Nitrogen partitioning and tree grass coexistence in savannas

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Abstract

Coexistence between trees and grasses in savannas is generally assumed to be due to a combination of partial niche separation for water acquisition and disturbances impacting the demography of trees and grasses. We propose a mechanism of coexistence solely based on the partitioning of the two dominant forms of mineral nitrogen (N), ammonium (NH4+) and nitrate (NO3-). We built a mean-field model taking into account the capacity of grasses and trees to alter nitrification fluxes as well as their relative preferences for NH4+ versus NO3-. Two models were studied and parameterized for the Lamto savanna (Côte d'Ivoire): a first where nitrification only depends on the quantity of available NH4+ and a second where nitrification rate is also controlled by tree and grass biomass. Consistently with coexistence theories, our results show that taking these two forms of mineral N into account may allow coexistence when trees and grasses have contrasted preferences for NH4+ and NO3-. Moreover, coexistence is more likely to occur for intermediate nitrification rates. Assuming that grasses are able to inhibit nitrification while trees can stimulate it, as observed in the Lamto savanna, the most realistic case of coexistence would be when grasses prefer NH4+ while trees prefer NO3-. Mineral N partitioning is thus a stabilizing coexistence mechanism that would act in interaction with already described mechanisms based on disturbances by fire and herbivores. This mechanism virtually applies to all African savannas where grasses have nitrification inhibition habilities but should be thoroughly tested through empirical studies and new models taking into account spatial heterogeneity in nitrification rates.

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