学 位 論 文 内 容 の 要 旨

博士の専攻分野名称：博士（農学）　　氏名：Frankie Kiew

学位論文題名

Effect of forest conversion to oil palm plantations on carbon dioxide balance in tropical peatlands

熱帯泥炭林のオイルパームプランテーションへの土地利用変化が二酸化炭素収支に与える影響

Over millennia, tropical peat swamp forest (PSF) has stored a large amount of carbon (C) both in biomass and soil. Currently, however, this C-rich ecosystem is exposed to disturbances related to land-use change. For example, the large distribution of PSF in southeast Asia chiefly in Indonesia and Malaysia has been affected by the rapid expansion of oil palm plantations (OPP). Other than significant changes in vegetation, plantations need drainage for lowering groundwater level (GWL) to keep better palm growth and potentially enhances oxidative peat decomposition. In order to understand the environmental impact of OPP from the view point of global warming, it is crucial to assess the change of carbon dioxide (CO_2) balance through the PSF conversion. To date, however, no study has reported the net ecosystem CO_2 exchange (NEE) of OPP established on peat. The objectives of this study are: (a) to monitor NEE of a PSF and an OPP in Sarawak, Malaysia by the eddy covariance technique, (b) to investigate the controlling factors of CO_2 fluxes, and (c) to quantify the annual CO_2 balances of the two sites and compare them to discuss the effect of the land-use change on ecosystem CO_2 balance.

1. Carbon dioxide fluxes above a peat swamp forest.

NEE has been measured above a relatively drained secondary PSF since 2010. NEE was partitioned into respiration (RE) and photosynthesis (GPP) using an empirical method. RE differ significantly in the dry and wet periods ($p < 0.01$). However, no significant difference was found in GPP. Thus, the seasonal difference in NEE (0.52 g C m^{-2} d^{-1}) was mainly attributable to that in RE (0.57 g C m^{-2} d^{-1}). Lower GWL in the

dry period was the main cause for greater RE, because lower GWL enhances peat aeration and potentially increases oxidative peat decomposition. Mean (± 1 standard deviation) of annual NEE, RE and GPP were −136 ± 51, 3546 ± 149, and 3682 ± 149 g C m^{-2} yr^{-1} for four years until 2014. The annual NEE was comparable to those of some tropical rain forests on mineral soil. Aboveground biomass (AGB) was estimated at 140 and 146 t ha^{-1}, respectively, in 2016 and 2017. Mean soil C content at 0-25 cm and 25-50 cm depths from 2011 to 2014 were estimated at 52.2 ± 0.7% and 53.9 ± 0.7% respectively.

2. Carbon dioxide fluxes on an oil palm plantation

NEE has also measured above an OPP established in 2004. GWL in OPP (-60 cm) was much lower than in PSF (-17.6 cm) on average and was relatively stable, because GWL was controlled by ditches. Similarly, soil moisture was maintained at around 0.56 m^3 m^{-3}. RE showed no significant relationship with GWL but was positively correlated with soil moisture ($P < 0.001$). Mean annual NEE, RE and GPP from 2011 to 2014 were estimated at 1034 ± 229, 3663 ± 182, 2630 ± 106 g C m^{-2} yr^{-1}, respectively. AGB was estimated at 21.4 and 54.2 t ha^{-1}, respectively, in March 2011 and July 2014. Soil C content measured annually from 2011 to 2014 were 55.3 ± 0.8% and 56.4 ± 1.0%, respectively, at 0-25 and 25-50 cm.

3. Effect of land conversion on ecosystem-scale carbon dioxide balance

The annual NEE was negative in PSF (a moderate CO_2 sink) but positive in OPP (a large CO_2 source). In contrast, annual RE values were similar each other, though it was expected to increase after the land conversion owing to lowered GWL and much woody debris left on the ground. The unchanged RE was probably caused by less autotrophic respiration due to much less AGB in OPP than in PSF. Thus, the large CO_2 emissions from OPP was attributable to 26% reduction in annual GPP mainly because of less AGB.