Soil Health: The Unseen Foundation of Biodiversity

by Irene M. Unger, Ph.D.

As we celebrate 40 years of Missouri Natural Areas, undoubtedly many will think about the rare plants, animals and geological features protected by this valuable land protection system. The remnant prairies, old growth forests and woodlands, wetlands and caves, and their associated inhabitants provide inspiration as we strive to protect them and the biodiversity that they foster. Nevertheless, we may well be overlooking a key component: how often do we think about the soils that underlie and support these areas?

Soils are teeming with life: as many as 10,000 to 50,000 species of microorganisms may inhabit a single gram of soil. This unseen life provides us with many of the ecosystem services upon which we and other organisms rely, including clean water, the decomposition of organic matter, and nutrient cycling. Much like climate, soils help determine which plants flourish; in turn, these plants determine which animals thrive. Therefore, it is quite accurate to state that soils and geology are the foundation of the biodiversity we seek to preserve and protect in our Natural Areas. Thus, just as a wildlife manager may also be a plant ecologist because wildlife depends on plants for habitat and food, a landscape manager may also be a soil scientist for similar reasons.

While we know that different ecosystems (e.g., prairies vs. forests) support different microbial communities, much is yet to be learned about the relationship between the soil microbial community and the terrestrial plant community it underlies. For example, what is the pace and character of the succession of the soil microbial community in response to aboveground disturbances, including our restoration efforts? We know that in many ways, plant development drives animal succession. Even animals not necessarily tied to a particular set of plant species may be tied to the dominant

Photos by Irene M. Unger

Two Westminster College students assess soil color as a part of sampling for MO-DIRT (Missourians Doing Impact Research Together), a citizen science program looking at soil heath and how it is influenced by microclimate. Soil color can be used to estimate the organic content of the soil, an important component of soil health.

plant forms. In other words, it might not matter as much which trees are present, but rather that trees are present. What, then, is the role of the soil microbial community? Does the development of plants drive the succession of soil microbes or is it the other way around? We know the vital role soil microbes play and thus could argue that they are the driving force. However, we also know the soil microbial community changes in response to changes in the aboveground terrestrial community. As a terrestrial community transitions during the restoration process, the soil microbial community will transition with different groups (i.e., bacteria vs. fungi) responding in different ways. While some changes in the soil microbial community may come quickly with fluctuations in the aboveground community, there appears to be a lag-effect of decades or more before the soil microbial community of a restored prairie or forest resembles those of native remnants in our designated natural areas.

The soil microbial community is diverse and resourceful. It responds to changes — favorable or not — in its habitat, just like any other community. For example, we know that plowing or tilling affects soil structure by reducing the amount of macropores (i.e., large pores that drain freely by gravity). This in turn affects not only how water and the nutrients it carries moves through the soil (macropores allow for easy movement of air and water), but it also reduces habitat for soil microorganisms. Soil microbial community diversity is typically higher in natural systems, such as remnant prairies, than in those that have been plowed or managed for crop production. The deep and expansive rooting systems of the diverse perennial grasses and forbs in native prairies provide habitat and carbon-rich secretions, whereas the seasonal loss of aboveground materials provides other important nutrient molecules through plant litter. Similar resource additions are not provided by annual, monoculture cropping systems such as corn and soybean fields. Diversity begets diversity.

We also know that other disturbances, including flooding, periodic fires, and logging, can affect the biodiversity of the soil microbial community. For example, the duration and the nature of a flood event (i.e., stagnant vs. flowing water) can result in changes in the abundance of different microbial groups, with some being favored and others diminished. These changes may impact soil nutrient cycling and, subsequently, in the ability of the terrestrial plant community to reestablish after a flood event.

Invasive species including garlic mustard (*Alliaria petiolata*) and sericea (*Lespedeza cuneata*) also alter the soil microbial community through their root secretions and litter contributions. For example, soil microbial community structure and function in the soils associated with the rooting zone of sericea differs from that of soils associated with native prairie vegetation. In a recent study, I partnered with other soil scientists to demonstrate that these invasive plants may continue to have an influence long after they are removed, particularly if their roots remain (top-killed only), or if these plant species are capable of producing chemicals that influence the germination, growth, survival and reproduction of other native plant species. We discovered that even though a restored or reconstructed prairie may resemble a remnant prairie on the surface, differences may remain in soil chemistry, structure and microbial community. As noted above, these differences may translate into reduced ecosystem services.

By protecting high quality functioning ecosystems, natural area managers are protecting more than the plant, animal, and geologic communities. While a primary objective is to preserve these visible components of natural areas, in protecting these areas, soil microbial communities and their vital ecosystem services are also preserved. The value of these ecosystem services must not be underestimated because they help to provide the foundation for the aboveground diversity. In addition, the protection and study of natural areas are vital to efforts to restore damaged ecosystems as they serve as reference condition landscapes towards which ecosystem restoration efforts aspire. As we celebrate 40 years of Missouri's natural areas, we celebrate both the seen and unseen biodiversity of these significant landscapes.

Irene M. Unger, Ph.D, is Associate Professor of Biology and Environmental Science; Environmental Science/Studies Program Coordinator; and Sustainability Coordinator at Westminster College

Contact: Irene.unger@westminster-mo.edu