Minnesota Department of Natural Resources

The Roots of Healthy Habitat

Whether you're talking about the vitality of wildlife, plants, or people, healthy soil is the matrix for a good life.

by Brian DeVore

Numbers can make or break a farm: bushels to the acre, pounds of milk per cow, dollars in the bank. But to Minnesota crop and livestock producer Duane Hager, such figures mean little unless they are rooted in one über statistic: How many billions of organisms are residing in his soil?

"You've got life in the soil, and it's just like your livestock—you have to feed it," says Hager, who farms near the Mississippi River in Wabasha County. On a summer day, he checks on his subterranean herd by walking into a cornfield with a shovel. The soil's been feeding on the roots of small grains such as oats, as well as manure from his dairy herd, and stalks and leaves from previous corn crops. And the eating's been good.

Although a tablespoon of healthy soil contains more organisms than there are people on Earth, most of those fungi, bacteria, and invertebrates are too tiny to see with the naked eye. But the result of their feverish activity is evident: A clump of soil Hager unearths has a crumbly, cottage-cheese texture, which leaves room between particles for water, roots, and oxygen to flow. An earthy fragrance wafts up, produced by organisms called actinomycetes. This soil is so buzzing with life it could produce an electrical current, given the right circumstances.

Hager says his soil erodes little, soaks up water even in low areas, and "flows" off his field equipment. These are clear benefits of healthy soil, but Hager asks, "What are the hidden costs of not taking care of that soil life?"

Plenty, it turns out. Farmers, scientists, and natural resource professionals are increasingly concerned about the consequences of treating our soil like dirt. What happens when we leave soil bare or apply chemicals that kill the microbes that make it healthy? These practices not only threaten the soil's ability to produce food, they also limit its capacity to store greenhouse gases, protect water, and support wildlife. How soil is managed has major environmental implications in Minnesota, where half the land is farmed.

"We go way beyond the fields with soil health. The field is part of an ecosystem. Soil health affects pollinators, wildlife, water quality, and, most importantly, people," says Douglas Miller, Minnesota soil health coordinator for the Natural Resources Conservation Service. "Anyone who likes to hunt, swim, or enjoy the outdoors—this is something they should be interested in."

Build Robust Soil

Whether on the farm or in a garden, healthy soil supports not only plants but also the billions of microorganisms beneath our feet. Here are ways to build soil health:

- **Keep soil covered. Plant a quick-growing cover crop such as buckwheat after harvesting the season's last garden vegetables. The cover protects the soil, smothers weeds, and puts lots of roots in the ground.**
- **Till the cover crop in spring to enrich the soil before planting.**
- **Use mulch between garden rows and walk lightly on the ground to avoid creating paths of compacted soil.**
- **Work the soil when dry, not wet, to minimize compaction.**
- **Compost, compost, compost. Backyard compost piles rich with organic matter—vegetable scraps, egg shells, coffee grounds, leaves, grass—create humus. Add it to soil to boost biological activity.**
- **Find more tips from the U.S. Department of Agriculture.**

Murky Waters. On a winter day, Miller pulls out photographs from the 2012 growing season in south-central Minnesota. One taken in April could have come straight out of the Dirty '30s when drought and wind eroded soil: Dust fills the air above rows of newly sprouted corn. A photo taken after a June downpour shows corn plants drowned at the bottom of an eroded slope. An August photo shows heat-stressed corn with leaves rolled in to preserve moisture.

"The soil has failed to function as it should," says Miller. The inability of soil to absorb rain—causing the soil to either erode or flood out—is abnormal, he says, as is the ease with which it blows away. "If the topsoil was protected with plant residue and not over-tilled, this erosion would not have happened."

More than 46 percent of the world's soil is suffering from "destroyed" biological functions, according to the International Soil Reference and Information Centre. It's easy to overlook soil's ill health because in general it does what we want it to do: produce bumper crops. But those yields are increasingly reliant on inputs of petroleum-based fertilizers and other chemicals. A vicious cycle has been launched: More chemicals result in less biological activity, which means even more chemicals are needed to prop up yields.

Unhealthy soil threatens to hobble the great strides made in conservation since the Dust Bowl. U.S. Department of Agriculture figures show that erosion on U.S. cropland dropped 43 percent between 1982 and 2007. That accomplishment resulted in large part from conservation tillage, which shuns plowing, and from retirement of erosion-prone acreage through initiatives such as the Conservation Reserve Program. But soil conservationists worry that the news won't be so good when USDA's updated figures come out later in 2014. In some places, soil is so compacted and devoid of life that roots and moisture can't penetrate it—rain may as well be slapping a sidewalk. This makes it harder to grow crops and means more water runs off the surface without soaking in, carrying soil with it.

Eroded sediment running into waterways is the top cause of nonpoint source water pollution in farming states like Minnesota, according to the U.S. Environmental Protection Agency. Sedimentation raises temperatures in lakes and rivers and fills the nooks and crannies where caddisflies and other aquatic invertebrates normally thrive. Murky water makes it harder for smallmouth bass, northern pike, and other predator fish to hunt. These conditions favor species such as carp, according to Ryan Doorenbos, Department of Natural Resources fisheries supervisor in Windom.

"Sedimentation increases turbidity," he says. "That reduces light penetration and inhibits growth of aquatic vegetation. That vegetation improves water quality by tying up nutrients, reducing wave action, and providing fish habitat."

Organic Matters. Humans can exert control over the fate of this natural resource. And it's easier to increase soil's quality than to build its quantity. Creating a 1-inch layer of soil can take a century or more. "But you can increase your organic matter in a number of years," says Caryl Radatz, soil survey regional director with NRCS in Minnesota.

Energy-rich organic matter—plant and animal residue, along with the tissues of living and dead microorganisms—controls everything from how much nutrition plants get to how much rain the soil can soak up. Unbroken prairie soils can have 10 percent or more organic matter. Due to intensive tillage and chemical use, organic matter levels in some Midwestern crop fields have plummeted below 2 percent.

Organic matter forms the basis of the food chain that supports key species on the land. For example, researchers at North Carolina State University have learned pollinators prefer visiting plants grown in soil where compost, as opposed to chemical fertilizer, has been used to provide fertility and build microbial health.

"If you have a healthy soil, you have healthy plants," says Richard Olsen, DNR assistant area wildlife manager in Glenwood. "If you have the plants, you have the bugs that are going to attract the wildlife. It's all connected."

Deposits in Soil Bank. "Half of a soil's organic matter is carbon, so the connection is pretty clear between building organic matter and storing carbon," says John Baker, a soil scientist with the USDA's Agricultural Research Service. He is studying greenhouse gas emissions and cropping systems. The United Nations says soil stockpiles 2,500 gigatonnes of carbon, more than Earth's atmosphere and all its plants.

In prairies, wetlands, forests, and other perennial plant systems, a diversity of plant roots builds organic matter to create a basement pantry that's always open. As of 2013, Minnesota had 1.25 million acres enrolled in CRP, which keeps environmentally sensitive land covered with grasses and forbs. But about 196,000 acres of grassland were converted to row crops in Minnesota between 2006 and 2011, due to high commodity prices and a federal crop insurance program that encourages tillage. Such grassland conversion rates haven't occurred since the 1920s and '30s, according to *Proceedings of the National Academy of Sciences*. The plant regime replacing those perennials—monocultures of corn and soybeans—covers the soil only around 90 days a year. That means a lot of bare ground and some lean months for the soil food web.

One place where soil's basement pantry is being restocked is North Dakota's Burleigh County. There, farmers, conservation experts, and scientists have attracted attention from as far away as Australia by growing "cover-crop cocktails" of small grains and other plant species between planting and harvesting of row crops. In concert with rotational grazing and no-till, this practice helps protect and feed the soil. Soil organic matter is going up, and erosion and runoff are down, according to microbiologists.

In 2013 about 50 Minnesota farmers signed up for a new USDA program that funds multispecies cover cropping for up to five years. And the National Wildlife Federation has launched a program that recognizes certain farmers as "cover crop champions." Among other things, the program pays those farmers who plant cover crops to talk to other farmers about the many benefits: Cover crops provide food and shelter for grassland birds, insect pollinators, and other wildlife. Cover crops can reduce nutrient and pesticide runoff by 50 percent and sediment in water by 75 percent.

Farmers need to see an economic benefit as well. Gabe Brown represents that juncture where public good meets private incentives. On a September day, the Burleigh County producer shows off a stand of corn that's thriving despite droughty conditions. During the past decade, Brown has raised his soil organic matter content from less than 2 percent to nearly 6 percent. Now his soils make better use of moisture and cook up their own fertility. Brown has not relied on commercial fertilizer since 2008. That's good for the environment. And it's money in the bank: Each 1 percent of organic matter holds the equivalent of $700 in soil nutrients, according to the Ohio State University Extension Service.

"We're working hand in hand with nature," says Brown, holding a clump of dark soil and watching two white-tailed deer browse near a windbreak. "I look at it as an investment."

Looking for volunteer opportunities?