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Diminishing soil carbon stocks caused by the land-use change from secondary forests to terraced rubber plantations

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Conversion from forest to rubber plantations (Hevea Brasiliensis) is an important recent land-use change in the Upper Mekong Region in Southeast Asia, for which the impacts on soil carbon stocks have hardly been studied. Due to the mountainous topography most of the established rubber plantations include narrow terraces. Terrace bench construction involves redistribution of the soil within the plantations. The objectives of our study in Xishuangbanna prefecture, Yunnan province, China were: to quantify the changes in soil carbon stocks (1) upon the conversion from secondary forest to rubber plantations, and (2) induced by terrace bench construction.
We selected seven randomly selected clusters. Each cluster contained between one and three rubber plantations and one secondary forest which was the immediate reference land-use type. In total, there were 11 rubber plantations ranging in age from 5 to 46 years. In each land-use type, we measured soil carbon stock from a 20-m x 20-m plot down to 1.2-m depth. To gain insight into the effects of terracing, we additionally sampled the terrace benches in three rubber plantations aged 5, 29 and 44 years. In each plantation, six transect were positioned perpendicularly to terrace benches. Each transect consisted of 4 sampling points on the terrace bench and one sampling point on the undisturbed terrace riser, the latter is our reference position.
All rubber plantations had lower soil carbon stocks than the forests with a mean difference of 37.4 Mg C ha-1 in the entire 1.2-m depth, which equals a 19% loss of the initial soil carbon stock. Strongest decrease was found in the top 0.15-m of the soil, exhibiting a mean loss of 27%. In the topsoil the soil carbon stock declined exponentially with years since land-use conversion and reached a steady state after $\sim$20 years. The soil carbon losses observed in this study are much larger than published estimates on changes in aboveground carbon stocks. Results from the terracing case study indicate that the observed soil carbon losses could not be explained by terrace bench construction. In the two oldest plantations we even observed slightly higher soil carbon stocks on the terrace benches compared to the reference position. Comparisons of the sampling points on the terrace bench with the reference position indicated that topsoil removal at the inner side of the terrace benches caused an initial decrease in the soil carbon stock followed by a net gain in soil carbon stock in the two oldest plantations. Our study shows that the conversion from secondary forests to rubber plantation leads to a large decrease in the soil carbon stocks; this implies that not accounting for soil carbon changes may cause a large error in the estimates of total ecosystem carbon fluxes arising from land-use changes.