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Vegetation cover and physiognomy effects on C and N in frequently burnt and unburnt soils in an African savanna

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Abstract

Fires are a common phenomenon which affects many terrestrial ecosystems. It drives ecosystem composition and structure, rendering numerous ecosystems dependent on fires for maintaining their health and functioning. Although an important process, fires are found to lead to substantial impacts on soil nutrients around the world. However, disentangling the direct effect of fires on soil nutrients versus the indirect effect via fire-induced changes in vegetation, is not often considered. Previous studies focused only under tree canopies and open areas, thus neglecting the role of shrubs (a dominant landscape vegetation type) in nutrient dynamics in burnt and unburnt sites. Therefore, we used a long-term fire experiment in a large African savanna park to investigate the effect of fire on soil total carbon (C) and nitrogen (N) under trees, open areas as well as shrubs. Soil samples (0 - 5 cm) were collected from soils burnt annually and soils which have remained unburnt for >65 years. Our results suggest that tree and shrub canopies enrich soil C and N compared to open grassy areas. In unburnt soils, mean total N under tree and shrub canopies are up to five times the concentrations of N in soils in open areas (0.07%, 0.05% and 0.015%, respectively). However, annual fires appear to homogenize N concentrations across the burned plot regardless of the vegetation type. Although not statistically significant ($p>0.05$), in unburnt areas, mean soil C concentrations in open grassy areas are lower compared to C concentrations below tree canopies. Even when burnt, soils below trees and shrubs still maintain higher concentrations of C. Elevated soil C and N under trees and shrubs could be due to leaf fall and decomposition below canopies, herbivores congregating below trees depositing faeces and urine, and a pull-effect by tree and shrub roots pulling nutrients closer towards the canopy. These results are important if one considers the broader ecological impact of bush thickening and fire exclusion on the enrichment of soil C and N, with cascading effects on other ecological processes and dynamics.

Keywords: experimental fires, soil nutrients, vegetation structure