Digging Into Soil Health

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The chronic diseases of our era—from heart disease and diabetes to cancer and obesity—have their roots in nutrition. But don't forget that nutrition has its roots in the soil.

Healthy soil grows healthy food, and healthy food makes for healthy people. It's a sweet, simple chain of events that carries consequences and yet is often overlooked. You wouldn't be doing your job as a dietitian if you didn't grasp the connection between chronic disease and diet. After all, seven of the top 10 causes of death are linked to diet. But how often do you trace nutrition back to agriculture? When you get right down to it, nutrition gets its start in the soil, where food grows. There is a small but expanding movement that aims to connect the dots between agriculture and human health. Dietetics professionals can be a key part of this movement by cultivating fertile ground for a healthy society.

"I believe nutrition professionals need to broaden their expertise beyond how food influences the health of individuals … to how individual, community, and societal food choices affect the availability and quality of natural resources: soil, water, genetic biodiversity, and nonrenewable energy. Everything we and animals eat is linked to soil. It is the life-support system for plants, animals, and eaters. Healthy soil is the basis for a healthy planet," says Angie Tagtow, MS, RD, LD, Food & Society Policy Fellow and owner of Environmental Nutrition Solutions in Elkhart, Iowa.

Super Soil, Teeming With Life

Soil scientists tend to wax poetic when they talk dirt. They describe soil as the Earth's skin—a delicate living, breathing ecosystem covering much of the Earth's surface. One teaspoon of soil from native grassland contains between 600 million and 800 million individual organisms, many of which have yet to be discovered, with several microscopic miles of fungi, more than 10,000 individual protozoa, and 20 to 30 beneficial nematodes. Soil is a virtual community of living organisms.

The soil to food web is powered by the primary producers: plants, lichen, moss, bacteria, and algae in the soil that use the sun's energy to fix carbon dioxide from the atmosphere. Other soil organisms get energy and nutrients by feeding on the organic compounds found in plants, other organisms, and waste products. As organisms decompose, their nutrients become food for plants and other organisms. This web is an essential lifeline for all plants to receive nutrition and, in turn, for animals and humans to receive nourishment. Healthy soil also makes clean water and air possible.

When people talk about soil "health," they are describing its capacity to be used productively without negatively impacting its future productivity, the ecosystem, or the environment. Soil health involves biological, chemical, and

physical measures of soil quality. It deals with the soil's natural characteristics, such as its texture, as well as with its dynamic quality components that can be changed depending on how the soil is managed. For example, management practices such as compaction, biological functioning, and root proliferation can affect soil quality. Natural and dynamic characteristics can interact, as some soil types are naturally more susceptible to degradation and poor management than others. Soil functions most effectively when the physical, chemical, and biological components are in a state of dynamic balance—a balance between the living and the dead.

Soil reacts dramatically to how it is treated. The old thinking was that soil is an inert sponge for holding nutrients and water for plants. But today we know that soil teems with life and minerals and can strengthen or weaken. Cycling active organic matter into the soil helps maintain soil structure, provide nutrients, retain and recycle added nutrients, and provide habitat and water-holding capacity. The soil's fertility can also be enhanced through a variety of organic matter that provides for maximum soil biological diversity. Nitrogen-fixing bacteria also form specific associations with legumes, further enriching the soil. Soil biological process is not an easy fix; it takes time, depending on the soil, environment, and land management practices.

"We know that biological diversity is almost always better for soil. Microbes are all specific to some extent, so the more you have, the better it is. For example, there are seven to eight different species of bacteria that decompose something. If you only have one in soil and it is killed off, there could be part of the compost that might not decompose. We call this 'functional redundancy,'" says Marianne Sarrantonio, PhD, an associate professor of sustainable agriculture at the University of Maine. "You hope to have soil that is similar to what you see in the natural ecosystem. In the spring, the ground warms up, activity increases, and you see earthworms. Then the activity evens out a bit as the plants capture the nutrients released."

Modern Agriculture Takes Its Toll

A plot of dirt tells the story of the age-old dance between life and death that feeds our planet. Decaying matter goes back to the earth and feeds it, creating a cycle in which the soil becomes fertile and ready to support life again. This balance was understood and put into practice every day on your great-grandfather's farm.

"Before modern fertilizers were available, farms had to be more in balance. The nutrients in the soil were in balance because farms had livestock and the manure was applied to the field. They grew cover crops to return nutrients to the soil and used organic material as well. They didn't go to the store and buy a big bag of fertilizer. They planned the whole crop rotation to benefit the soil," says Sarrantonio.

Today, modern agriculture is a vastly different scenario, with enormous centralized farms growing single crops and relying on synthetic inputs for productivity. How does that affect soil health? "To some extent, if you grow the same crop year after year, you can reduce the biological diversity of the soil. Rotation is better than monoculture. Crops that require intensive tillage, produce compaction, and high pesticide use can decrease soil health. This is opposed to a system that includes rotation, no tillage, and adds organic materials back to the soil," says Harold van Es, PhD, a professor and the chair of the department of crop and soil sciences at Cornell University and coauthor of Building Soils for Better Crops.

Erosion is a big threat to soil health. Poor land and agriculture management practices allow wind and water to degrade the soil by removing organic matter, clay particles, and nutrients, thus destroying the community of soil organisms.

Erosion decreases nutrient bioavailability, root growth, plant fertility, biological productivity, moisture retention, and water filtration of soil, and erosion perpetuates further erosion. According to Tagtow, Iowa experienced erosion last year. During June 2008, 60% of Iowa's counties lost an average of 7 tons of soil per acre due to flooding, amounting to 15,680 lbs of soil lost per acre in one month. The Soil Science Society of America reports that it takes 500 years to build 1 inch of topsoil.

"Erosion is a big concern for soil health, though the 1930's Dust Bowl era was the most notorious period for erosion," reports van Es.

The soaring use of chemicals and monocropping beginning in the 1950s has also been linked with excessive erosion and water contamination. But van Es notes that erosion has decreased with good land management practices and government programs to control it.

Modern soil enhancements don't always take into account their effects on soil biological activity. "Synthetic fertilizers are nitrogen based and have some negative impacts on soil health; [they] can acidify the soil. The big impact when farmers use synthetic fertilizers is that they tend not to use organic fertilizers. In the pre-World War II era, most farmers used manure and soil rotation. But when synthetic fertilizers came along, they supplied nutrients. Nutrients are important, but the organic matter is also important because it sustains the life of the organisms in the soil. The paradigm I often use is that we used to feed the soil, and the soil would feed the plants. The organic material applied to the soil decomposes, and the plant takes up those nutrients. With synthetic fertilizer, you directly feed the plants but not the soil," explains van Es.

Modern agriculture's dependence on pesticides is another sore spot for soil. "The use of pesticides on soil is like a vicious cycle. When soil is degraded and in poor health, it is less resilient to pests. Pesticides lower the biological diversity in the soil so that there are less beneficial organisms in the soil that might keep pathogenic organisms and insects in check. This results in farm management that is inclined to include more pesticides. Poor soil health leads to increased pesticides, inputs, and cost, which negatively influence the health of the soil," says van Es.

On the other hand, a diverse mixture of plant materials creates a more hostile environment for pests. Crop rotations help take away the crop-specific overwintering sites that pathogens and insects need to survive.

Contaminating the soil with toxins and heavy metals is also a concern, especially in urban areas, according to van Es. "Chemicals can be taken up in food and affect human health. It is difficult to decontaminate soil," he says.

Current livestock practices further impede soil health. "Livestock concentration needs improvements. There is an excess of nutrients on livestock farms that builds up to excessive levels that pose big environmental concerns. In large feedlots, there is no good way to recycle the nutrients and organic materials. We're taking nutrition away from some other areas, and it is trapped in the place where livestock are concentrated," says van Es.

Before you start idealizing your ancestor's farm as the model of soil health, it's important to gain perspective. "If you go back far enough, agriculture has never been truly sustainable," says Sarrantonio. "As soon as a farmer put the first plow into the soil, he made a negative impact. But it really picked up speed after World War II and the first bagged fertilizers became available. People forgot how they used to manage their soil without fertilizers. There is a

slow march to reduce chemical use, tillage, and to save the soil through improved soil systems. But it pales in comparison with farms using synthetic fertilizers."

A Sustainable Soil System

When it comes to soil health, it's all about sustainability. Sustainability has been defined as the capacity of being maintained over the long term to meet the needs of the present without jeopardizing future generations' ability to meet their needs. Tagtow reports that a sustainable food system includes diversified farming systems that renew the soil and regenerate natural resources by maintaining soil nutrients, reduce dependence on chemical pesticides and fertilizers, promote crop diversity, decrease erosion, and preserve water quality. Sustainable food systems slow the rapid loss of farmland to residential and commercial development. And sustainable communities can be centered around profitable local food production.

There is a more sustainable farming solution that mimics nature and balances its consequences with the environment. Sarrantonio paints a picture of sustainable soil management that includes a return of as much plant residue to the soil after harvest as possible, decreases tillage as much as possible, brings other biological soil amendments to the farm (eg, animal manure, organic material), and plants legumes and cover crops that protect the soil and add organic materials back into it.

"There are family farms doing a terrific job of this," says Sarrantonio. "They might not bring it back 100%, but they are bringing it back to a better level. A lot of change is coming to farms. Many people recognize that family farms, where the farmer owns the land and farms it, take better care of the land. The family values the land because they own it. There is no incentive for large, corporate farms to value the land."

Organic Production Meets Soil

We can learn a lot from the age-old, natural cycle of decomposition, renewal, and life. "To some extent, organic production is a little closer to these principles and understanding of the natural system of soil. It can sustain the whole ecosystem underground. When you create an artificial environment, you decrease the health of the soil," says van Es, who likens soil health to human health. You go to the doctor to check out your blood pressure and cholesterol, adding dietary and exercise strategies to manage conditions and stay healthy. It's all based on understanding a course of action to protect a body function. There are management guidelines for soil health as well.

Tagtow adds, "Ironically, we treat soil, plants, livestock, and humans in similar ways. When disease occurs, a chemical is applied or pharmaceutical is prescribed. The etiology of the disease is often ignored, and disease prevention strategies are not adopted. Taking a preventative or wellness approach to soil, water, and biodiversity is the key for ensuring a resilient, sustainable, and healthy food system, now and in the future."

Organic farms rely on organic inputs and organic sources of nutrients to feed the soil, according to van Es. "The set of rules and guidelines for organic production generally result in improved soil health. Organic fertilizers contain carbon, organic matter, and compostable material. The nutrient content is much lower than a bag of synthetic fertilizer. Organic fertilizer might contain 3% nitrogen compared with a conventional fertilizer that might contain 32% nitrogen. In an organic system, there is more balance of nutrients and less overaccumulation of certain

nutrients," notes van Es, who offers an analogy of donuts. You may get a lot of energy from donuts but not other nutrients or compounds that are important to sustain human life.

Healthy Soil's Nutritional Payback

Does soil health directly impact the nutritional quality of food? "There is a very direct link between the health of the soil and the health of the plant. If you have diseased soil, you can't have a healthy plant. This is well established," says Sarrantonio. "But it's hard to pin down the knowledge about how soil affects nutritional quality of plants."

Soil scientists believe that we've barely scratched the surface on understanding this issue, but the bits of data coming in are intriguing. Van Es calls the whole field of connecting soil health to plant health to human health an "exciting area that is very researchable."

For starters, it does appear that the fruits and vegetables we are eating today may have fewer nutrients than they did 50 years ago. Donald R. Davis, PhD, a research associate with the Biochemical Institute at the University of Texas in Austin, analyzed data gathered by the USDA in 1950 and 1999 on the nutrient content of 43 fruit and vegetable crops, discovering that six out of 13 nutrients had declined in these crops over the 50-year period. Seven other nutrients showed no significant, reliable changes. The minerals phosphorous, iron, and calcium declined between 9% and 16%; protein declined 6%; riboflavin declined 38%; and ascorbic acid declined 15%. (A 2005 issue of Food Technology reported his findings.)

"Science shows that the greater diversity of organisms in the soil, the greater nutrient profile of the soil. Well-nourished soil will grow plants with optimal nutrient profiles. If animals and people eat those plants, they will have greater micronutrient intake. Just like plants, animals, and humans, soils need to be fed in order to keep the vibrant and diverse community of organisms alive," says Tagtow.

Growing evidence links organic production with higher levels of vitamins, minerals, and antioxidants. For example, a 10-year study comparing organic tomatoes with conventional tomatoes published in a 2007 issue of the Journal of Agricultural and Food Chemistry suggests that organic tomatoes had 79% higher levels of quercetin and 97% higher levels of kaempferol, on average, than conventional tomatoes. This increase corresponded not only with increasing amounts of organic matter accumulating in organic plots but also with reduced manure application rates once soils in the organic systems had reached equilibrium levels of organic matter.

Organic food also contains fewer potential toxins such as synthetic pesticides and antibiotics. And meat and milk from pasture-raised, grass-fed animals contain greater levels of beneficial fatty acids such as omega-3s, alpha-linolenic acid, and conjugated linoleic acid, according to researchers from California State University, Chico and the University of California Cooperative Extension Service.

Get Dirty

So what's in soil health for you as a practicing nutrition professional? Tagtow urges dietitians to ask themselves two questions: How do my decisions today affect the quality and availability of soil in the future? What can I do to restore and protect natural resources?

Seems like dirt can be all in a day's work for dietitians. After all, there would be no nutrients to discuss without it.

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Dietitians on Dirt Duty

Angie Tagtow, MS, RD, LD, suggests that dietitians can use their understanding about a sustainable soil system as a tool in the following areas:

• Nutrition education: Dietitians who provide dietary guidance can influence client and patient knowledge and behaviors on selecting food that offers human health and ecological health benefits. Dietitians can link eaters to farmers who grow food while building the soil.

• Foodservice management: Foodservice operators can assess their environmental impact and determine strategies for conserving water and energy while minimizing waste. Composting food wastes would be a direct strategy for building local soil.

• Advocacy: Dietitians can advocate for local, state, and federal policies that support soil stewardship.

• Research and education: Educators and researchers can incorporate soil to health concepts into courses, internships, and research agendas.

• Corporate consultation: Dietitians working for food companies can make decisions on raw material acquisition, product research and development, and processing procedures that conserve natural resources and reduce or eliminate wastes.

Sustainable Food System Resources

American Dietetic Association (www.eatright.org)

• Harmon AH, Gerald BL, American Dietetic Association. Position of the American Dietetic Association: Food and nutrition professionals can implement practices to conserve natural resources and support ecological sustainability. J Am Diet Assoc. 2007;107(6):1033-1043.

• Healthy Land, Healthy People: Building a Better Understanding of Sustainable Food Systems for Food and Nutrition Professionals: A Primer on Sustainable Food Systems and Emerging Roles for Food and Nutrition Professionals, American Dietetic Association Sustainable Food System Task Force (2007)

• McCaffree J. Water and sustainable agriculture: What they mean to food and nutrition professionals. J Am Diet Assoc. 2008;108(2):215-216.

Hunger and Environmental Nutrition Dietetic Practice Group (www.hendpg.org)

• Journal of Hunger & Environmental Nutrition, http://jhen.haworthpress.com

• Organic Food Production Talking Points, www.hendpg.com/files/HEN_Organic_Talking_Points_April_2007.pdf

• Tagtow A, Harmon H. Sustainable food systems: Perspectives from the United States, Canada, and the European Union. J Hunger Environ Nutr. 2008;3(2&3):103-105.

Other Organizations and Publications

• American Public Health Association Policy Statement, "Toward a Healthy, Sustainable Food System," www.apha.org/advocacy

• Building Soils for Better Crops by Fred Magdoff and Harold van Es

• Community Food Security Coalition, "Community Food Security: Promoting Food Security and Building Healthy Food Systems," www.foodsecurity.org/pubbs.html

• Cornell University College of Agriculture and Life Sciences, Cornell Soil Health, www.hort.cornell.edu/soilhealth

• Health Care Without Harm, "Healthy Food in Health Care, A Menu of Options," www.noharm.org/us/food/issue

• Institute for Agriculture and Trade Policy, "Food Without Thought: How U.S. Farm Policy Contributes to Obesity," www.iatp.org

• The Leopold Center for Sustainable Agriculture, www.leopold.iastate.edu

• The Organic Center, www.organiccenter.org

• Prevention Institute, "Cultivating Common Ground — Linking Health and Sustainable Agriculture," www.preventioninstitute.org

Glossary of Terms

• Compaction: The compression of particles to make a dense mass, or the compressed state of the resulting mass

• Crop rotation: A system of farming in which a piece of land is planted with different crops in succession in order to improve soil fertility and control crop pests and diseases

• Erosion: The gradual wearing away of soil by physical breakdown, chemical solution, and transportation of material

• Fungus (fungi): A single-celled or multicellular organism without chlorophyll that reproduces by spores and lives by absorbing nutrients from organic matter. Fungi include mildews, molds, mushrooms, rusts, smuts, and yeasts.

• Monoculture: The practice of growing a single crop in a field or larger area

• Nematode: A worm, often microscopic, with a cylindrical unsegmented body protected by a tough outer skin cuticle

• Nitrogen fixing: The natural conversion of atmospheric nitrogen by bacteria found in the nodules of legumes into compounds in the soil that plants and other organisms can use

• Photosynthesis: A process by which green plants and other organisms turn carbon dioxide and water into carbohydrates and oxygen, using light energy trapped by chlorophyll

• Protozoa: A single-celled organism that can move and feeds on organic compounds of nitrogen and carbon (eg, an amoeba)

• Tillage: The plowing or harrowing of land in preparation for growing crops

— Source: Encarta Dictionary