Geophysical Research Abstracts
Vol. 15, EGU2013-6430, 2013
EGU General Assembly 2013
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CO_2 fluxes in converting a tropical savanna to a managed ecosystem

Mila Bristow (1), Lindsay Hutley (1), Jason Beringer (2), Stephen Livesley (3), and Stefan Arndt (3)

(1) Charles Darwin University, Research Institute for the Environment and Livelihoods, Darwin, Northern Territory, 0909, Australia (mila.bristow@cdu.edu.au), (2) School of Geography and Environmental Science, Monash University, Vic, 3800, Australia, (3) Department of Resource Management and Geography, The University of Melbourne, Vic, 3121, Australia

Clearing and burning of tropical savanna is a globally significant emission of greenhouse gas although there is large uncertainty relating to the magnitude of this flux. Australia's tropical savannas occupy over 25% of the continental land mass and they significantly influence the national greenhouse gas budget. The tropical savanna region is also earmarked as one potential area of agricultural expansion in Australia given predicted rainfall declines across southern agricultural regions. It is currently unknown what impact a conversion of savanna woodlands to agricultural cropping will have on carbon and water budgets.

We measured continuous CO_2 exchange using eddy covariance flux towers before, during and after a land use change event in a savanna woodland in the Northern Territory of Australia. Our experimental design included flux measurement in an uncleared savanna and at a second savanna site prior to, during clearing and conversion to agricultural land. In addition, we measured the biomass of the savanna vegetation to quantify loss of standing carbon during conversion.

The uncleared savanna was a weak net sink annually ($\sim$0.5 t C $ha^{-1}yr^{-1}$). In the 5 months prior to clearing, the late dry season to the early wet season (Oct 2011 to Mar 2012), the analogue savanna site was also a weak sink (mean daily sink $\sim$0.05 t C ha^{-1} d^{-1}). Clearing shifted the site to a net source of CO_2. It remained a permanent CO_2 source regardless of subsequent weather events, with pulses of increased respiration associated with rainfall events. The cleared debris (63 t biomass ha^{-1}) was burnt in the late dry season a process that took 10 days (burning, stock piling, re-burning). Using savanna specific fuel emission factors we calculated the emissions from this fire event assuming all above ground, and 90% below-ground biomass was incinerated. The burning released a further 25.1 t C ha^{-1} from cleared debris, plus 6.3 t C ha^{-1} as a net emission as measured by the tower, generating huge CO_2 emissions to the atmosphere, totalling 31.4 t C ha^{-1} (or 115.4 t CO_2-e ha^{-1}). The overall difference between uncleared and cleared savanna sites was equivalent to 12 years of carbon sequestration in this ecosystem.

Our study clearly demonstrates that the conversion of savanna to agriculture could lead to much greater C losses from the ecosystem that previously assumed. If implemented the clearing of tropical savannas in Australia will come at a large C cost that will have major implications for the national greenhouse gas budget.