Changes in Soil Carbon Stocks in Regenerating Tropical Dry Forests: Variation with Soil and Forest Type

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Tropical Dry Forests: Unique and Endangered

Tropical dry forests (TDF) have many endemic species and were once widespread, comprising over 40% of the total area of tropical forest. Conversion to other land uses such as cattle pastures has reduced the total area of TDF by up to 98% in some regions. Despite dramatic losses in TDF over the past several centuries, secondary forests are beginning to regenerate. The rates of recovery in key ecosystem processes such are carbon storage are poorly known for TDF.

Objectives and Approach

The goal of this project was to determine the rate of change and influences on soil C stocks in regenerating tropical dry forests using the chronosequence approach.

I predicted that soil C stocks would increase with stand age, but that the rate of increase would depend on forest type.

Study Sites

Map by Justin Becknell

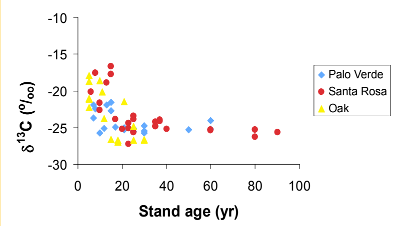
We sampled trees and soils in two National Parks in Costa Rica, Santa Rosa and Palo Verde. Mean annual rainfall is ~1,575 mm in Santa Rosa and 1,700 mm in Palo Verde, with large interannual variation. Mean annual temperatures are ~25 ºC. Both protected areas contain secondary forests regenerating from grazing or crops. Soils are classifed as Inceptisols and Vertisols.

Methods

We identified 60 forested stands that varied in age from ~5 to > 100 yrs. Stands were grouped into three forest types that have different tree species and soil fertility: Palo Verde (highest soil fertility and intermediate diversity), Santa Rosa (intermediate soil fertility and highest diversity) and Santa Rosa oak (lowest fertility and dominated by *Quercus oleiodes*). In each stand, we installed 20 x 50 m plots, identified and measured trees, and collected soils. Ten soil samples were collected from mineral soil (0-10 cm) and bulked by plot and a separate set of samples for bulk density was collected. Soil carbon and δ^{13}C was measured at the UC Davis Stable Isotope Facility.

Results

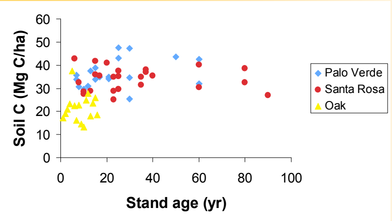
Figure 1. Stable C isotopes, $\delta^{13}C$, as a function of stand age for three forest types



Stable C isotopes show:

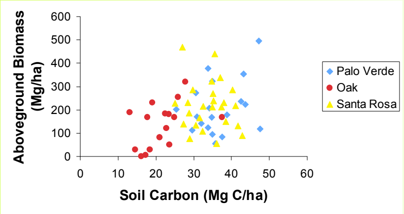
- pastures likely contained a mix of C3 and C4 species
- forest-derived carbon is incorporated into surface soil within 20-30 yrs.

Figure 2. Soil C stocks (0-10 cm) as a function of stand age for three forest types



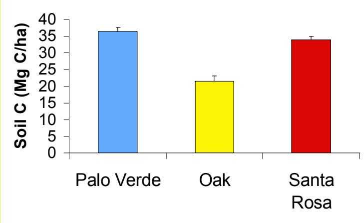
Soil C stocks increased with stand age in oak forests ($P = 0.04$), but not in Palo Verde or Santa Rosa. In oak forests, soil C stocks were also positively correlated with soil Al, Ca, Cu and P.

Figure 3. Soil C stocks in relation to aboveground biomass.



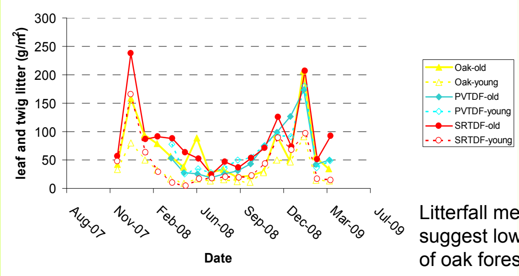
Even though aboveground biomass increases with stand age, soil C stocks are poorly correlated with aboveground biomass.

Figure 4. Soil C stocks (0-10 cm) by forest type



Averaged over stand age, oak forests contain 40% less soil C than species-rich dry forests, which appear near saturation.

Figure 5. Long-term productivity measurements



Litterfall measurements suggest lower productivity of oak forests.

Conclusions

Changes in soil carbon stocks following grazing depend upon forest type. In this region, carbon pools in most surface soils appear near equilibrium.

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