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Effects of land use on carbon cycling of tropical ecosystems in Panama

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Introduction

Land-use change has significant impacts on the carbon cycling of terrestrial ecosystems. In particular tropical ecosystems are affected by ongoing land-use change, primarily driven by the demand for timber and arable land. Since biophysical and biogeochemical feedbacks influence the global climate, an improved understanding how different land-use types affect carbon cycling in tropical ecosystems is needed. However, continuous measurements of ecosystem scale carbon fluxes are still scarce in tropical regions, with only few localities in Central America. Although carbon accounting within the Clean Development Mechanism (Kyoto Protocol) might also be an option for Panama, no information on carbon sinks and sources of Panamanian ecosystems is available up to now. Within our project, we thus aim to quantify the carbon dioxide and water vapour fluxes of two tropical ecosystems with different land-use in Panama (afforestation and pasture), to assess potential differences in the driving factors of net ecosystem fluxes, and to estimate the carbon sequestration potentials for both land-use types.

Material and Methods

The eddy covariance method is used to measure carbon dioxide and water vapour fluxes between ecosystem and atmosphere. We have been running two flux towers in Sardinilla, Central Panama since February 2007. Our flux measurement systems consist of open path infrared gas analyzers (Licor-7500) and CSAT3 sonic anemometers (Campbell), both hooked up to an industrial PC running a LINUX system. Additional measurements include soil climate profiles, soil respiration fluxes, leaf area index (LAI), biomass production as well as grazing intensity.

Sardinilla is located about 40 km north of Panama City, at 9.3° N, 79.6° W at 70 m a.s.l.. The site has a mean temperature of 26.5 °C and receives 2350 mm precipitation annually, with a pronounced dry season from January to April (less than 50 mm rain per month). One tower has been installed in an improved afforestation (i.e., a plantation using native tree species only), and the second one in an adjacent, traditionally grazed pasture (Fig. 1). Like other countries in Central America, Panama experienced considerable land-use change in the last 60 years (WRIGHT & SAMANIEGO 2008). The site, part of the "Sardinilla Project", was logged in 1952/1953 and used for agriculture for two years, before being converted into pasture (WILSEY ET AL. 2002). In 2001, parts of the site were turned into an improved afforestation (as a tree diversity experiment; POTVIN ET AL. 2004) while grazing continued on the adjacent pasture.

Figure 1: Seasonal changes in phenology at the two Sardinilla flux tower sites. Dry season pictures were taken in March 2007, wet season pictures in June 2007 (360° panoramas).

Results and Discussion

Considerable differences between both land-use types are observed in diurnal and seasonal Net Ecosystem Exchange (NEE). In the rainy season, mean midday assimilation was higher in the pasture ecosystem. However, night-time respiration rates in the pasture were higher during all seasons. The pasture system was more susceptible to soil water limitations (likely due to shallow roots) and assimilation was reduced in the dry season gradually to zero until the onset of the rainy season. In contrast, mean midday assimilation was lower in the afforestation system than that of the pasture during the rainy season, but assimilation was sustained in most of the dry season (Fig. 2). Both ecosystems were carbon sources in April and May 2008, which might be related to ENSO (La Niña) and a prolonged dry season in 2008. In addition, carbon release in the 9 ha pasture seemed also to be related to grazing intensity. During most of the year, grazing intensity was relatively low (8-12 cattle per 9 ha), but increased up to 70 cattle for short periods. Such high stocking rates reduced standing biomass and thus also assimilation fluxes, leading to carbon losses from the pasture system. In summary, the pasture ecosystem lost about 229 gC/m² from June 2007 to March 2009 (2008: 114 gC/m²), while the 8-year-old afforestation system gained about 315 gC/m² (2008: 181 gC/m²).

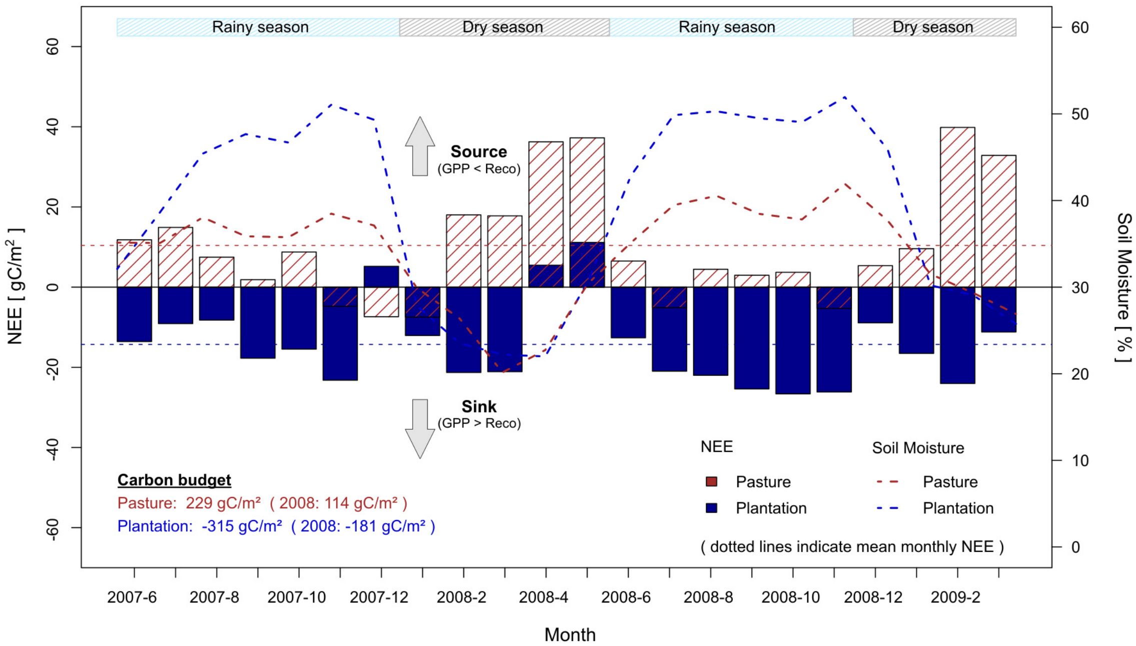

Figure 2: Monthly NEE (bars) and soil moisture (dashed lines) from June 2007 to March 2009.

Conclusions and Outlook

Our results show considerable diurnal and seasonal differences of NEE between tropical pasture and native tree species afforestation in Panama. High midday assimilation rates in the pasture ecosystem are related to the intense productivity of dominating C_4 grasses. However, respiration losses exceed photosynthetic inputs and the pasture system is a carbon source. Besides the seasonal constrained availability of water, grazing intensity seems to be a major influence in the pasture ecosystem. Our results indicate a carbon storage potential for the afforestation system. Since our measurements only provide an insight into the initial establishment phase of improved afforestation projects, it will be essential to investigate whether these differences already allow estimating carbon storage potentials, or whether longer-term developments will reduce these important differences of CO_2 uptake with increasing age of the plantation.

References

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