

Carbon dioxide balance of tropical peat ecosystems

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Tropical peatlands, which are widely distributed on lowlands in Southeast Asia, have accumulated a huge amount of soil carbon under peat swamp forests over millennia. However, the carbon pool is presently disturbed on a large scale by land development and management, and consequently has become vulnerable. Peat degradation occurs most rapidly and massively in Indonesia, because of fires, drainage and deforestation of swamp forests. Peat fires release carbon dioxide (CO₂) through peat combustion intensively but occasionally, whereas drainage increases CO₂ emission steadily through the acceleration of oxidative peat decomposition. Therefore, tropical peatlands present the threat of switching from a carbon sink to a carbon source to the atmosphere. However, the ecosystem-scale CO₂ exchange is still unknown in tropical peatlands. A long-term field experiment in Central Kalimantan, Indonesia showed that tropical peat ecosystems, including a relatively intact peat swamp forest with little drainage (UF), a drained swamp forest (DF) and a drained burnt area (DB, a former swamp forest), functioned as net carbon sources. Mean annual net ecosystem CO₂ exchange (NEE) (with a standard deviation) for four years from July 2004 to July 2008 was 174 with 203, 328 with 204 and 499 with 72 gC m⁻² y⁻¹, respectively, for the UF, DF and DB sites. The carbon emissions increased according to disturbance degrees. We found that the carbon balance of each ecosystem was chiefly controlled by groundwater level (GWL). The NEE showed a linear relationship with GWL on an annual basis. The relationships suggest that GWL lowering of every 0.1 m causes additional net annual CO₂ emissions of 79-238 gC m⁻² probably because of the enhancement of oxidative peat decomposition. In addition, CO₂ uptake by vegetation photosynthesis was reduced by shading due to dense smoke from peat fires ignited accidentally or for agricultural practices. Our results may indicate that tropical peatland ecosystems are no longer a carbon sink under the pressure of human activities.

Keywords: drainage, draught, eddy covariance technique, ENSO, fire