The Unseen World of Soil and Sand

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At the end of August, shortly after writing our 'stressed out' August New Farm column(www.NewFarm.org/columns/Martens/august/index.shtml), we took a much appreciated vacation to the Outer Banks of North Carolina. One afternoon, I left Klaas and the kids swimming at the Cape Hatteras National Seashore and walked alone south along the beach toward Cape Point, the easternmost tip of the United States that juts far out into the Atlantic, nearly to the Gulf Stream. Off to my right was the famous Cape Hatteras lighthouse, rising tall and hazy in the shimmering heat. Up ahead, there was nothing but beautiful empty sunswept beach, no people, no buildings, no sign of human hand.

As I walked, I became very aware that I was not alone at all. Small silvery fish and an occasional crab darted in the surf, rainbow-hued coquina clams and industrious sand fleas burrowed rapidly in the sand each time a wave receded, sandpiper birds nimbly played tag with the moving water, their long beaks pecking constantly at the sand. Indeed, around my feet was a complex and deft choreography of movement and interaction that had nothing to do with me. But the real choreography of the beach, the most important life, lay totally unseen from my eyes.

LIFE ON A GRAIN OF SAND

In the April 1995 Discover Magazine, Viginia Morell wrote an utterly delightful article entitled "Life on a Grain of Sand." (www.discover.com) In this, she describes the strange and wonderful microscopic jungle of tiny animals and plants that thrive in the seemingly sterile sand. A single handful of wet sand can contain over 10,000 such creatures, a complex myriad of eating and being eaten, of movement, of variation and of reproduction.

These are really unusual looking creatures. The meiofauna, as the tiny invertebrate animals are called, are equipped with all sorts of odd appendages and body shapes that are well adapted to this unique environment. The tardigrade, popularly known as the 'water bear' is a mere half millimeter in length, looking like a tiny piece of silver confetti with legs and claws. The claws enable it to grip and move over the sand grains. Some types of tardigrades have suction toes to hold them in place, while others have a teardrop-shaped bubbles on the end of their tails to enable them to hover between sand grains like miniature Zeppelins, grazing on microscopic algae!

The vast majority of these creatures have yet to be identified or named. In the Discover article, Dr. Robert Higgins, retired researcher with the Smithsonian Institute, says "It is such a rich and complex world but it is one we've barely scratched the surface of. It is impossible to say how many more species are left to be found and identified. A beach without meiofauna would be a very different place. Without them, all the dead material - fish, shellfish, seaweed - that washes up on the shore would simply accumulate and the bacteria would build up until the beach became anoxic (starved of oxygen) and toxic. " Instead, these creatures recycle, decompose, and in turn serve as food for larger animals, filling the beach with a constant healthy cycle of life.

When I was teaching biology at the local community college in the late 1990's, I used to give this article to my students to read when we reached the invertebrate unit. Once, a bright older student came up after class, her eyes glowing, and she said "Thanks! This article made me realize how much I never knew existed!"

LIFE IN A HANDFUL OF SOIL

As organic farmers, we know that the living diversity in our soils exceeds this wonderful beach world by many orders of magnitude. In one teaspoon of soil, there may be over 60 million bacteria, but if that teaspoon comes from the root zone of a healthy plant, the number of bacteria may exceed one billion. Bacteria, fungi, algae, actinomycetes, tiny invertebrate animals, and larger insects and earthworms all thrive in a complex and ever-changing community of interaction, predation, competition and balance. Decomposing organic matter provides nutrients and shelter, living plant roots provide protection and food. Indeed, living plants exude huge quantities of sugars and other rich molecules into the soil to feed and select the most preferable microbes for around their roots.

Slowly we are learning to view the soil as a complex interrelated whole system and soil ecologists are beginning to understand what happens when the balance is altered. A healthy soil has a large diversity of microbes and larger animals, each keeping the others in balance. When any group of organisms in the system is eliminated or damaged, the delicate balance of interrelationships will be shifted. Our agricultural practices have a profound effect on the life in the soil. Changes in soil chemistry and physical structure, nutrient availability, plant species, and tillage practices can cause microbial populations to shift dramatically. Pesticides and fertilizers can kill certain types of microbes, causing populations of others to balloon to fill the void. Diverse crop rotations, cover crops and crop residue can build soil organic matter and enhance microbial diversity, while the lack of fresh organic matter, air or adequate crop rotation can suppress it.

A recent article posted on the New Farm website (www.NewFarm.org/news/0803/082903/gm_fungus.shtml) clearly describes how totally unexpected results may occur when this balance is disrupted. Canadian research is showing that soil applications of gylphosate herbicides can kill many types of beneficial bacterial and fungi, but tough old Fusarium fungus seems relatively unaffected. In the absence of competition, the Fusarium will grow rampantly and infect the roots of many different species of plants. Corn and wheat, infected by Fusarium, have a nasty habit of developing high levels of potent mycotoxins, or fungal toxins, which can contaminate grain. When contaminated grain is fed to animals,

mycotoxins can either be toxic or unpalatable, or even in minute quantities, can act like estrogen and disrupt reproduction. All this - because of the microbial balance in the soil.

Dr. Janet Thies at Cornell University is using molecular (i.e. biotech) methods to define the composition of microbial populations in different soils and to monitor shifts within them in response to varying management practices. To us, this is a wise and good use for biotech, using these powerful new tools to better understand what is going on in the natural world and especially to better understand the profound effects that our human activities have on this unseen world.

LIFE IN THE EYE OF A STORM

Much has changed at Cape Hatteras in the past month. Hurricane Isabel ripped through the islands with a great fury and destruction. A new inlet has been opened up near where I walked, connecting ocean to sound and breaking the highway in half as easily as if it had been made of children's blocks. Buildings, powerlines, and other stuff of human civilization were demolished or damaged. Our favorite fishing pier was shredded. Sand, always restless and moving, migrated far and covered much. The Outer Banks will dig out, tack wires back up, replace broken windows, tear down and rebuild, and life and leisure will go on, but the beach has been unalterably changed.

The Cape Hatteras lighthouse still stands unscathed. Built tough and aerodynamically to withstand storms, it stood unwavering for many years, warning ships nearing the coast of danger. But several years ago as the beach eroded and the ocean approached its base, people realized that something needed to be done to protect this landmark. There were several choices, but rather than try to build up the beach to keep the sand from moving, those people in charge wisely choose instead to move the lighthouse to safer ground. This past month, as other more modern structures crumbled in Isabel's fury, the lighthouse stood firm, an inspiring testament to the wisdom of human invention that works in harmony with nature rather than against.

Years ago as a teenager, I wrote a term paper on beach erosion for a high school oceanography class. As part of the research, I contacted a professor at Duke University named Dr. Orrin Pilkey who shared his recent journal paper that showed in scientific terms why building elaborate structures on a beach or devising engineering feats to stabilize the beach will never work in the long term. As Dr. Pilkey succinctly stated, "beaches move." That is nature. We humans may think we are in control in the short term, but nature will always eventually prevail. Sure enough, that is exactly what many people now see in the chaotic aftermath of Isabel

Over the past 50 years, our agricultural system has sought to control, subdue, mold, and kill nature. We have used with abandon vast quantities of acidic synthetic fertilizers, toxic pesticides, potent antibiotics and insidious hormones, we have eliminated biodiversity with monoculture and we have suffocated the fresh air from the soil with no-till and heavy equipment. And when this wasn't enough, we have sought to redesign the very genetics of life. Short term,

many have thought this is the answer. After all, we recently heard that the American media assumes that the average American has a memory span of about 10 days. Beyond 10 days, most people can remember big events, but not the details and will rarely question if given contradictory information. We humans like short term.

I do admit my own hypocrisy here. From time immemorial, people have been reminded of the folly of building on shifting sands. But we do so enjoy getting together each summer with many extended family members, a big rental cottage, a long car trip, and the amusements and amenities of a beach vacation. The short term benefits outweigh the long term costs, especially when the costs are not directly borne by us. Pretty typical, aren't we?

However, we really must question where is our modern approach to agriculture and environmental stewardship is taking us, long term. Where will we be in 25, 50 or 100 years if we continue to neglect and abuse the unseen but extremely critical life that lies just beneath our feet and in our water? The United Nations estimates that by the year 2050, the world's current population of more than 6 billion people will increase to 9.3 billion. How will we feed and provide clean water to the burgeoning human life on this planet if we do not tend the unseen life around us?

This month, as we enter the thick of harvest at the end of another challenging year, we should consider what soil scientist Dr. William Albrecht once said: "Nature always bats last."