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Carbon stocks in a miombo woodland landscape: spatial distribution and controls

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Carbon accounting in terrestrial ecosystems has received increased attention in light of recent global climate change and the consequent development of international treaties and emissions trading schemes. Despite being the second largest continent on earth, knowledge on Africa's carbon stocks is limited. The most common savanna type in sub-Saharan Africa is miombo woodland, which covers 2.7 million km^2 of southern, central and eastern Africa, and is relatively understudied compared to other biomes. To increase our understanding of the distributions of vegetation and soil C stocks in miombo woodlands we conducted a field study in a miombo woodland landscape in central Mozambique. Our objective was to determine how vegetation and soil carbon stocks are distributed in a miombo woodland landscape, and to asses what controls the vegetation and soil C stock distributions. To address the lack of landscape scale studies on spatial variability of carbon stocks in miombo woodland we sampled along a 5km transect, using a cyclic sampling scheme to allow geostatistical analyses of the data. We sampled multiple variables such as soil C stocks at two depths (0.05 and 0.30 m), soil texture, above-ground biomass C stocks, litter and altitude simultaneously along the transect. Soil C stocks (9-22 Mg C ha^{-1} and 29-79 Mg C ha^{-1} in the top 0.05 m and 0.3 m respectively) and above-ground biomass C stocks (8-42 Mg C ha^{-1}) varied significantly at short distance intervals, reflecting the inherent high heterogeneity of the miombo woodland landscapes. 70% of above-ground biomass C stocks were found in large trees (diameter at breast height > 30 cm). Geostatistical analyses revealed spatial autocorrelations at short distances for soil C stocks (< 15 m and < 31 m in the top 0.05 m and 0.3 m respectively), and at larger distances for above ground biomass C stocks. Soil C stocks in the top 0.05 m were significantly correlated to altitude (r^2=0.33), as was large-tree above-ground biomass C stocks (r^2=0.70). Deeper soil C stocks at 0.3 m were significantly correlated to soil clay content (r^2=0.38), and soil clay content was negatively correlated to altitude (r^2=-0.54). High values of large-tree above-ground biomass and surface-soil C stocks are found on ridges and at higher altitudes, where soils are better drained. Opposite to this, deeper-soil C stocks are larger in areas with higher soil clay content, such as in seasonally water logged soils (dambos) found in low lying areas. The distribution of soil and vegetation carbon stocks in miombo woodland is controlled by micro relief and resultant distributions of soil textural properties and vegetation. The strong correlation found between micro-relief and above-ground biomass could be used in remote sensing studies to estimate biomass C stocks on regional scales in miombo woodlands, although an altitudinal resolution of less than 10 m would be necessary. Management of C stocks in miombo woodlands should consider conserving areas with large trees on ridge tops and low lying dambos.