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DEPARTMENT OF BIOLOGICAL AND ENVIRONMENTAL SCIENCES

Carbon and Nutrient Cycling in Afromontane Tropical Forests at Different Successional Stages

Brigitte Nyirambangutse

Department of Biological and Environmental Sciences
Faculty of Sciences

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Abstract

To date, studies of the carbon and nutrient cycling in tropical montane forests have been restricted to a few, mostly neotropical, sites. This thesis investigated the carbon and nutrient cycling of early (ES) and late (LS) successional forest stands in Nyungwe forest, one of Africa's largest remaining tropical montane forests. The stocks and fluxes of carbon and nutrients, as well as the factors controlling these, were studied in 15 new forest plots established within this PhD project.

Paper I explored forest carbon dynamics and demonstrated that Afromontane tropical forests contain large amounts of carbon, with the carbon stocks of LS stands being higher than those reported for tropical montane LS forests in South Asia and Central and South America. The total C stock was 35% higher in LS compared to ES stands due to significantly larger aboveground biomass (AGB), but productivity did not differ between the two successional stages. Differences in species composition and stem properties (wood density, heigh:diameter relationship) explained the differences in AGB between ES and LS forest stands.

Paper II investigated canopy nutrient cycling. It was found that neither leaf nutrient concentrations (exception: K) nor nutrient resorption efficiencies during senescence differed between ES and LS species. Furthermore, total leaf litterfall and its content of C, N, P and K did not differ between ES and LS stands. Mean resorption efficiencies of N (37%), P (48%) and K (46%) were much higher than for other nutrients. Nutrient resorption efficiency exhibited a very large interspecific variation which was not related to the leaf concentration of the respective element. High leaf N concentrations, intermediate N:P ratios, and low resorption efficiencies compared to values reported for other TMF together indicate high fertility and likely co-limitation by N and P in this forest.

Paper III showed that interspecific variation in photosynthetic capacity among tropical montane trees was related to within-leaf N allocation rather than to total area-based leaf N content. While ES species had higher photosynthetic capacity (+58 to +67 %), dark respiration (+41%) and photosynthetic quantum yield (+38%) than late-successional species, the two groups did not significantly differ in total leaf N content, chlorophyll content or leaf mass per unit area.

In Paper IV investigated the spatial and temporal variation in soil CO2 efflux and found that the daytime variation correlated with soil temperature (Ts) while the nighttime variation did not. Spatial variation in soil CO2 efflux was strongly related to soil carbon and nitrogen content.

The results demonstrate that Nyungwe montane rainforest contains large amounts of carbon (especially in LS stands) and have high productivity. The thesis also shows that accounting for the effects of forest disturbance on stand structure, especially species composition, substantially improves the estimations of carbon stocks. Furthermore, it contributes to the understanding of these forests by elucidating which factors that control tree growth, photosynthetic capacity and soil CO2 efflux. The findings of this thesis contribute to reducing a large knowledge gap regarding the carbon and nutrient stocks and dynamics of African tropical montane forests at different successional stages.

Keywords: Tropical montane forest, Africa, Nyungwe, Successional stage, Carbon stock, Net primary production, Photosynthesis, Soil CO2 efflux, Nutrient cycling