Letter From the Desk of David Challinor
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When a friend recently told me he had a truckload of dirt delivered to enlarge his garden, I gently reminded him that dirt is what you sweep under the rug; soil, not dirt, was delivered to him! Scientists, organic gardeners and others who study and work with this medium fight a losing battle to alter most people's perception that soil and dirt are synonymous. Actually, soil is an extraordinary, dynamic combination of minerals, chemicals and organisms, both alive and dead. We depend on it for much of our food. This letter is about soil and how it affects us all.

Converting solid rock to soil is a slow process. Consider the Appalachians: millions of years ago they were as high as the Rockies, but today perhaps one-third of their original solid rock volume has been ground into soil particles by a combination of physical and chemical processes, creating the soil of the Piedmont and the coastal plains, the silted sea bottom of our Atlantic shelf, and the shallows of the Gulf of Mexico. Their once jagged peaks are now rounded and generally forested. The weathering of these ancient peaks continues apace and the soil so produced continues to fill in the Chesapeake and other coastal estuaries.

On land, soil is the relatively thin layer that is the interface of the atmosphere, hydrosphere (rain and fog, streams and lakes), geosphere (rocks) and biosphere. Only by the interactions of these four spheres is soil created. For example, the acids in the hydrosphere's rainwater react with the calcium carbonates in certain rocks and cause them to dissolve, thereby creating subsurface caverns. Changes in atmospheric pressure create winds that propel soil particles with such speed and volume that they literally sandblast away soft rock outcroppings.

Soil itself consists of mineral particles from once solid rocks and organic particles from decayed plant and animal parts and products. Most soils are roughly an equal mixture of solids and the open spaces between; where dry conditions prevail, these pores are filled with air. When wet, water seeps into some of them, or in water-saturated soil, water fills up all the pores.

Rather than dwell on the details of soil classification, let me emphasize the importance of all soil types as shelters for those organisms that have evolved to live a buried life, such as truffles and mole rats. With a few exceptions, such as epiphytes (like Spanish moss) or certain parasites (mistletoe), rooted terrestrial plants are dependent on soil for their four essential macronutrients: nitrogen (N), phosphorous (P), potassium (K), and calcium (Ca). Plants and trees absorb these elements in large volumes through their roots. This means that when a fast-growing, nutrient-rich crop such as corn is harvested for silage, leaving only roots behind, farmers have to replace the soil nutrients lost with the harvested crop. To do so they spread chemical salts such as ammonium nitrate and potassium chloride over the soil. These salts easily dissolve in water and furnish nitrogen and potassium to plants almost immediately. Cow manure mixed with straw or sawdust will also replace lost nutrients, but at a slower rate. Applying fertilizers to soil can backfire: rapidly dissolving salts often leach from the soil and evaporate into the air before plant roots can absorb them. Even cow manure application is not risk-free. On poorly drained fields in Holland, the soil cannot handle the enormous volume of cow manure that is spread on them. The nitrogen-supersaturated soil is as detrimental to a crop as having too little available. The Dutch dairy farmer's dilemma is how to dispose of his cow manure if he cannot put it all on his pastures.

The four dominant elements in the biological soil components are: carbon (C), nitrogen (N), oxygen (O), and hydrogen (H). The C from decomposing plant parts combines with the soil's O to form carbon dioxide (CO_2). This gas is released into the air where it is "inhaled" by plants and trees as part of photosynthesis. H and O combine to form water, which is then returned to the hydrosphere. N is first released as ammonia (NH_4+), which in turn is broken down by specialized bacteria into soluble nitrates to be taken up by plant roots. This simplified description of the soil's role in the nutrient cycle does not do justice to the complex and dynamic process by which the world renews its biological resources and repairs or mitigates human and non-human assaults on its biosphere.

When acid rain falls on a forest, scientists were initially concerned that the combinations of high acidity and rainfall could be lethal to vegetation. Although red spruce in the high Appalachians apparently did succumb to acid rain, most forest trees in North America have withstood its toxic effect by the buffering action of soil bacteria. About 20 years ago, one rainfall at the Smithsonian's Research Center in Edgewater, MD had a pH of 3.2, or about as acidic as table vinegar. The forest there survived this dousing and subsequent less acidic ones, again by the action of soil bacteria making the soil less acid.

Trees have their own survival strategies; they must be resilient because they cannot move to a place with better growing conditions. As long as the soil stays fertile and watered, a tree can often survive with half its roots cut off. A cut root sprouts new rootlets, just as a cut branch does. What is often lethal to a tree is to bury its base under a foot or two of fill as is often done in altering the grades in a housing development. This deprives the roots of oxygen and the tree will generally die the following year. It will survive in the short run from nutrients stored in its trunk and branches, but only while they last. Always look for a wide stone well around the base of a tree where the natural grade has been altered. Even a good well cannot guarantee survival of a large tree, but it greatly improves the odds.

An easy way for gardeners to improve soil is to increase its organic matter content by regularly adding decomposed leaves and grass clippings. Doing so can change a tight, almost poreless clay into a friable (crumbly) loam in a few years. The transformation of leaves and clipping to odorless dark brown mulch takes time and care, but the results are rewarding. For fast conversion, the carbon to nitrogen ratio of the decomposing mulch should be roughly balanced. Fresh lawn clippings tend to compact and, because they have a high N content, anaerobic (lives without oxygen) bacteria breaks down the rich grass into ammonia compounds causing the pile to smell like a stable. Dry leaves are high in carbon and if kept mixed and aerated with grass or other green cuttings, the balanced mixture will decompose without odor. One can speed the process by adding bacterial innoculants to the pile. Such additives are available commercially and are specially prepared to work on grass or leaves, whichever is dominant.

Particularly effective decomposers are small red earthworms that thrive in warm mulch piles. They, too, are available from garden supply houses and are about half the size of the well-known garden earthworm that Charles Darwin studied. He reported in a paper published in 1881 that earthworms in a meadow can turn over (by consuming and excreting soil) from 10 to 20 tons of earth per acre per year. Look at the ground closely in the spring and you can often see little piles of spherical earth secreted by an earthworm around its hole. Many holes will also have leaves or other plant parts pulled down by the worm for feeding. All this activity aerates the soil to encourage aerobic bacteria as well as increases its organic matter content and porosity. Earthworms in the family Lumbricidae have about 170 species, of which 40 or more live in various soils of eastern USA. Some taxonomists argue that the commonest species (Lumbricus terrestris) is not native to North America but may have been accidentally imported by the Vikings! Evidence or proof are hard to find. Other soil dwellers are mites, roundworms, springtails, pill bugs and millipedes. Most are so small that you need a microscope to see them.

The Zoo's invertebrate exhibit has a semicircular table with about 10 microscopes and stools. Children are encouraged to take a spoonful of soil and view it under the microscope to identify the invertebrates that are illustrated in large-scale drawings over the viewing table. Relatively few children under eight years old have the patience to look long enough to find them, but those who do have a whole new world opened to them. I admit my bias and excitement in watching this microscopic world and believe the exhibit is successful if even only one child in 20 explores it. The others, hopefully, will at least have learned that soil is not dirt.

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