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Carbon stocks and fluxes in managed peatlands in northern Borneo

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Oil palm is the largest agricultural crop in the tropics and accounts for 13 % of current tropical land area. Patterns of land-atmosphere exchange from oil palm ecosystems therefore have potentially important implications for regional and global C budgets due to the large scale of land conversion. This is particularly true for oil palm plantations on peat because of the large C stocks held by tropical peat soils that are potential sensitivity to human disturbance. Here we report preliminary findings on C stocks and fluxes from a long-term, multi-scale project in Sarawak, Malaysia that aims to quantify the impacts of oil palm conversion on C and greenhouse gas fluxes from oil palm recently established on peat. Land-atmosphere fluxes were determined using a combination of top-down and bottom-up methods (eddy covariance, canopy/stem and soil flux measurements, net primary productivity). Fluvial fluxes were determined by quantifying rates of dissolved and particulate organic C export. Ecosystem C dynamics were determined using the intensive C plot method, which quantified all major C stocks and fluxes, including plant and soil stocks, leaf litterfall, aboveground biomass production, root production, stem/canopy respiration, root-rhizosphere respiration, and heterotrophic soil respiration. Preliminary analysis indicates that vegetative aboveground biomass in these 7 year old plantations was 8.9-11.9 Mg C ha^{-1}, or approximately one-quarter of adjacent secondary forest. Belowground biomass was 5.6-6.5 Mg C ha^{-1}; on par with secondary forests. Soil C stocks in the 0-30 cm depth was 233.1-240.8 Mg C ha^{-1}, or 32-36% greater than soil C stocks in secondary forests at the same depth (176.8 Mg C ha^{-1}). Estimates of vegetative aboveground and belowground net primary productivity were 1.3-1.7 Mg C ha^{-1} yr^{-1} and 0.8-0.9 Mg C ha^{-1} yr^{-1}, respectively. Fruit brunch production was approximately 67 Mg C ha^{-1}over 7 yearsor 9.6 Mg C ha^{-1} yr^{-1}. Total soil respiration rates were 18 Mg C ha^{-1} yr^{-1}, with 26 % accounted for by root-rhizosphere respiration and 74 % from heterotrophic soil respiration. This translates to a peat mineralization rate of 10 to 17 Mg C ha^{-1} yr^{-1} in the upper 35 cm soil depth above the water table. Fluvial C fluxes were 1.9 Mg C ha^{-1}yr^{-1}, or roughly three times the flux from secondary forest. Findings from the partitioned soil respiration and fluvial flux measurements indicate that peat mineralization may be occurring. However, it is unclear if this represents a net loss of C from the ecosystem, due to the apparent increase in soil C stocks following land conversion, rather than an expected net reduction in soil C. This unexpected finding implies that other processes may be offsetting C losses from heterotrophic decay and fluvial exchange.