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Carbon dynamics in aboveground coarse wood biomass of floodplain forests in central Amazonia

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Tropical forests store large amounts of carbon in the aboveground coarse wood biomass (AGWB), but uncertainty remains regarding their function as significant carbon sinks due to gaps in understanding forest dynamics. This aspect has increased the number of studies monitoring changes in AGWB in the Amazon basin. The aims of these studies include obtaining data on C-sequestration and its relation to environmental parameters and responses to climate change. However, most of these studies have been carried out in non-flooded terra firme forests. In the Amazon basin two main types of floodplains along the large rivers can be distinguished by the characteristics of the flood-water and their flooding regime: the nutrient-poor black-water floodplains (igapó) and the nutrient-rich white-water floodplains (várzea). In this study we estimate C-stocks and C-sequestration in the AGWB of floodplain forests of the várzea and igapó of central Amazonia. Inventory data of 7 ha representing forests of different successional stages growing under varying nutrient status were converted to predictions of AGWB by allometric models using diameter at breast height (DBH), wood density and tree height as independent variables. Carbon sequestration was estimate by growth models based on tree-ring analyses which is a new approach in tropical forest research. Therefore age-DBH and DBH-height relationships by non-linear regression models were modeled. C-stocks (50% of AGWB) varies between 90-115 Mg C/ha in the nutrient-poor igapó floodplain forests and 8-120 Mg C/ha in the nutrient-rich várzea floodplain forests. C-sequestration in AGWB in the central Amazonian várzea (2.7-8.5 Mg C/ha/year) is much higher than igapó (1.2-2.0 Mg C/ha/year). C-sequestration in the AGWB of terra firme forests, however, is only 41–53% of that in the várzea. High C-storages and low C-sequestration rates in the AGWB of terra firme forests result in low C-turnover rates of 56–80 years. In the várzea floodplain forests, the mean C-turnover rate (mean residence time of C) in the AGWB is only 25.9 years. The results indicate that C-dynamics of AGWB vary considerably between floodplain forests depending on the nutrient status, the hydrological regime and the successional stage.

Ring-width indices of tree species from the floodplain forests of central Amazonia correlate significantly with the length of the terrestrial phase. Thus, the yearly oscillation in ring width captures the interannual variation in the length of the terrestrial phase. During El Niño years, basin-wide negative rainfall anomalies generally occur, leading to a weakened flood-pulse and an extension of the terrestrial phase. Trees in the central Amazonian floodplains respond to these anomalies by a significant increase in growth. In the adjacent non-flooded terra firme forests, however, tree growth is correlated with precipitation patterns. Tree-ring chronologies of tree species from central Amazonian terra firme forests correlate significantly with rainfall. The opposing climate-growth relationship between terra firme and várzea is important in the context of the interannual variation of carbon sequestration in the AGWB of adjacent Amazonian forests. The drier and warmer climate conditions during an El Niño cause a decrease in soil moisture in terra firme forests and thus reduced photosynthesis, increased heterotrophic respiration rates, and a lower net primary production. Therefore, most parts of terra firme forests act as carbon sources during an El Niño event, as suggested by biogeochemical models. Floodplain forests, however, sequester part of the climate-induced carbon emissions of terra firme forests.