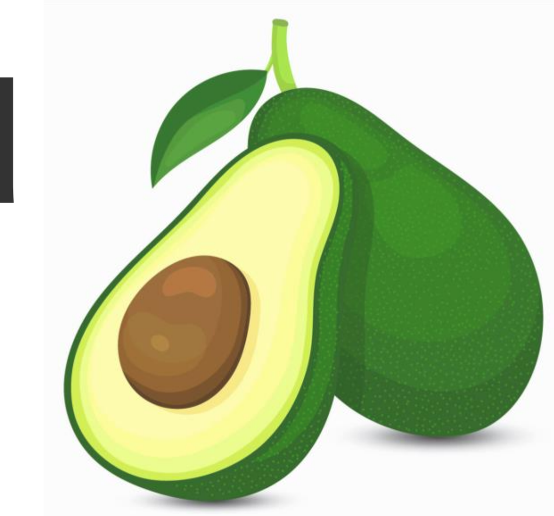
School of Environment and Natural Resources

Soil physical properties under avocado and tropical forest



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INTRODUCTION

Soil is a finite resource, vulnerable to degradation as soil organic carbon stocks (SOCS) may vary with changes in soil carbon sequestration rates, vegetation, land use, soil moisture and physicochemical properties (da Costa et al., 2018). Agricultural soils tend to have lower SOCS than natural systems (Lal, 2005); soils of the tropics have the lowest aboveground to belowground carbon storage ratio (Lal, 1987). Increasing SOCS in this region can improve soil quality, plant productivity, and reduce greenhouse gas emissions, such as CO_2, serving as a climate change mitigation strategy.

OBJECTIVES

1. Quantify SOCS of two land management systems: an avocado orchard (AO) and a tropical forest (TF)
   - H1: SOCS are greater in the TF because the system is less disturbed and there is higher plant diversity. Rate of carbon sequestration is faster in natural systems than in horticultural settings.
2. Evaluate the effect that SOCS have on soil structure and water reserves as influenced by land management
   - H1: In the TF, soil has stronger aggregates that allow for better soil structure than the AO because its higher organic carbon content protects it from physical degradation.
   - H2: In the TF, soil moisture is higher because of the organic carbon's high affinity to water. It moves with greater ease due to adequate aggregation. However, as organic carbon content increases in the soil, so does its water retention.

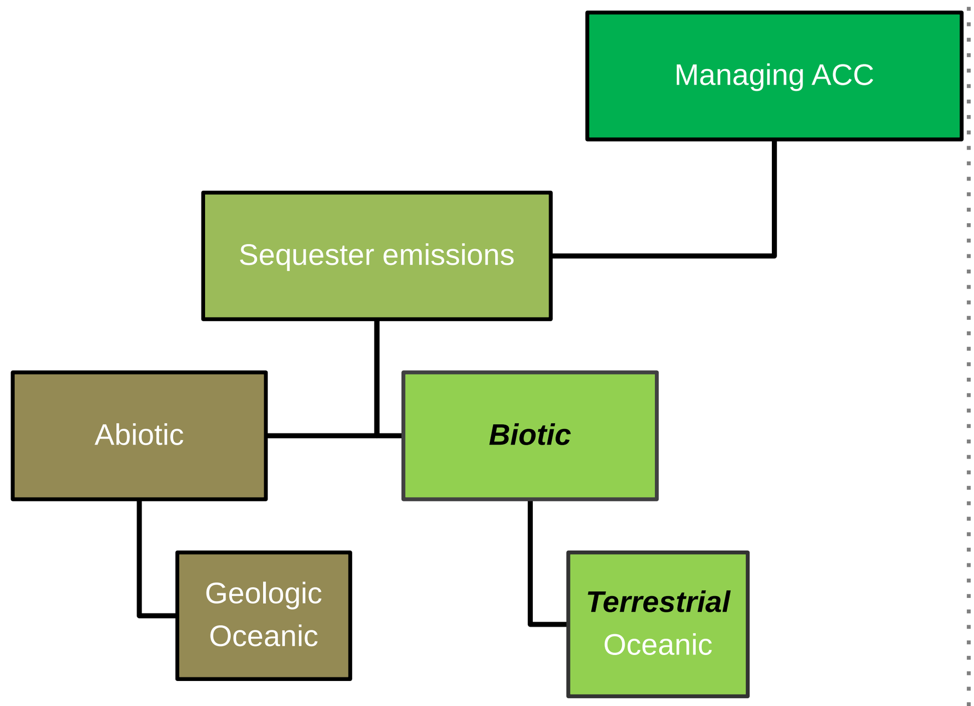

Figure 1. Alternatives to sequester CO_2 to reduce emissions (Lal, 2020)

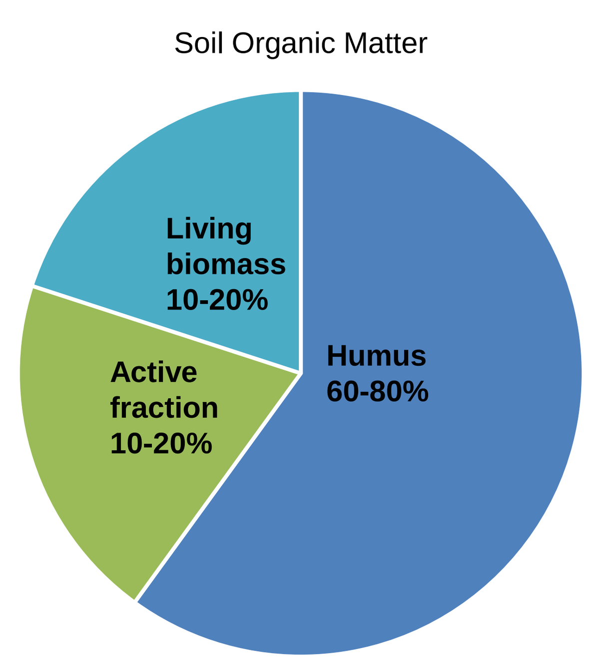

Figure 2. Constituents of soil organic matter (Vermont Agric Exp Stat Bulletin, 1908)

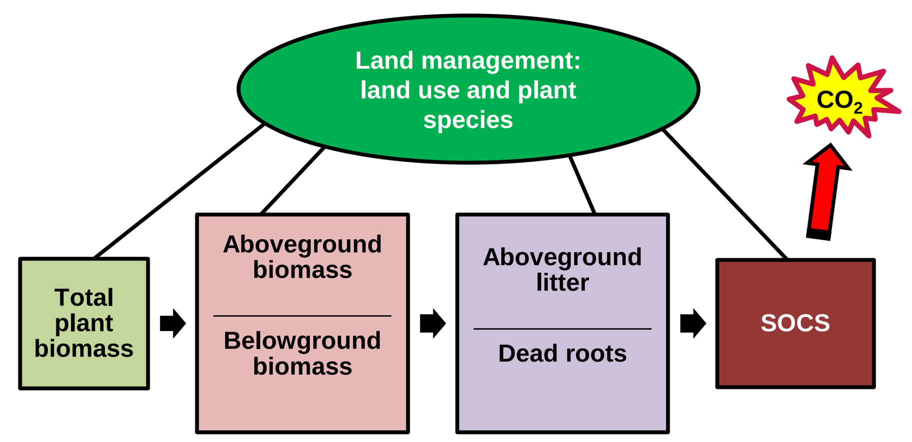

Figure 3. Conceptual model of SOC dynamics influenced by land use and plant species, according to land management (Department of Natural Resource, Ecology and Management Iowa State University, 2019)

METHODS

The study will be conducted in Jayuya, Puerto Rico. Exact location is yet to be determined. Within AO and TF, plots will be selected according to slope, elevation, aspect, soil type, tree age, variety, height, and trunk and canopy diameter. Samples will be taken from 0-20, 20-40, 40-60 and 60-100 cm of depth using a hand auger and a push probe, distancing 30 and 60 cm away from the trunk. Between AO and TF, a total of 64 disturbed and 16 undisturbed samples will be collected.

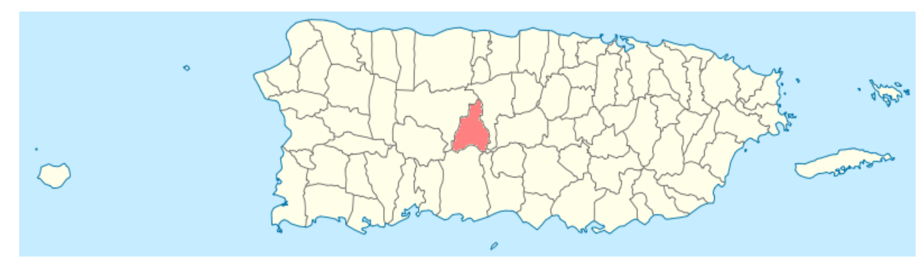

Figure 3. Map of Puerto Rico highlighting Jayuya

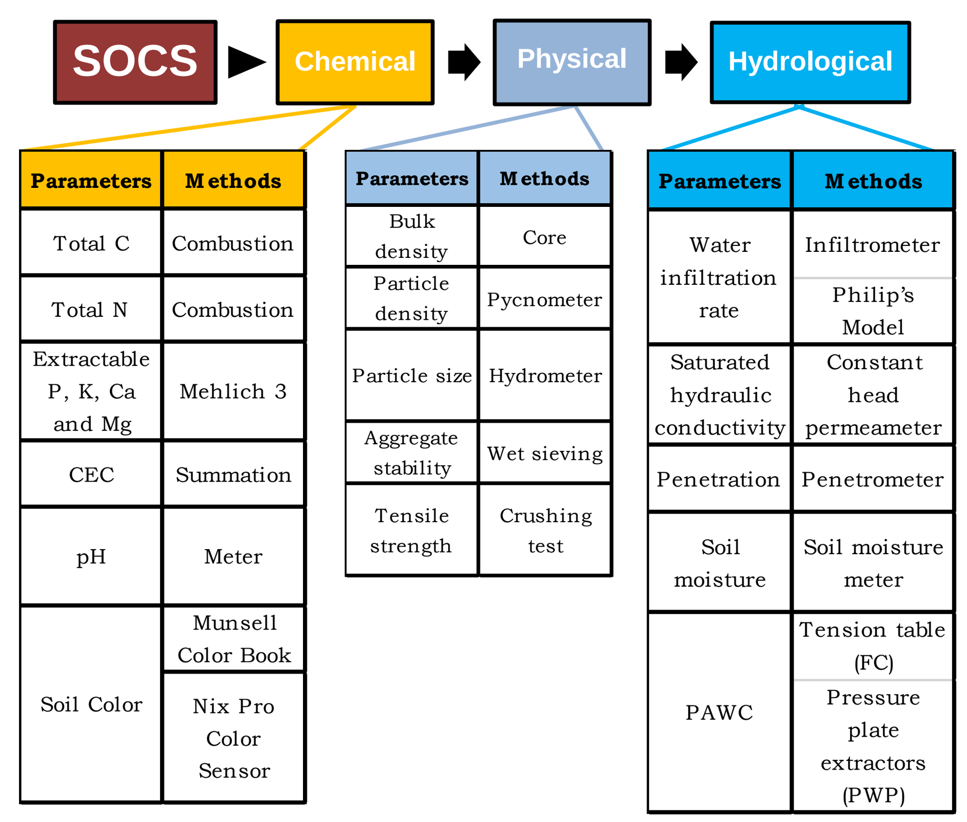

Figure 4. Sequence of soil sample analyses, including parameters and methods for each type of analysis.

EXPECTED RESULTS

For optimum avocado production, base saturation, clay content, soil depth, aggregate shape and hydraulic conductivity are key factors (Fig. 4). Forested systems have higher SOCS, FC and AWC than agricultural ones (Table 1). OM is higher in forests than in AO, leading to stronger aggregates (Table 2). SOCS tends to decrease with increasing soil depth. The highest C fraction is in the soil (Fig. 5).

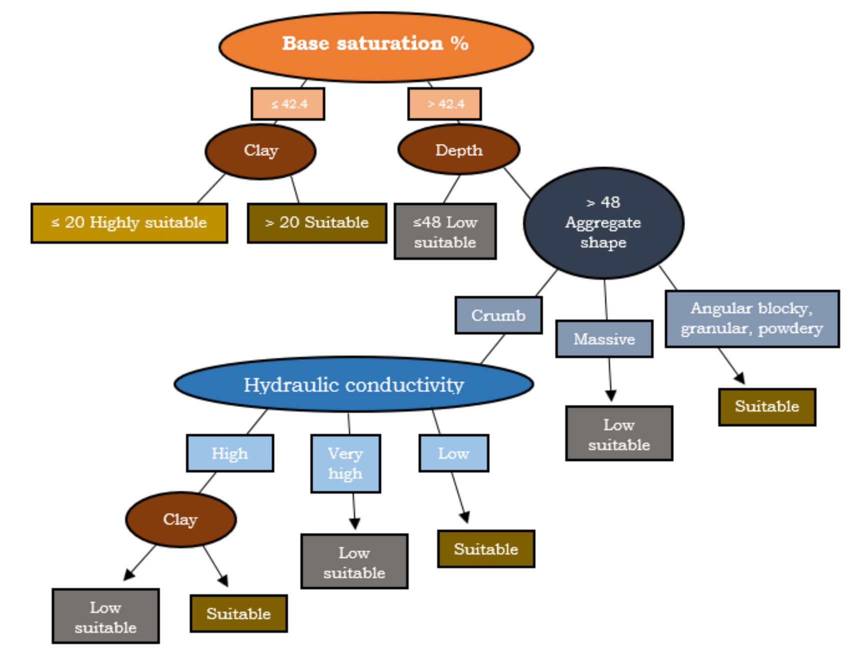

Figure 5. Soil suitability for avocado growing. (Dubrovina and Bautista 2014)

Table 1. Soil physical and hydrological properties according to land use (Saha et al., 2011)

Land use	pH	Texture	ρb ($Mg\ m^{-3}$)	FC (%)	PWP (%)	AWC (%)	SOCS ($Mg\ ha^{-1}$)
AG	7.5 ± 0.02	SCL	1.55	22.3 ± 1.9	8.5 ± 0.8	13.8	14.2
FO	7.1 ± 0.04	SCL	1.53	28.4 ± 2.2	9.5 ± 0.9	18.9	29.1

Table 2. Land use and soil depth's effect on pH, organic matter and wet-stable aggregates (Bravo-Espinosa et al., 2014)

Land use	Depth	pH	OM (%)	WSA (%)
AO	0-5 cm	6.5 ± 0.24	6.6 ± 2.9	65.0 ± 3.4
	5-20 cm	6.6 ± 0.20	5.1 ± 1.8	
POF	0-5 cm	6.6 ± 0.33	7.0 ± 3.5	70.0 ± 1.8
	5-20 cm	6.5 ± 0.33	5.4 ± 2.3	

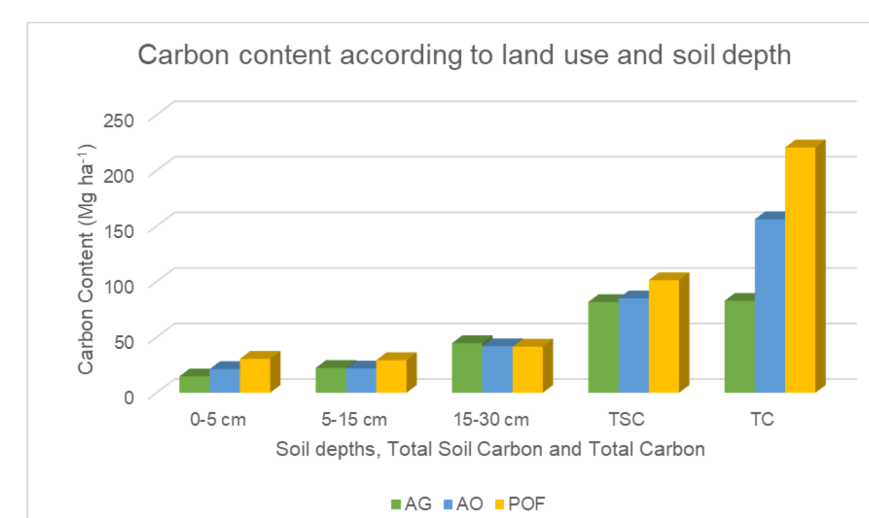

Figure 5. Land use and soil depth influence on carbon content (Ordóñez et al., 2008)

SIGNIFICANCE

Despite being the 4th most important tropical crop, avocado hasn't received the same attention as coffee or cacao in terms of carbon sequestration. Water requirements of avocado trees have been poorly researched. Trees operate as large but slow carbon sinks in forests and SOC enhances soil health which may lead to an increase in productivity. The extent of carbon (C) sequestration in soils under agroforestry systems in relation to soil types (fraction sizes) and vegetation structure remains largely unexplored

CONCLUSIONS

Quantifying SOCS will promote the potential that the industry has to reduce CO_2 emissions and portray themselves as carbon sinks, not sources, and to support forest ecosystem conservation as they also contribute to decreasing emissions. It will provide data to explain the effect that land-use management has on the soil's capacity to mitigate climate change. Practices that maintain an adequate soil structure suitable for enough water retention that can increase crop productivity should be evaluated, encouraged, and implemented.

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