Carbon Fluxes in the Tropical Rain Forest in Response to Environmental Factors

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Introduction

What critical factors influence soil respiration?

Soil respiration is the measure of CO_2 released through microbe-mediated decomposition. This measure reflects the health and productivity of ecosystems and indicates the ability for soil to sustain plant growth.

As global temperatures rise it becomes increasingly important to understand impacts on soil respiration as it releases nine times more CO_2 than human emissions annually (Schlesinger et al., 2013).

Soil respiration increases with temperature and decreases at moisture extremes (Moyano et al., 2012).

Light reaching ground level due to varying canopy structure can be a factor for soil moisture and temperature. Canopy closure may affect soil respiration by indirectly influencing the microclimate.

We observed the effect of canopy cover in an arboretum because the arboretum is cleared of underbrush. This allows us to observe a direct correlation.

I hypothesize that less ground coverage (more light) results in more soil respiration. Moreover, I predict that soil respiration will increase proportionally with soil temperature.

Methods

Sites were located in the arboretum at La Selva Biological Research Station, located in a Tropical Wet Forest in northeastern Costa Rica.

Three dark and light plots were selected. At each treatment plot, 3 PVC collars were constructed and accessed as follows:

- Placed PVC collar (9.96 cm diameter) 3 cm into the soil and initiated data collection after 1 hour to reduce disturbance effects.
- Soil temperature and moisture probe placed 5m away from collar, with measurements every second for 5 min and averaged for each collar (N = 18 collars).
- Densiometer was used to measure the density of canopy of the forest
- Preformed a linear mixed effects model in R Studio.

Figure 1. Densiometer procedure. Densiometer consisted of 24 ¼ inch squares divided into 4 sections. Canopy was estimated by counting covered dots. *Picture provided by Dr. Eric Norberg*

Results

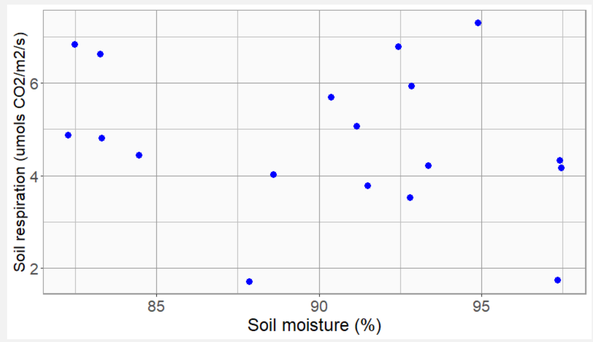

Figure 2 A-C. Results of a linear mixed-effects model that examined the relationship between soil respiration and (A) moisture (%), (B) average temperature (˚C), and (C) canopy density (%) at each plot (n = 18). Soil respiration was calculated by determining mass flux, the rate of mass transfer per unit surface area (µmols CO_2/ m^2/s). The REML criterion at convergence was 46.2. The fixed effect estimates suggest that none of the predictor variables had a statistically significant effect: average moisture percentage (p = 0.369), average temperature (p = 0.695), and canopy density (p = 0.798).

Figure 3. CO2 flux sensor, and temperature and moisture probe. PVC collar measured carbon in the chamber every second for 5 min to assess respiration rate. **B**uilt and provided by Jessica Murry

Conclusions

The aim of this research was to observe a trend between environmental factors and soil respiration in the tropics. The results of the linear mixed-effects model suggest that none of the measured environmental factors had a statistically significant effect on soil respiration. With no p values less than or equal to 0.05, I failed to reject the null hypothesis.

Previous work found soil temperature to directly influence soil respiration (Moyano et al., 2012). Other studies have evaluated soil respiration in canopy gaps with a significant direct influence on soil temperature (Roth 2019, Han et al., 2020).

That being said, I was unable to find a correlation between temperature and moisture. To improve the design I would expand the study to incorporate a greater spectrum of canopy closure. Similarly, the temperature and moisture gradient in the current data is on a very small scale, and given a broader view, my data could show a larger trend.

Given greater resources I would collect soil samples to ID the microbiome. These microbial communities determine the response to environmental change due to their role in biogeochemical cycles. A greater number of replicates would be required as the communities are considerably different geographically and highly stratified during decomposition (Baldrian et al., 2011).

In conclusion, the present study suggests that additional factors beyond soil temperature, moisture, and sun light significantly influence soil respiration. The complexity of soil respiration and the involvement of microbial processes motivates additional research aimed at fully understanding the factors that influence carbon fluxes in different forest ecosystems.

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