# Understanding the dynamics of aboveground biomass in a Mexican tropical dry forest

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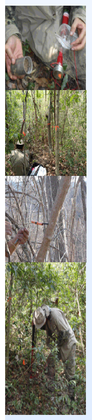
## ♦ Abstract

Land use/cover changes and selective logging highlight the vulnerability that carbon stocks of diverse ecosystems are subjected. Under this context, the tropical dry forest has been one of the most endangered and probably one of the most $CO_2$ emitters. However, little is known about the location and magnitude of carbon stocks losses. As a result the aim of this research is to: quantify, allocate and understand the factors responsible for their natural carbon sequestration.

## ♦ Introduction



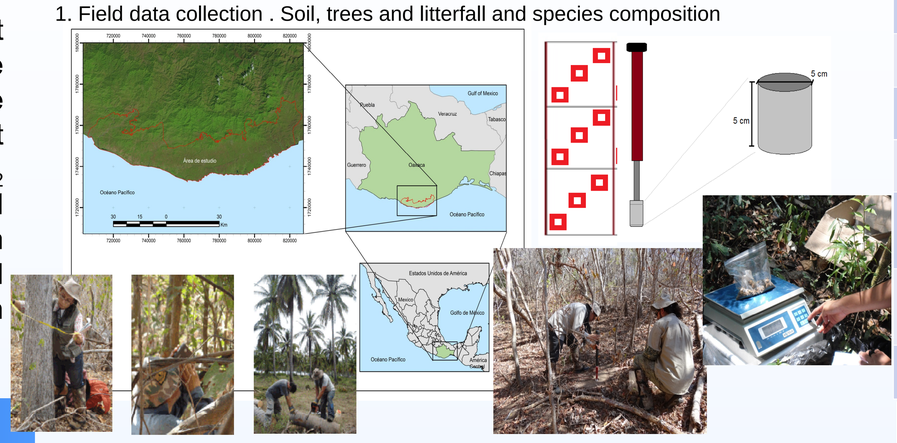
It is recognized that climate change will have impacts on the permanence of forest and therefore on forest carbon stocks (Meir and Pennington, 2011). However, Tropical Dry Forest (TDF) may increase its distribution range according to the future dry and warmer environmental conditions (FAO and Formin Findland). According to Skutsch *et al.,* (2009) TDF carbon emissions are important, because more carbon losses may occur even though their carbon content is lower per hectare than other tropical forests. Globally it has been estimated that around 78% of the original tropical dry forest has been modified (Mooney et al., 1995) and it is considered as one of the most endangered in the world (Janzen, 1986). In Mexico this vegetation represents nearly 60% of all the tropical vegetation (Miranda and Hernández, 1963). Nevertheless, little is known about the potential above ground biomass (AGB) under no human disturbance. Moreover, this can be the first attempt in trying to reproduce potential biomass in a TDF.

## ♦ Hypothesis

- H1 Most of AGB is allocated in small stems. However, big stems (>50 cm) may drive differences across the landscape.
- H2 Because of high topographic variability (complexity) across the landscape, carbon stocks and soil carbon stocks are highly heterogeneous. Therefore, they do not show spatial autocorrelation over medium to high distances.
- H3 Microclimatic refuges against water stress will be the major driver for plant AGB stocks allocation. While, soil chemical properties may not play as major drivers at a landscape scale as do physical properties (bulk density and sand content).
- H4 In less stressed climates senescence will be lower with higher LAI and longer leaf expression relating to an extended grown seasonality and higher live AGB.

## ♦ Methods & Materials

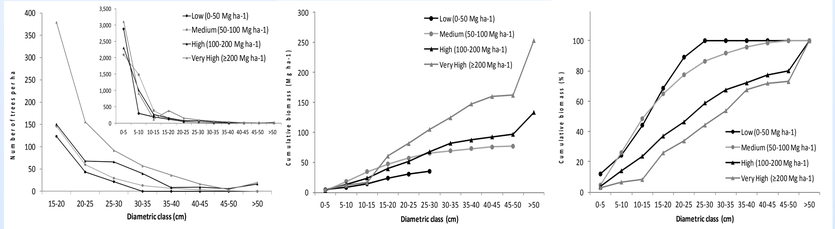
1. Field data collection . Soil, trees and litterfall and species composition

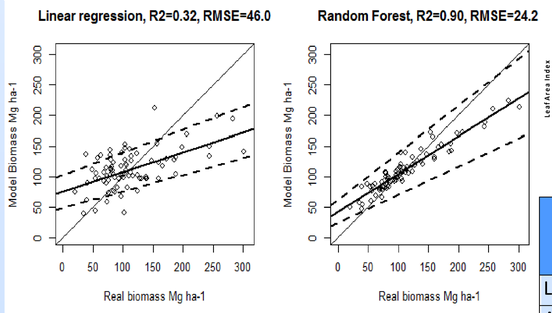


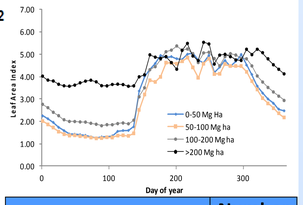

2. Data selection through time series from 1985 to 2014 to characterize mature vegetation.

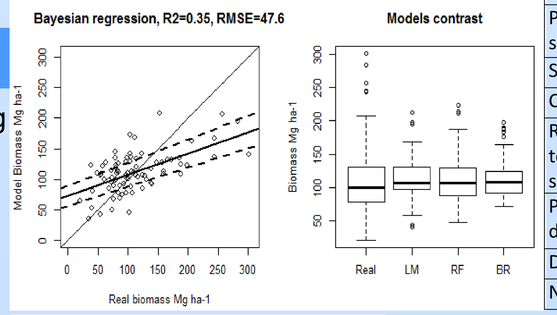
3. Multivariate analysis (multiple linear, bayessian and RandomForest regression. Proxies to nutrients, water availability and solar energy where derived from Topographic, climatic, physical and chemical soil properties, and LAI.
4. Data assimilation to reproduce daily carbon allocation was done though DALEC model and: Field estimations of AGB, litterfall, SOC and LMA; Allometric equations for fine and coarse roots, and live leaves estimates; Daily Modis LAI and climatic data.

## ♦ Results

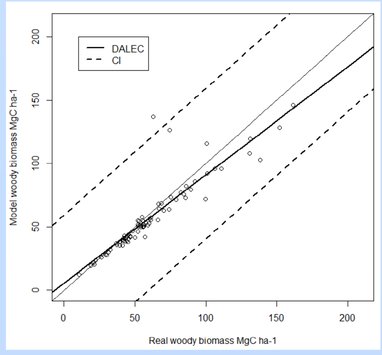



| Variable ranking | Number of models |
|---|---|
| LAI | 2 |
| Altitude | 2 |
| Potential incoming shortwave | 3 |
| Sand | 3 |
| Clay | 2 |
| Ratio (max temp / min temp) during dry season | 3 |
| Precipitation during dry season | 2 |
| Distance to rivers | 2 |
| NP | 1 |




- A total of 357 species where measured. In average there are 13 spp per sampling plot.
- About 50% of the biomass is allocated in 17 spp.
- *Cochlospermum vitifolium, Caesalpinia platyloba* S. Watson and *Brongniartia bracteolata* represent about 20%.

| Topographic* | Soil** | Climatic*** | Others |
|---|---|---|---|
| Altitude | Texture (sand; clay; lime) | Temperature (monthly and yearly, max, min and mean) | Potential incoming shortwave (april-june; dry season)* |
| Slope | Soil organic carbon | Precipitation (montly and yearly) | LAI (mean, dry and wet season, annual ranges) |
| Aspect | Total Nitrogen; N-NO3; N-NH4 | Temperature yearly ranges | |
| Soil concavity (TOPEX) | Microelements: Na, Mg, Ca, N, P | Isothermality | |
| Compound Topographic Index (CTI) | Ratio CN, NP | Mean, max and min temperature during dry and rainy season | *DEM 20x20 pixel **Field information ***WorldClim data |
| Distance to rivers and streams | Bulk density | Mean, max and min precipitation during dry and rainy season | Modis LAI |
| Distance to coast | pH | Ratio (max temp / min temp) during dry season | |

## ♦ Discussion

- Trees under 10 cm in DBH sum up over 3,000 tress per ha, and trees with a DBH ≥ 50 cm only are present in plots with high and very high biomass with a mean of ~20 trees per hectare.
- In average, 80% of AGB is comprised in small trees (<25 cm DBH);100% for low, 92% for medium, 67% for high and 54% for very high AGB groups. Mean woody biomass 129 Mg $ha^{-1}$
- Access to water by precipitation, distance to rivers and streams and soil drainage (sand and clay) showed to be important drivers for AGB. Climatic stress also can be understood by altitude, aspect and temperature ratio (max temp / min temp) and potential incoming shortwake during dry season.
- Only NP ratio showed to be an important factor for AGB.
- Spatial autocorrelation in trees AGB and SOC is under 230m, while leaf litter is in about 1,500m (data not shown).
- Most of the measured biomass is allocated in few species.
- DALEC suggests that mean woody B reaches 121 (min=26, Max=307) Mg $ha^{-1}$ with a turn over rate of 20 (min=4, Max=70) years.

## ♦ Conclusion

- Natural AGB is the expression of multifactor interaction of bioclimatic properties
- Access to water and temperature during dry season showed to be main drivers for AGB. Also, a balance between sand and clay show to be an important driver. Only NP showed to be an important driver.
- LAI helps to understand AGB stands, mainly >200 Mg $ha^{-1}$
- RandomForest performs the best for biomass prediction.
- DALEC is capable to reproduce woody C estimates,

## ♦ References

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## ♦ Further analysis

Understand how biodiversity may correlate to AGB
Spatialize potential and current AGB
Chronosequence analysis

## ♦ Acknowledgements

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