Graduate Student Spotlight

Julio César Pachón (SWS Ph.D. 2021)

Dissertation (tentative title): "Novel Indices of Soil Microaggregation to Understand Soil, Water, and Ecosystem Processes"

Despite humanity's dependence on soil, there are many gaps in our understanding of its formation and the changes it undergoes in both natural and managed systems. The biogeochemical processes that bind soil particles lead to basic soil structure, termed microaggregates, whose physical properties influences numerous ecosystem processes. The overall goal of my research is two-fold: (1) to improve how we measure soil microaggregation and (2) to understand the environmental drivers and consequences of this phenomena. To accomplish these goals, I have developed a novel method to quantify microaggregation that is rapid and more detailed than traditional methods. I am applying my method regionally across the Southeastern US to identify ecosystem processes that control microaggregation, in Sub Saharan Africa to characterize the effects of microaggregation on aboveground productivity, and in Florida to evaluate how microaggregation influences soil hydrology.

Research Question:
What are the environmental drivers and consequences of soil particle interactions?

"This whole idea of collecting data and making it more useful begins with the thought that by making it user-friendly and giving it back to the different stakeholders, they can improve overall management," Julio Pachón said. "It's not one-sided if many people have access to it. The communication can be a little more honest, there's an evenness of power."

The research Pachón is conducting is part of the evolution of soil science. He believes the study of soil processes is on the verge of being upturned.

"There is a need to rewrite the way we classify soils using the advent of technologies such as spectrophotometry and laser diffraction," Pachón said. "This reclassification will be similar to the upset in biological taxonomy that DNA technology allowed."

> *"The work I want to do deals more with gathering existing data and developing it to be user-friendly, so stakeholders can work with it in ways that I may not even envision."*

For more than a century, professionals have recognized aggregation and used it as a proxy for soil health. Pachón argues that developing and standardizing the estimation of soil aggregates with laser diffraction technology will lead to stronger landscape models. Those, in turn, will explain the movement of water, air, and chemicals in Earth's critical zone – that layer between the bedrock and the upper atmosphere.

Talking about Soil

Julio Pachón at a workshop with ISRIC in Wageningen, Netherlands. (Photo provided)

Pachón was born and raised in Colombia, where his interest in soil first took hold. His family moved to the United States in 2001, when he was ten years old, and settled in Miami. Pachón attended MAST Academy, which is a maritime and science technology magnet school in Miami. During high school he volunteered at the Everglades National Park and later worked as a tour guide.

"That's what set me up to go to Cornell after high school," explained Pachón. There, he earned a bachelor's degree in Science of Natural and Environmental Systems. He also took advantage of all the opportunities he could find. Pachón traveled to Limpopo, South Africa, to be part of a soil microbiology research group to reinvigorate soils; to Intag, Ecuador, to help the local coffee cooperative maintain a high quality of coffee through inexpensive methods; and a semester of studying abroad in Brazil. After graduating, he worked with 2Seeds Network, based in Washington D.C. That experience took him to Kijango, Tanzania, where he was part of a team that overhauled a small business education initiative.

"Through the program, I got to know one of the local parents, Mama Sophia, who mentored me on how to work the land," Pachón recalls. "We talked about how to try out different agricultural practices by starting experimental plots."

The two experimented with elevated beds and leaving bean residues on the ground of maize rows in three different areas of her field.

"I chose these treatments based on conversations I had with Mama Sophia and what I read from the soil."

The removal of bean residues with all of their nutrients was common practice. At the end of the growing season, the corn yield in the elevated rows with bean residues was about 30 % greater.

"Even in this remote area, people like Mama Sophia listened to weather reports on the radio. I could not help but imagine, what if the radio told villagers about other trends on the land," Pachón wondered. "If Mama Sophia had a better understanding of the macronutrients in her soil and those trends, her corn crops would have increased long before I arrived in Kijango.

"What if people talked about soil moisture levels and soil nutrient fluxes like they talk about the weather," he thought.

The Path to the University of Florida

The experience in Tanzania was eye-opening for Pachón, it reinforced his desire to work in international research and development. However, he also realized achieving his goals would require further education. As he looked at possible graduate programs, UF ranked high on the list because of its reputation and strong international ties.

His application caught the eye of Dr. Allan Bacon, assistant professor of environmental pedology, who was just hired into the SWSD.

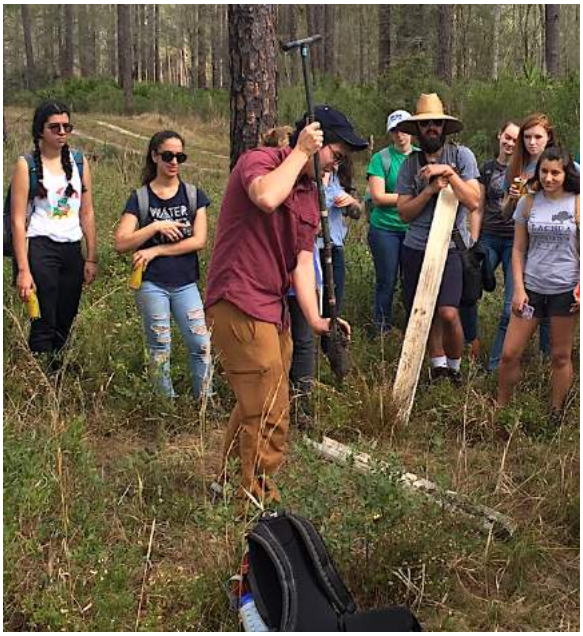
“I had heard all kinds of conflicting information about what constitutes a ‘promising graduate student,’ so I decided to look for someone with genuine life experience,” Bacon recalled. “Having traveled the world, Julio fit that bill. His undergraduate education and tremendous research experience were icing on the cake, I had to give him a call.”

Pachón was taking time off and had travelled to Hawaii when Bacon reached him.

“Waves crashing in the background couldn’t muffle Julio’s excitement nor his vision for how higher education could help him meet his goals,” Bacon said. “After ten minutes, I knew I needed this guy.”

He agreed on the spot, recognizing Dr. Bacon’s enthusiasm and the opportunity to join a lab in its inception; knowing that starting his own lab might become a possibility in the future.

Just before Pachón arrived at UF, Bacon added another important team member to the lab – a laser diffraction particle analyzer. Bacon said he had never used the technology, but that its potential utility in soil science was “written on the wall.” He asked Pachón to put it to the test.



Pachón teaching soil science to a forestry class in the field. (Photo provided)

“We had some notions about what sort of research Julio might conduct, but these notions were quickly thrown out the window,” Bacon said. “As Julio familiarized himself with the analyzer, he quickly discovered he could use the instrument to quantify soil aggregation in a whole new way that provided unique insights into this important environmental phenomenon.”

“Soils are fascinating,” Pachón said. “We have this rock that slowly weathers away, but the beautiful thing is as it comes back to the surface, it slowly comes back together in such a way that it becomes the catalyst for much of the life on land.

Conducting the Research

“It’s remarkable that with the particle size analyzer and four grams of soil, you can start getting an index of that microaggregation, the possibilities for research are extensive given how many projects have stored soil samples. It was exciting from the get-go,” Pachón said.

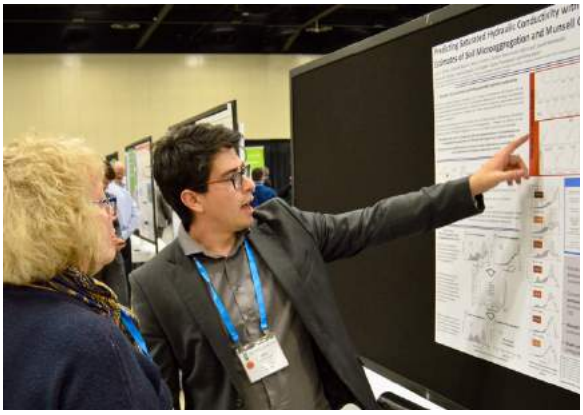
With the right tool in the lab and understanding its capabilities, Pachón got to work.

“For the first part of my dissertation, I took soil samples from the Calhoun Critical Zone Observatory (CZO) going down to eight meters deep to look at changes in physical properties of soil aggregates across profiles for soils formed in situ,” he explained. “I also used the PINEMAP (Pine Integrated Network: Education, Mitigation, and Adaptation Project) soils to look at differences in the physical properties of soil aggregates for soils across the Southeastern U.S.”

Another aspect of the research looks at changes in physical properties of soil aggregates across time. For that, Pachón used soil samples from the Calhoun Long Term Soil-Ecosystem Plots (LTSE), which has taken samples from 1962 to present in five-year intervals. A third research component is developing hydrologic models using soil aggregate data for samples at Calhoun CZO and with the soils from Florida’s soil survey that were taken back in the 1960-80s.

“It was very visionary to try to keep those soils here, not knowing exactly what they were going to be used for someday,” he said. “Luckily, I don't need that much of each one, so we can still save quite a bit for whomever needs some.”

The National Science Foundation awarded him a Graduate Research Fellowship. The three years of funding from NSF, and a small match from UF, will allow him to conduct the research and complete his degree.



Pachón explaining his research during a poster session at the 2019 Tri-Societies meeting in San Antonio, TX.

If that was not enough, Pachón hopes to complete another aspect of the research involving the soils of sub-Saharan Africa. Pachón is working with Dr. Pedro Sanchez, research professor of tropical soils, on a soil functionality classification system he has been developing.

The World Agroforestry Center (ICRAF) has data he can use to run his aggregate indexing, because ICRAF has laser diffraction data at different levels of dispersion. Pachón wants to use that data in conjunction with all the other soil data they have to model a selected number of soil constraints to plant growth with laser diffraction and spectrophotometry data.

“Soil classification done up to now is not very user friendly,” Pachón said. “But this soil functionality classification that Pedro has been developing tells you valuable information that’s more accessible, such as this area is soil erosion prone or nutrient deficient or rich in toxic elements.”

The goal is to classify all of sub-Saharan Africa with the information from the World Agroforestry Center in a more efficient and cost-effective way.

Future Plans

Pachón hopes to complete his dissertation and earn his Ph.D. in 2021. The other long-standing goal he has is to get more people to talk about soil like they talk about the weather.

“Farmers and people who work on the land, people who have close relations to land, in developed countries have a wide variety of tools, education, and resources to manage resources at a pretty high level,” he said. “They have sensors and data that match topnotch institutions anywhere. However, this is not true in most areas of the world, and this gap widens the living standards between people in most rural areas of the world and those in urban and developed rural areas.”

Pachón hopes to even out this inequality by getting more information into the hands of those who need it, in a form that they can understand. He points to the great wealth of knowledge in the United States and at the hands of farmers.

“At the same time, we still have a wide-ranging set of problems, of which an infamous example is the Gulf of Mexico with anoxic conditions,” Pachón said.

“There are still plenty of problems to be addressed in developed countries. In part because the topnotch data and information are in the hands of a few people,” he added. “If we can get more user-friendly information about local natural resources and how it changes over time to a wider community, then they will use it to address some of these problems. Asymmetry of information is a problem from the local area, to internationally.“

Taking Advantage of Opportunities

Julio has jumped at both privately and publicly funded opportunities. He views these as being key to developing conscientious global citizens who will tackle today’s and tomorrow’s challenges. To this end, Julio has worked, supported, and fundraised, so other people can further their potential.

“The ability my family had to move between two countries allows me to see the immense benefits that migration may bring to both the people moving, the receiving countries, and other countries given the sense of internationality you develop,” Julio said.

“Recent efforts to limit migration globally worry me,” he added. “I hope that the continuous transfer of knowledge and technology, along with controls for international financial transparency, can mitigate the number of people fleeing insecurity and poverty.”