Scoop up a handful of dirt from your garden or backyard. It may look like nothing’s there. In fact, you’re holding some 200 billion organisms, including tens of thousands of different species. And most of them are in the midst of a vital job: recycling dead plant and animal debris.

“If it weren’t for the activities of soil organisms, we’d be buried in organic (once living) matter,” says Serita Frey, UNH professor of soil microbial biology. “Anything organic that lands on the soil gets decomposed very quickly by these organisms: leaves, trees, dead animals.”

Invisible to the human eye, this work is nonetheless critical to the health of our planet. “I don’t think ecosystems could survive without decomposition,” Frey says. “If organic materials weren’t broken down, the nutrients held within those leaves wouldn’t be available for plants to take up again. It’s this whole cycle that has to happen for the world as we know it to sustain itself.”

But what if we are unwittingly disrupting that cycle? Frey’s research examines the impact of human activities on soil microbial communities, especially fungi. These tiny, diverse organisms — many of which have yet to be identified by scientists — are the main decomposers in the temperate deciduous forests of the northeastern United States.

Consider fossil fuel burning: Along with fertilizer used for agriculture, it’s causing a worldwide increase in nitrogen, an important nutrient that can also be hazardous to the environment. Auto exhaust, coal-fired power plants, and other industrial activities emit nitrogen into the atmosphere, where it often travels great distances before returning to earth in rain, snow and dry particles. For instance, winds blow polluted air masses from the Midwest and Mid-Atlantic to the Northeast, which has nitrogen levels five to ten times higher than in pre-Industrial times.

“It’s basically causing an inadvertent fertilization of natural ecosystems, and in the Northeast, mostly forest ecosystems,” Frey says. “The northern forests didn’t evolve under these conditions. They haven’t adapted to these conditions. They’re used to very low nitrogen.”

Since coming to UNH in 2002, Frey has been studying the effects of excess nitrogen in the Harvard Forest, an experimental research site in central Massachusetts. There, researchers spray fertilizer onto forest plots to simulate excess nitrogen entering the soil through precipitation.

Her team has found some dramatic changes in the treated soil, she says. “We see a suppression of decomposition, so that it’s not occurring as rapidly as it does in an unfertilized forest. And we see an accumulation of organic debris on the forest floor — a thicker layer of un-decomposed or partially decomposed leaf material.”
Fungi break down organic matter by releasing digestive enzymes into the soil, Frey explains. Nitrogen appears to suppress these enzymes, especially those necessary for completely degrading complex materials such as oak leaves, pine needles and wood. In addition, nitrogen seems not only to reduce the amount of fungi present, but also to change the types of species present. The current hypothesis is that the species found in greater abundance — those able to tolerate higher nitrogen levels — are not as effective at decomposition as the species that have declined because they cannot tolerate nitrogen.

Frey and her team are taking a multi-pronged approach to better understand how and why nitrogen is altering decomposition. Using molecular techniques, they’re sequencing the DNA of fungal communities to get a clearer picture of which species are present, as well to what extent genes involved in decomposition are being expressed (or not) in the presence of nitrogen.

They’re also growing fungi in the lab and conducting experiments under different nitrogen conditions. Working with Anne Pringle of Harvard University, for instance, they’re studying fungi from an evolutionary perspective. That is, they want to figure out if fungi evolve in response to nitrogen fertilization in a way that changes their ability to decompose organic materials.

Ultimately, Frey’s research may have implications far beyond the lab. “There could be regulations or policies enacted that would reduce nitrogen pollution in the atmosphere,” she says, “and I think for a lot of reasons that could be beneficial. There’s too much nitrogen in the environment, and that also harms water quality and human health.”

Meanwhile, Frey is looking at how other recent changes — including warmer temperatures — are affecting soil microbial communities. Though she’s been doing this work since graduate school, in a sense she’s been preparing for it much longer, since she was a child of four or five growing up on a dairy farm in Virginia. Each year, she’d help her father collect, dry and pack soil samples to send away to a lab for routine testing. Then, during her sophomore year at the University of Virginia, she simultaneously took courses on ecology and microbiology. She was intrigued to learn that microbes have a role not only in disease, but also in environmental processes.

That was the turning point that led her to a career in soil ecology. “It merged my longtime interest in the environment and my new fascination with very small things — things we can’t see but we know are doing really amazing and important work.”

Frey’s research is a key component of the NH EPSCoR Ecosystems & Society project to measure changes in climate and land use in small streams across the state.

To learn more about Serita Frey’s work, visit: http://www.youtube.com/watch?v=h0XpJdPRROw
http://nre.unh.edu/faculty/frey
http://unh.edu/news/campusjournal/2011/Nov/02profile.cfm