Soil Ecology Update: Report from the Ecological Society of America Annual Meeting

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NEW LIGHT ON NUTRIENT FLOW

Take a nanoscale particle built with semiconducting material that shines under ultraviolet light. Attach the particle to a carbon compound and feed it to a fungus. Watch in real time as the root-associated fungus absorbs the brightly lit compound and then feeds it to the plant.

That was the brainchild of graduate student Matthew D. Whiteside, an organic chemist turned microbial ecologist in the lab of Kathleen K. Treseder at the University of California, Irvine. Much to the surprise of Treseder, the plan worked, and it has resulted in a new tool for tracing the flow of soil nutrients in ecological field work. She described the technique at a workshop on fungal environmental studies at the Ecological Society of America (ESA) meeting in Milwaukee.

The nanoparticles, known as quantum dots, "are like bright little LEDs," or light-emitting diodes, says Treseder. They have been used to home in on tumors in biomedical applications, but, she says, "this is the first time they've been used as a tool for ecologists."

The technique is shedding light on the question of whether root-associated fungi known as arbuscular mycorrhizae take up organic forms of nitrogen and transfer them to plants. The standard view has been that these fungi prefer inorganic nitrogen. But Whiteside hitched the amino acid glycine to a quantum dot and watched as the fungus absorbed the glycine (but not the quantum dots alone) into vacuoles, from where it moved into the nitrogen-demanding chloroplasts in grass. Ultimately, the researchers hope to apply the tool to the larger question of how the biosphere's increasing load of inorganic nitrogen from manufactured fertilizers is affecting the balance of carbon and nitrogen in soil, and consequently in the atmosphere.

The quantum dots would substitute for radioactive or other tracers in field studies, but the nanoparticles potentially pose other risks. The US Environmental Protection Agency is funding research to determine whether nanotechnologies are harmful to human health and the environment, and as with other tracers, the quantum dots may be altering the organism in some unforeseen way.

Treseder says the dots' sensitivity means that only a small amount get used, and while they are currently built out of heavy metals, the next generation of dots will be made with iron, which should allow them to be recovered from soil with a magnet.

"Microbial uptake is difficult to study in natural systems," says Ann Russell of the National Science Foundation's Ecosystem Science Program. "This new application of nanotechnology should prove to be a valuable tool in unraveling the mysteries of nutrient uptake through arbuscular mycorrhizal fungi, and may pave the way for other future applications." A report on proof of the quantum dots method is slated for the January issue of *Ecology*.

CARBON FLUX IN A CHANGING CLIMATE

Tracing how fungi and other soil microbes process carbon and other nutrients has become particularly important as the carbon load in the atmosphere increases and manufactured nitrogen increases in the biosphere. Soil microbes transfer an enormous amount of carbon to the atmosphere—some 10 times the amount from fossil fuel burning. How might this change in a warmer world? Numerous presentations at the ESA meeting in August took up the question of climate change and belowground carbon flux. Microbial response is turning out to be extremely varied, according to site, communities, and overall background climate.

For example, rain seems to be a crucial variable for fungal communities in northern California. At the Angelo Coast Range Reserve, ecologist Christine Hawkes, of the University of Texas at Austin, and her colleagues watered meadow plots at a rate corresponding to a predicted 20 percent increase in precipitation for northern California. They found that an increase in spring rain led to a change in the fungal community composition and a 200 percent increase in microbial respiration six months later. For this Mediterranean climate, an increase in rain, depending on when it falls, could result in a greater loss of carbon from the soil—and a further increase in atmospheric carbon.

Other researchers are finding that changes in fungal respiration depend on the species. Some plants are known to slow their respiration at higher temperatures, so Glenna Malcolm, in Roger Koide's lab at Penn State University, looked at what root-associated fungi known as ectomycorrhizae might do under the same conditions. (Ectomycorrhizae associate with the roots of such trees as oak and pine, whereas the more common arbuscular mycorrhizae associate with 80 percent of vascular plants.) Three of twelve fungal species tested did slow their respiration rates, by 20 to 45 percent, when incubated at a higher temperature. Although field results may differ from these lab findings, Malcolm suggests that the structure of the fungal community can determine how a soil's overall respiration rate would be affected by a rise in temperature.

The push to understand all the variables in soil carbon flux comes not only from ecologists but also from climate scientists, Hawkes says. "It's an idea whose time has come."

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