The Foundations of our Forests

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Conservation Scientist, Soil and Microbial Ecology, Chicago Botanic Garden Characterized by warm temperatures, high rainfall and a 365-day growing season, tropical rainforests are an unparalleled display of biodiversity. These

Louise studying a sample of soil. (C) Chicago Botanic Garden

Tropical rainforests play a key role in the global carbon cycle. Forests are nature's carbon sequestration solution – trees pull carbon dioxide from the atmosphere to fuel photosynthesis and generate resources – like oxygen, wood, fruit and habitat – that we and other species depend on for survival. Today, these forests are the frontlines of climate change and, unlike vertebrate and impressive and unique ecosystems provide resources we need – from shelter to medicines to food – while releasing oxygen, cycling and filtering water, and sequestering one substance we're keen to reduce: carbon.

invertebrate species, forests are unable to adapt by quickly moving to new locations.

We already know that deforestation has intense effects on a forest's ability to continue providing vital services – including carbon cycling. Clearing forested land releases all that sequestered carbon into the atmosphere, species lose their habitats, and the soil is left exposed, promoting drying and erosion. But what about disruptions that aren't as obvious to the naked eye – like changes in the climate? My research focuses on an often overlooked, but crucial, part of the ecosystem – the soil. 2015 is the UN Year of Soils, and my work seeks to understand just what goes on far beneath the canopy. Tropical soil is not unlike the forests it fosters – bursting with life, full of a great diversity of organisms and micro-organisms, each serving a particular purpose and filling a niche in the system. I am particularly interested in the fungal species that live in symbiotic relationships with tree species – they provide a service, such as capturing and delivering resources like nitrogen or phosphorus or water to plant roots – in exchange for sugars that allow them to keep growing. These fungi are called arbuscular mycorrhizal fungi, and each fungal species has a different function and role to play. If you disrupt the diversity in the community, there's a good chance you'll also disrupt the host plant's ability to get the nutrients it needs.

A tree with fungi growth. (C) Chicago Botanic Garden

There's a lot we still don't know about soils and the species that live within them – we don't even have a full roster of who those species are! Just this month, my fellow Soil Ecology Society members and I continued the long-standing debate over just how many microbes there are in a teaspoon of soil and what their function might be. But, thanks to enhanced research techniques such as next generation genetic sequencing, we're getting closer. We know that fungi play specific roles in tropical forest communities, and we know that climate alters the roster of species in the soil. But the real question is, when a soil community is disrupted by changes in precipitation and temperature, what happens to the plants it supports? Do different fungal species move in and take over, allowing the plants to continue to thrive? If not, what do we, as conservation professionals, need to do to account for the loss of fungal species in restoration or conservation plans? Plant biology and conservation graduate student Benjamin Morgan and I are currently working to lay the foundation for answering these questions at three sites in the Yucatan. All three are in a part of the world where temperatures are expected to rise in the next 20 years, and one is slated for potential resort development in the future. We're documenting the diversity of arbuscular mycorrhizal fungi present in the soil and the functions that each species may serve. To date, we've found 163 species in one forest stand; this is the highest diversity of arbuscular mycorrhizal fungi detected in a plant community. This way, should the ecosystem dynamics change in the future, we will be able to identify the changes in soil fungi that followed. The same techniques can be applied to understanding the impacts of climate change. If we have a baseline picture of what the soil make-up was before changes in temperature or precipitation occur, we can better identify when changes are happening and what the consequences of those changes might be. As a result, we have started a manipulative experiment to measure the response of arbuscular mycorrhizal fungi to a reduction in rainfall. As the first experimental test of reduced rainfall in a dry seasonal tropical forest, these data will help improve the climate model predictions for the region. In Southern California, researchers found that soil fungi (not plants) were the first species to show signs of stress due to air pollution. It's possible that these species could be the "canaries in the coal mine" for recognizing when climate impacts are starting to take hold in an ecosystem. As efforts to mitigate and adapt to global climate change intensify, we must continue to work to better understand what's happening to the soil communities at the foundation for our ecosystems.

Rancho Higuera – a study site in the Yucatan. (C) Chicago Botanic Garden

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