Carbon soil dynamics in secondary tropical dry forests in Northwestern Costa Rica regenerating from grazing

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Abstract

The goal of my research project is to understand how ecosystem processes like carbon sequestration in soils changes as young forests regenerate on lands that were previously used for grazing. The objective is of my project is to re-visit the same area that Dr. Powers studied 5 years ago and determine if the chronosequence and longitudinal studies reveal the same soil carbon dynamics as previously predicted, as well as to see if soil carbon sequestration increases with forest age, as many conceptual models predict. From the data analysis, the carbon concentration and carbon isotope followed our predicted assumptions for the concentration to increase slightly and the carbon isotope would become more negative. We predicted the bulk density would decrease over time as the soil became less dense but our data showed mixed results on whether it increase or decreased.

Chronosequence/Longitudinal Studies

There are two ways to study how species composition and ecosystem function change with forest regeneration (also called succession): chronosequence or longitudinal studies. In chronosequence or "space-for-time substitution" studies, the researcher selects a set of plots that are on similar soils and slope positions, but differ only in the number of years that they have been under a particular land use such as forest. Any differences between the plots are attributed to forest regeneration processes. By contrast, longitudinal studies repeatedly sample the same plot of ground over time. Because longitudinal studies are much more difficult to undertake, there are few comparisons between these types of studies to determine whether they yield similar insights into successional dynamics.

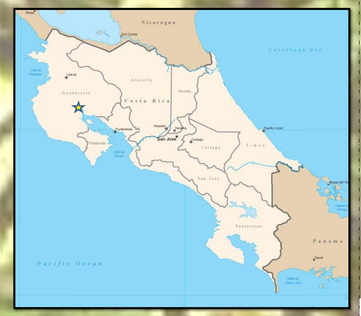
Background

One of the main gases that contribute to the greenhouse effect is carbon dioxide (CO_2). To understand the production of CO_2 and the release of it into the atmosphere we need to quantify the amounts of carbon in the soil, which is the largest pool of terrestrial carbon. Increasing carbon levels retained in the soil could help reduce the net amount of CO_2 released to the atmosphere. Not only will understanding the carbon retained in the soil help better understand the greenhouse effect, but it could also play a role in assessing soil quality.

In 2007 Dr. Powers completed a chronosequence study to analyze soil carbon stocks in different ages of regenerating tropical dry forests in the Northwestern area of Costa Rica. This study took advantage of the "natural abundance" method of using the stable isotope of carbon to infer soil carbon dynamics. This method relies on the differences in discrimination against the stable isotope of carbon (d13C) between plants that use the C4 photosynthetic pathway (tropical grasses) and plants that use the C3 pathway (trees). As the isotopic signature of carbon in the soil reflects the signature of the vegetation, this method can be used to determine the fraction of pasture versus forest-derived carbon source to the soil, and hence soil carbon dynamics. Her results of the onetime survey displayed increasing soil carbons concentration as forest aged, but a decrease in bulk density.

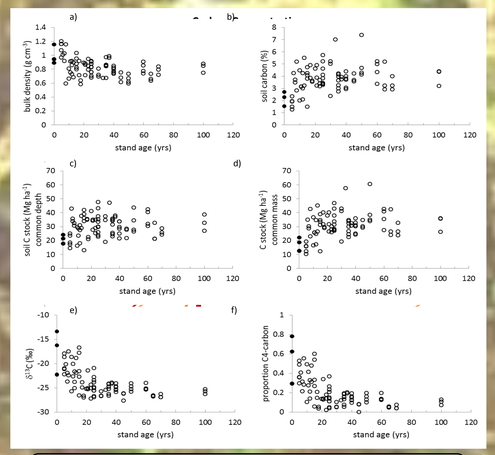
Experiment Design

This study was conducted in two reas in northwestern Costa Rica, Area de Conservación Guanacaste and Area de Conservación Tempisque. Within the two areas, the data was collected on the Sector Santa Rosa (formerly known as Parque Nacional Santa Rosa) in Area de Conservación Guanacaste and Parque Nacional Palo Verde in Area de Conservación Tempisque.



We can assume there will be differences in soil properties so four samples were taken in each corner of the plot from 0-10 cm from the surface. This required taking 5 samples along the median line of the plot with a core puncher. Another set samples were taken for bulk density.

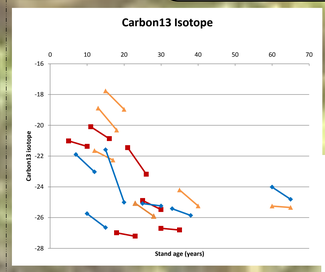
Results

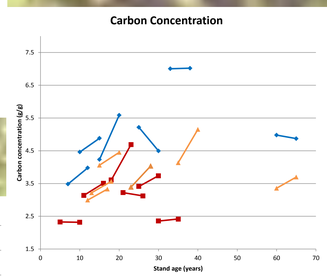


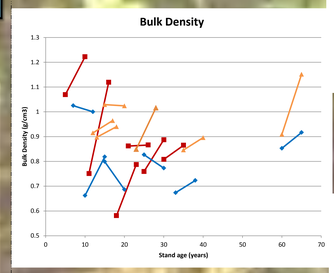
Dr. Powers' data results from 2007

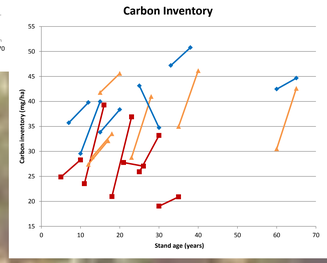
Results from 2012

Each line connects dots representing 18 permanent plots sampled in 2007 and resampled five years later. Colors refer to different forest types.









- Vegetation in the plots is moving towards C3 plants
- The carbon concentration and carbon isotope follow same trends that were predicted as well as the trends found in other studies - over a 5 year span, we would predict the carbon concentration to increase slightly over time
- The carbon inventory coincides with bulk density so when my bulk density data increase, the carbon inventory increased which contradicts our prediction

Future Directions

- Continue to analyze different nutrients in the soil collected for any other similar trends from the 2007 data set.
- Continue to repeat this chronosequence study in the years to come to help understand the dynamics of soil carbon.

References

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