Carbon cycle dynamics of the Mexican tropical dry forest within the North American monsoon region

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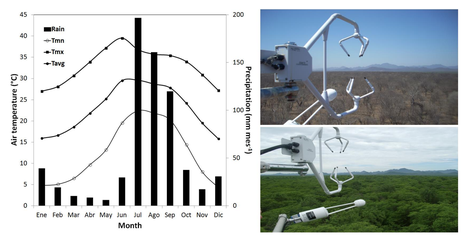
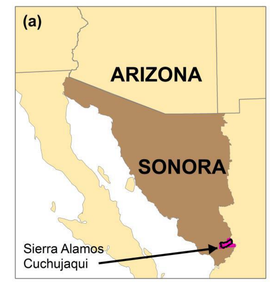
Context

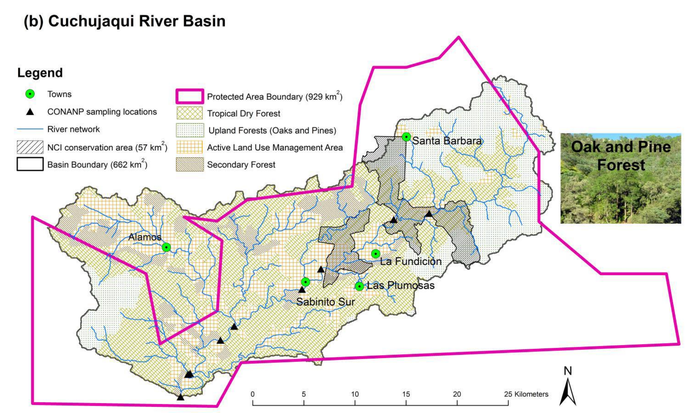
The tropical dry forest (TDF) is one of the most important ecosystems in the Americas due to its large geographical extension reaching the North American monsoon region in northwestern México. In this region, the TDF has been strongly impacted by grazing, wood extraction, mining and agricultural activities which have created a mosaic of successional stages across the pacific lee of the Mexican Sierra Madre Occidental. Currently, land uses span from mature TDF to non-native grasslands and cultivation lands that once abandoned form secondary forest. Such transformations have profound consequences in the carbon cycle but the magnitude of these impacts is still lacking in the region. Understanding the consequences of these land use transformations requires baseline data to understand the complex and sensitive interactions between the many components of the carbon cycle.

In 2013, we have launched a multi-scale Carbon and water monitoring program at the sierra de Alamos-Rio Cuchujaqui natural reserve in Sonora (APFF-CONANP) to assess the effects of climate, weather and land use variability in the functional dynamics of this ecosystem. We have instrumented a Mature TDF site for eddy covariance measurements of NEE and ET and laid out a 1 km by 1 km grid to sample carbon pools (soil, roots, organic layers, litterfall) and vegetation biomass in 20 national inventory-like conglomerates. We will be launching 2 tower sites in 2015; one at an adjacent recently abandoned (<5 years) agricultural site and one at a secondary forest). Combining information of stand flux and soil carbon pools across different successional stages we can produce information for process model parameterization of the dry end of the TDF. We aim at producing the emission factors associated with this ecosystem and to disentangle the fast and slow parameters that control the net ecosystem production of the TDF.

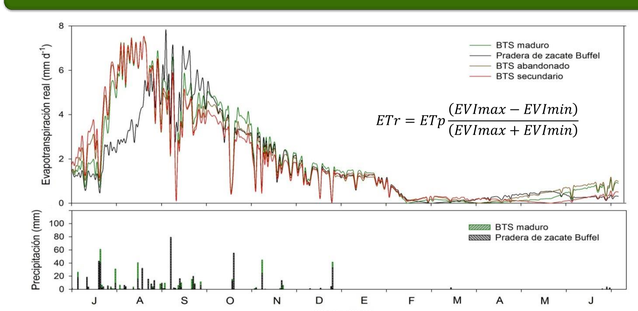
Natural Protected Area Sierra de Alamos Rio Cuchujaqui, Sonora, Mexico







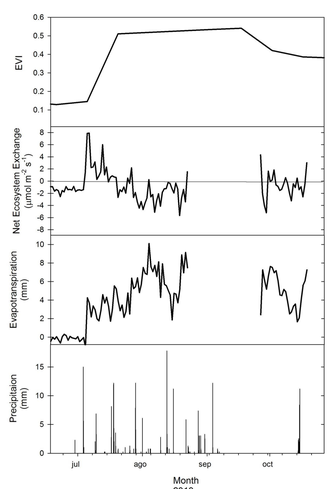
Baseline Data



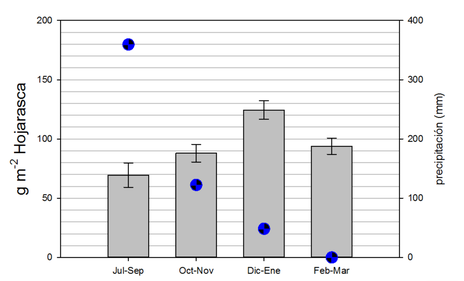
Evapotranspiration estimated with local meteorology and Lansat 8 imagery at the succesional gradient of TDF

Land use	Organic Matter	Carbon
	%	%
Mature TDF	5.5 ± 0.2	3.2 ± 0.1
Secondary TDF	4.2 ± 0.1	2.4 ± 0.1
Abandoned	2.8 ± 0.2	1.6 ± 0.1
Agriculture	4.2 ± 0.1	2.4 ± 0.1

Soil organic matter and carbon variation in soils from the sucessional gradient of TDF



Preliminary data for turbulent fluxes at the mature site during the monsoon season of 2013



Litterfall production during the 2013-2014 growing season at the amture TDF site.

Land use	Mínimun	Maximun	Average
	Ton C ha-1-Year-1	Ton C ha-1-Year-1	Ton C ha-1-Year-1
Mature TDF	0.05	2.18	1.94
Secondary TDF	0.07	1.78	1.37
Pastureland	0.57	2.36	2.42
Agriculture	0.16	1.99	1.76
Data derived from MODIS NPP (MOD17) from years 2000-2010			

Net Primary Production (NPP) derived from sate llite data at the succesional gradient of TDF

Main objectives

The enhancements to forest carbon monitoring in Mexico provided by this project are two-fold:

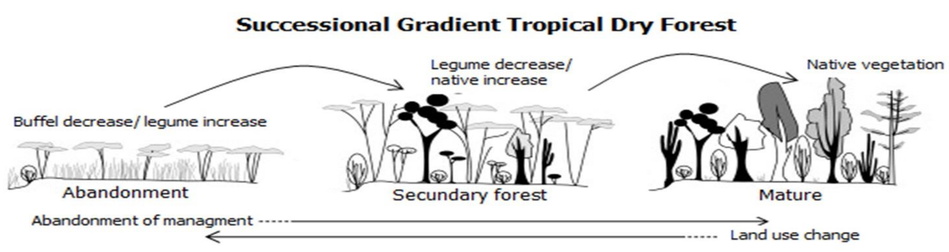
(1)To conduct key field measurements and collect detailed information of stand flux and soil carbon fluxes across different successional stages for parameterization and adjustment of Process Oriented Ecosystem Models (POEMs).

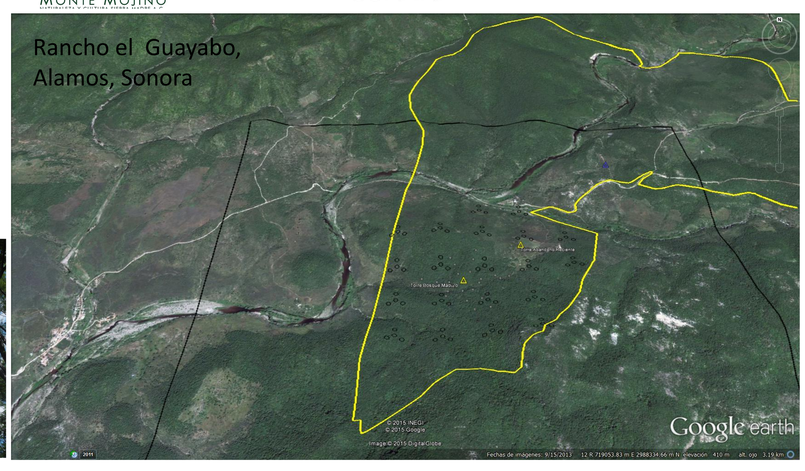
(2) Enhancement is the capacity building for carbon cycle monitoring in Mexico to inform decision makers about emission factors and the impact certain policies will have on future carbon sequestration potential of the TDF.

Ecological succession is a very dynamic process in the TDF but important changes in the landscape (greening) only occur during the rainy season when carbon fluxes respond to wetting and drying cycles. A common feature of these systems is an observed dominance of respiratory carbon fluxes following early rains (Perez-Ruiz et al., 2010) and it is a feature that has been poorly simulated by POEMs due to the dependence of heterotrophic and autotrophic respiration to seasonal variation and potentially confounding parameterization during drought stress periods. Furthermore, POEM results for the TDF will provide carbon fluxes to determine emission factors associated for the common land transformations in this ecosystem at much larger spatial scales than what can be monitored using the EC sites.

The POEM results, including comparisons with MODIS NPP and GPP, will inform the Mexican MRV system by producing Tier 3 information. Specifically, this study complements a Mexican MRV system by providing baseline data for land-cover classes in the northern Mexican TDF prior to their disturbance and will allow generation of emission factors associated with land use changes.

Carbon pools and fluxes in a Succesional Gradient at Sierra de Alamos, Sonora





Flux monitoring at mature site launched 2013

From this array, flux data will be analyzed to determine NEE and its components (GPP and Reco) across the sites. As we implement the array with three flux tower sites we will develop an intercalibration scheme to avoid potential biases in the estimation of NEE. In parallel to the EC tower sites, we are determining carbon pools in soils and vegetation to determine the Net Ecosystem Production (NEP) following the protocols used by the Mexican federal government "Inventario Nacional Forest y Suelos (INFyS)" and the "Reinforcing REDD+ readiness in Mexico and enabling South-South cooperation Program".

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Aknowledgments

We thank the personnel of the Reserva Monte Mojino and the CONANP´s Area Natural Protegida Sierra de Alamos-Rio Cuchujaqui for granting access to the field sites and their invaluable support on data collection and equipment deployment and stewardship. Funding for soil and vegetation inventory came from NASA grant NNH13ZDA001N-CMS, flux equipment is funded by CONACYT CB-2013-01: 221014, the Instituto Tecnologico de Sonora and the University of Delaware