Smithsonian.com

THE AGE OF HUMANS
LIVING IN THE ANTHROPOCENE

Soil Has a Microbiome, Too

The unique mix of microbes in soil has a profound effect on which plants thrive and which ones die

The microbes living in soil may be crucial for healthy plants. What’s more, soil microbiomes are hyperlocal, varying immensely from place to nearby place. (blueenayim/iStock)

By Carrie Arnold
smithsonian.com
August 11, 2016

[The Netherlands, home to windmills and clogs … is also home to intensively farmed cropland.][1] Holland’s small size and large population have meant that the country his historically needed savvy agriculturalists to feed its people. But as it grows less and less of its own food, the government has to buy out farmers to return cropland to a wilder state.

When this program started several decades ago, according to Martijn Bezemer, a biologist at the Netherlands Institute of Ecology, conservationists would simply stop planting and let the land be, or they would strip off the top layer of soil and leave the sandy subsoil exposed to the elements. Neither approach met with much success. It seemed that no matter how long they waited for a healthy grassland to take hold, the soil, degraded after decades of high-intensity farming, wasn’t recovering.

The government recruited Bezemer to try and speed up the restoration process. His group began experimenting with the process of inoculating degraded soils with dirt from healthy ecosystems. Just as physicians could treat many intestinal problems by transplanting gut microbes from a healthy person into a sick one, Bezemer’s group wanted to use healthy microbes to treat a sick ecosystem.

Their initial work in greenhouses and on small plots impressed Machiel Bosch, a nature manager for the government who was helping to oversee the restoration process in the Netherlands. Several years ago, when Bosch received a new parcel of land, he invited Bezemer to try his soil microbial transplants on a larger scale.

The results were recently published last month in the journal *Nature Plants*, revealing that small soil inoculations from grassland or heathland could help determine which plants would colonize the area and thrive in the future. “You don’t get the right plants if you don’t have the right soil,” says Bezemer.

Scoop up a handful of soil. The dirt you hold in your palms forms the basis of the life around you, from the earthworms crawling in your garden to the raptors hundreds of feet in the air. But soil is not just a lifeless pile of earth. Symbiotic fungi living in plant roots—known as mycorrhiza—help the plants extract vital nutrients. Other microbes break down decaying plants and animals, replenishing the materials used by the plants.

Historically, scientists believed that soil microbes were broadly similar around the world, from Asia to South America More recent work has revealed, however, that microbial populations are actually hyper-local, explains Vanessa Bailey, a microbiologist at Pacific Northwest National Labs. The soil she studies at the foot of Rattlesnake Mountain in Washington State is actually quite different from the soil at the top, with an elevation change of just 3500 feet.

What this means for scientists is two-fold. For one, it means that microbial diversity in soil alone is probably far more immense than anyone had anticipated. “We have the tools now to describe microbes in much greater detail than even five or ten years ago,” said Noah Fierer, a microbiologist at the University of Colorado at Boulder. “Yet 80 percent of the soil microbes in Central Park are still undescribed. There’s a lot of diversity to reckon with.”

The second implication is that two different ecosystems, even those in close proximity, could have very different microbes living in their soil. A plant might survive drought not because of something inherent to its physiology, but because of the assortment of symbiotic microbes in the dirt, Fierer said. Plant the seeds elsewhere, and they may not be able to germinate, grow and thrive without the proper mixture of bacteria and fungi. As researchers began learning more about the depth and complexity of these interactions, Bezemer realized that could explain why his native country’s attempts at returning farmland to native ecosystems was failing.

The process could work, Bezemer believed, if the right soil was present. At first, he tried moving the soil wholesale. It wasn’t a problem for small projects in pots and greenhouses, but scaling any projects up would be difficult, as soil is heavy and hard to move. Still, these early trials gave Bezemer enough data to show that seeds did better when they were planted in soil taken from other ecosystems where those species thrived.

Not only did the plants grow better, but the transplanted soil also prevented weeds and other non-desired plants from dominating the new system before the native species had a chance to take hold.

For Bezemer, the problem with this approach was the amount of soil needed. To adequately convert farmland to grass or heathland across the Netherlands, conservationists would effectively have to strip all of the soil from healthy ecosystems. But if microbes were the important factor, then maybe he didn’t need massive quantities of dirt.

Since no one knew exactly what microbes were important and in what quantities, Bezemer couldn’t simply sprinkle bacteria on the desired area. But, he theorized, perhaps small amounts of soil contained enough microbes to get the system started and set it on the desired path.

In some of the plots, the researchers removed the old layer of topsoil and exposed the sandy subsoil. In others, however, they left the existing topsoil intact. They then covered it with a centimeter or two of soil from either grassland or heathland, sowed a variety of seed, and waited.

The experiment took six years, but the data clearly showed that the donor soil steered the former agricultural land towards an ecosystem that looked like the original source. Grassland soil created grassland, heathland became heathland. Stripping the topsoil allowed for stronger donor soil effects, and the ecosystems also recovered faster.

Bailey, who published her own study earlier this year on how climate change might affect soil microbes, says that these results show not only the effects of donor soil on ecosystem restoration, but also how competition between soil microbes can affect how plants grow. The likely reason that the inoculations had less of an effect when the topsoil wasn’t removed was competition between the existing microbes and the ones in the transplanted soil.

“Microbes behave in surprising ways, and we need a better understanding of how they colonize soil and of all of the different ecological processes that these microbes carry out. We really have no idea,” Bailey said. Scientists still don’t know how and why these soil transplants work, just as they really don’t know much about why fecal transplants are so successful in humans. This paper shows, however, that the soil transplants do in fact work, Bailey says.

Fierer praised the study, saying it “highlights the links between soil and ecosystem health, showing the power that changing soil can have,” but also raised a note of caution. The researchers may have used a much smaller amount of soil than previous experiments, but it would still take massive amounts of dirt to restore even small areas. Nor can anyone be sure what in the soil is driving the ecological changes. Bezemer and other soil experts agree that it’s almost certainly the microbes, but given the complexity of soil, nothing can yet be ruled in or out.

Soil remains an ecological black box for scientists. Even now, researchers are just beginning to understand how microbes that we can’t even see could potentially shape the world around us.

The first sentence of this article was edited for Grade Level Appropriateness.[1]

https://www.smithsonianmag.com/science-nature/soil-has-microbiome-too-180960088/