CO_2 fluxes of tropical ecosystems with different land-use in Panama

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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 CO_2 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 CO_2 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.

Based on collaborations with Catherine Potvin (McGill University) and the Smithsonian Tropical Research Institute (STRI), we have been running two flux towers in Sardinilla, Central Panama (Fig. 1) since February 2007. 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. 2). 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" (www.gl.ipw.agrl.ethz.ch/infrastructure/research_sites/international/panama), 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.

Instrumentation & Experiences at the site

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 (Fig. 3). Additional measurements include soil climate profiles, soil respiration fluxes, leaf area index (LAI), biomass production as well as grazing intensity. After solving some problems in the beginning

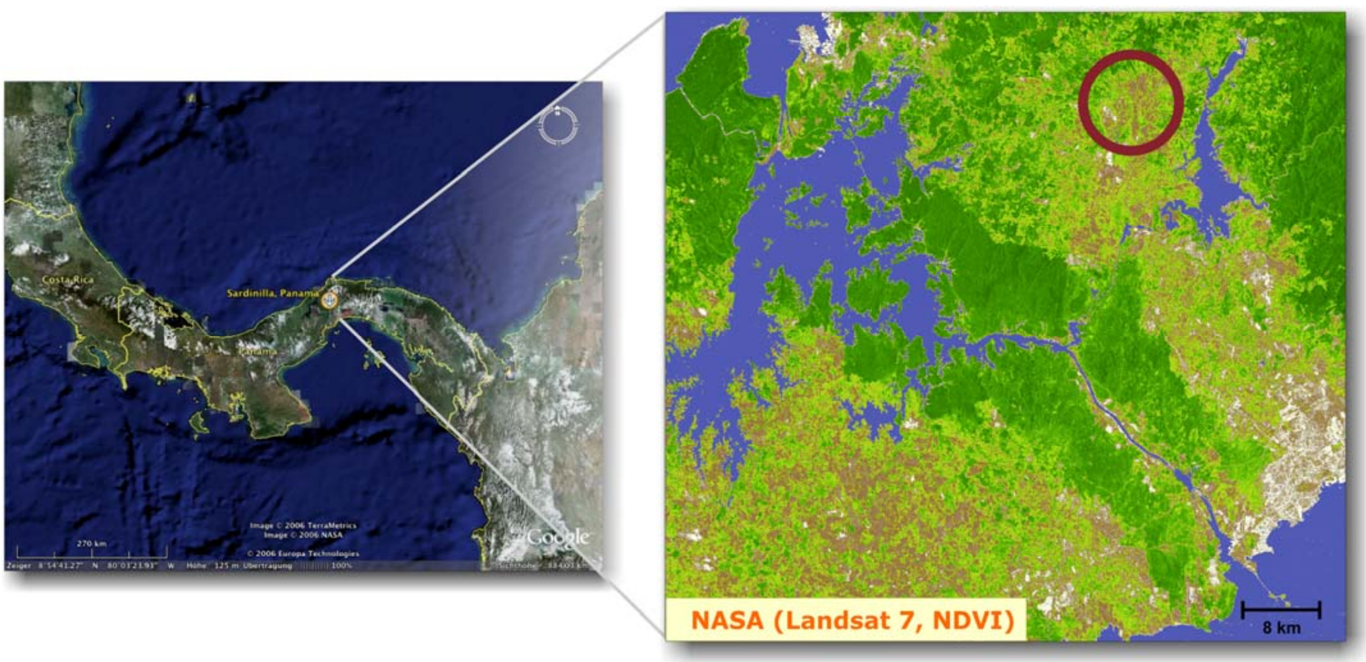

Figure 1: Location of Sardinilla, Panama

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Figure 2: 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).

due to heavy rainfall during the rainy season, we have been acquiring continuous flux data since June 2007. Particularly with the help of our local technician in Panama, we were able to cope with further challenges we experienced at our site, including insects in and around our installations (e.g., ants and spiders) as well as some security issues (e.g. equipment theft).

First results

Analyzing Net Ecosystem Exchange (NEE) of both ecosystems from June 2007 to March 2009, we observed considerable differences in diurnal and seasonal NEE between both land-use types (Fig. 4). High midday assimilation rates of the pasture ecosystem were likely related to the high productivity of dominating C_4 grasses. However, respiration losses in the pasture exceeded photosynthetic inputs at daily and longer time scales, resulting in a carbon source on an annual time scale. In contrast, the afforestation system was a carbon sink on an annual time scale, although mean midday assimilation was lower than that of the pasture during the rainy season. An interesting period was the prolonged dry season in 2008, when both ecosystems became carbon sources in April and May. The pasture ecosystem seemed to be more susceptible than the afforestation system (due to soil water limitations), as seen in the pasture assimilation flux being reduced gradually to zero during this drought period until the onset of the rainy season (Fig. 5). In addition, carbon loss of 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

Figure 3: Fieldwork in Sardinilla. (a) Sebastian Wolf and José Monteza (technician; right). (b) José Monteza cleaning sonic anemometer. (c) Curious visitor on pasture site. (d) Spider webs on sonic anemometer. (e) Sebastian Wolf taking soil respiration measurements. (f) José Monteza working at bottom of afforestation tower.

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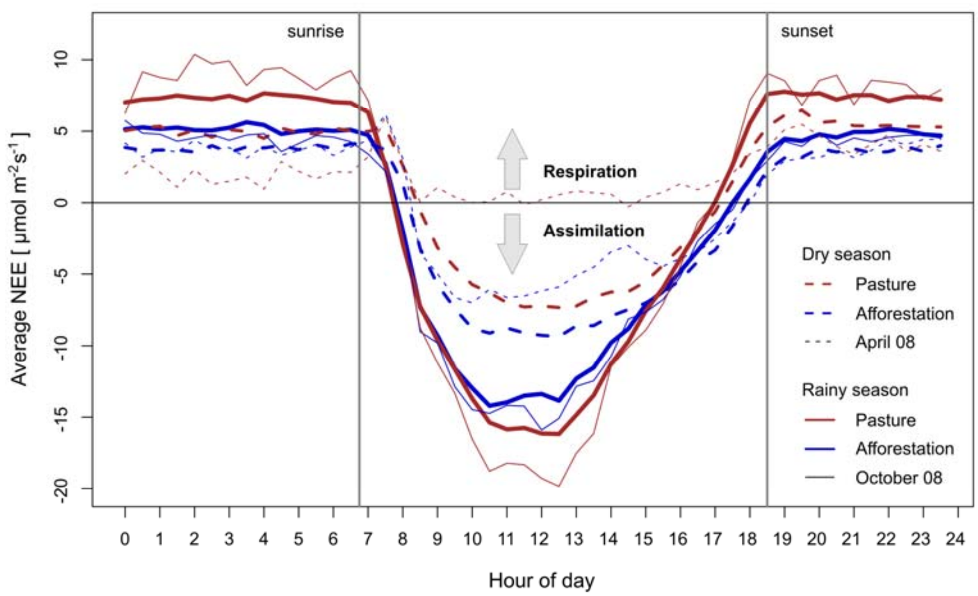

Figure 4: Seasonal mean diurnal NEE from June 2007 to March 2009. April and October 2008 show selected months with low and high ecosystem productivity.

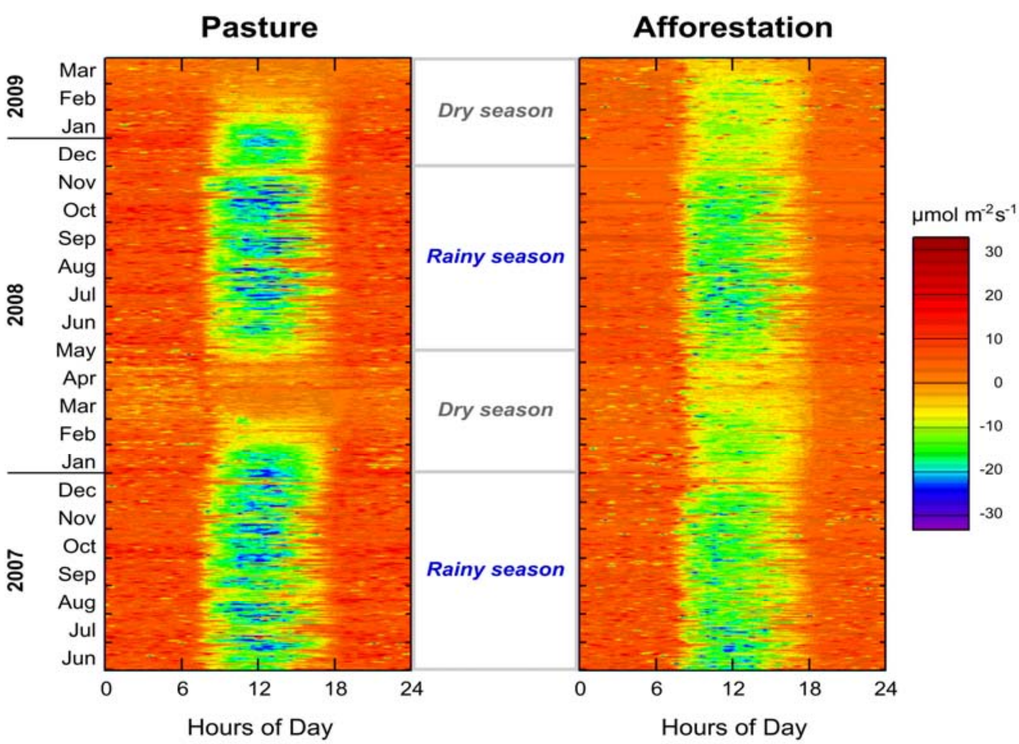

Figure 5: Fingerprints of gap-filled NEE from June 2007 to March 2009

and thus also assimilation fluxes, leading to carbon losses from the pasture system. Consequently, the pasture ecosystem lost about 230g C/m² from June 2007 to March 2009 (2008: 114g C/m²), while the 8-yr-old afforestation system gained about 315g C/m² (2008: 181g C/m²).

In summary, our results indicate a carbon storage potential for the native tree species plantation in Panama, at least during the establishment phase. Besides the seasonally constrained availability of water, grazing intensity seems to play a major role in the pasture ecosystem, leading to unsustained carbon losses.

Outlook

Measurements at the afforestation tower were discontinued in July 2009 while flux measurements over the pasture ecosystem are continued until at least January 2010. With more than two consecutive years of continuous data, we now have a small but unique dataset of two common land-use types in Panama. Because of the sparse flux coverage in Central America, these two datasets might also be of interest for the growing FLUXNET modelling community.

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