DOCTORAL THESIS

Carbon stock and fluxes in Nyungwe forest and Ruhande Arboretum in Rwanda

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ABSTRACT

Conservation and sequestration of carbon in forest ecosystems are potential strategies to reduce or stabilize the atmospheric greenhouse gas concentrations and mitigate climate change. Estimating the degree to which forest ecosystems may achieve that function requires continuous measurements of forest carbon stocks and fluxes from all over the world. The aim of this thesis was to collect quantitative data on climate, carbon stocks, annual carbon increment, litter production, and soil CO_2 effluxes in Ruhande Arboretum, a plantation of both non-native and native tree species, and Nyungwe forest, a national park of afromontane tropical forest vegetation, both situated in Rwanda. The annual mean air temperature at the Ruhande Arboretum (19 ºC) was higher than in the Nyungwe forest (14.4 ºC), but both sites showed small seasonal variation in air temperature and Nyungwe forest received a higher monthly precipitation than the Ruhande Arboretum. The carbon stocks were dominated by above-ground biomass in both forests which was 70% in the Ruhande Arboretum and 57% in the Nyungwe forest. The annual litter production was 3.4 Mg C ha^{-1} yr^{-1}, and followed a seasonal pattern. The mean annual soil CO_2 efflux was 13.5 Mg C ha^{-1} yr^{-1} in the Ruhande Arboretum and 10.2 Mg C ha^{-1} yr^{-1} in the Nyungwe forest. No significant effect by the species on soil CO_2 efflux was observed. The seasonal variation in soil CO_2 efflux was strongly influenced by precipitation patterns and soil water content. Diurnal variation of soil CO_2 efflux was bimodal and described a hysteresis relationship with soil temperature. Although, the daytime soil CO_2 efflux correlated with soil temperature, the most of diurnal pattern was most likely affected by the supply of photosynthetic products to the roots. Spatial variation of soil CO_2 efflux was mainly correlated to soil C and N stocks. The observed spatial, seasonal and annual soil CO_2 effluxes were comparable to those observed in other tropical forests. This study should be replicated in other forests and in other land cover types in Rwanda, which can help to calculate a carbon balance for Rwanda.

Keywords: Carbon stock; Litterfall production; Soil CO_2 efflux or soil respiration; Soil temperature; Soil water content; Spatial variation; Seasonal and diurnal variations.