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Effects of Savanna trees on soil nutrient limitation and carbon-sequestration potential in dry season

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Semi-arid savannah ecosystems are under strong pressure from climate and land-use changes, especially around populous areas like Mt. Kilimanjaro region. Savannah vegetation consists of grassland with isolated trees and is therefore characterized by high spatial variation of canopy cover and aboveground biomass. Both are major regulators for soil ecological parameters and soil-atmospheric trace gas exchange (CO_2, N2O, CH4), especially in water limited environments. The spatial distribution of these parameters and the connection between above and belowground processes are important to understand and predict ecosystem changes and estimate its vulnerability.
Our objective was to determine spatial trends and changes of soil parameters and trace-gas fluxes and relate their variability to the vegetation structure. We chose three trees from each of the two most dominant species (Acacia nilotica and Balanites aegyptiaca). For each tree, we selected transects with total nine sampling points under and outside the crown. At each sampling point we measured soil and plant biomass carbon (C) and nitrogen (N) content, δ13C, microbial biomass C and N, soil respiration, available nutrients, pH, cation exchange capacity (CEC) as well as belowground biomass, soil temperature and soil water content.
Contents and stocks of C and N fractions, Ca2+, K+ and total CEC decreased up to 50% outside the crown. This was unaffected by the tree species, tree size or other tree characteristics. Water content was below the permanent wilting point and independent from tree cover. In all cases tree litter inputs had far a closer C:N ratio than C4-grass litter. Microbial C:N ratio and CO_2 efflux was about 30% higher in open area and strongly dependent on mineral N availability. This indicates N limitation and low microbial C use efficiency in soil under open area. We conclude that the spatial structure of aboveground biomass in savanna ecosystems leads to a spatial redistribution of nutrient limitation and thus in C mineralization and sequestration. The effects on soil respiration are present, even under strong water scarcity. Therefore, the capability of a savanna ecosystem to act as a C sink during dry season is mainly (directly and indirectly) dependent on the spatial abundance of trees.