.

Plain Language Summary

The role of nutrient limitation on the resiliency of tropical forests to fire is still poorly understood. In this study, we quantify several different inputs and pools of nutrients that are important for post-fire forest recovery in forest stands that are part of long-term ecological research to better our knowledge of soil-plant interrelationships under fire disturbance. We find that fire can decrease the input of macronutrients such as nitrogen and change the relationships between pools of elements such as carbon and phosphorus. Our findings suggest that a decrease in nitrogen inputs can have long-term consequences for post-fire recovery of seasonally flooded forests in southern Amazonia.