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Wild Soils

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Humans are a part of and a creation of nature. Species evolve as a part of the whole, intricate, interrelated creation. A matrix of conditions and co-evolving organisms shaped humans. Soils continue to shape human nature and culture. Our principal religious mythology affirms humans were created from clay. From the viewpoint of evolutionary theory, humans are a response, though not necessarily an answer, to a question posed by nature.

For most people, the concepts of "soil" and "wild" could only be linked as an oxymoron, or a "poetic combination of contradictory words". After all, soils are some of the most common things in the world, obvious as the dirt underfoot, dust in the wind or mud on your boot. And wilderness is an area undisturbed by human activity, empty and pathless. What do they have in common? Can soils be wild?

Let's look at the basis of soils. Soils are generally said to be composed of forty to fifty percent mineral particles (rock dust), twenty to twenty-five percent water (less in the upper layers, more in the lower), twenty to twenty-five percent gases (more in the upper layers, less in the lower as replaced by water) and two to fifteen percent humus.

A cookbook approach doesn't do the soil justice. Finer distinctions of constituent mineral particles, the mix of water and air, and humic components give soils their distinctive characters. Mineral components are generally divided into clays, silts, and sands by particle size, and these particles behave differently both physically and chemically.

Most terrestrial plants require the air mixed with topsoil as much as they need sunlight, water and nutrients. Without the air, in marshes or on compacted soils, they cannot grow.

The water component of soil has three main forms. In drier soils, water remains as a film tightly bound to soil particles. Smaller soil particles will have more surface area per unit of volume; consequently more of the water contained in these soils will be held as a film. In damp soils, water also remains in the spaces between soil particles, where it is bound by surface tension. Wet soils contain more water than can be held in place by surface tension; this "free" water will move through and out of the soil (into springs and wells) if given an opportunity.

Humus consists of the living and the dead. From dead but once living organic matter, plants retrieve most of the nutrients needed for growth. A minor portion is extracted from minerals. From organic matter, they extract phosphorus, potassium, nitrogen, calcium, and magnesium. The presence or absence of organic matter drastically changes soil's ability to accept and hold water.

Probably the least well-known wildlife in the world are soil organisms. Most live in the top foot of soil and range in size from microscopic to gigantic and in numbers from several per acre to billions per ounce. Some soil scientists argue that the extent and importance of life in the soil should lead us to define soil as *living* medium. They argue that soil's function cannot be adequately defined using simple physical or chemical descriptions, as important as these are. Only when the live components and processes are included do soils assume their characteristic functions and meanings. Charles Darwin's appreciation of the importance of soil life led him to favor his treatise, *The Formation of Vegetable Mould Through Action of Worms*, over all his other works.

Life in the soil changes everything about soil. Root hairs threading through channels, bacteria and fungi active in decomposition, protozoa hunting bacteria, slime molds consuming bacteria and fungi, nematodes, collembollae and earthworms processing the vegetable and mineral matter, voles and moles tunneling—all these activities modify soils and give them special characteristics. A large number of soil fungi, the mycorrhiza, live in symbiotic relationship with the roots of vascular plants. Many of the organisms are extremely small (even those with chewing mouth parts may be only one two-hundred-fiftieth of an inch broad), but they compensate in numbers for their size. Analysis of partial catches show as many as 5,500 organisms (not including earthworms and nematodes) per cubic foot of soil. More than seventy different species have been collected from a square foot of rich forest soil, and the total animal population of forest soils approaches 10,000 organisms per square foot. These microorganisms produce enzymes and cause physiological processes that recycle and detoxify both natural and man-made organic substances. Life teems underfoot, but soil is clearly "wilderness" territory based on its mysterious inhabitants and processes.

Organisms of the topsoil are the best known of soil inhabitants, but they are by no means the only denizens of soil. Scientists at Penn State University have collected and studied thousands of organisms living hundreds of feet below the earth's surface. Topsoil organisms are largely aerobic (using oxygen to produce energy), but subsoil organisms are anaerobic and produce energy through denitrification (changing nitrates to nitrogen gas), sulfate reduction (changing sulfate to hydrogen sulfate) and methanogenesis (changing organic acids to methane). Microbiologists are testing these organisms' ability to degrade toxic industrial chemicals, especially under low-oxygen conditions (such as in groundwater).

Soil is a nutrient sink, with building blocks of life stored in minerals, organic matter and microorganism bodies. Agriculture aims at manipulating the productive potential of soils through cultural, mechanical and chemical means, but our attempts have not been informed by a knowledge of soil physics, chemistry or microbiology.

In fact, it could be argued that our actions on the soil have had damaging effects beyond our knowledge and our ability to repair. In *Soil and Civilization*, Edward Hymans characterizes man's destructive relationship with soil as parasitic and warns of classical cultures toppled by destruction of their soil bases..1. In pursuit of abundant food and fiber, our clearing, tillage, fertilization and pest control methods have depleted soil organic matter, allowed topsoil to erode away, disrupted soil ecosystems, and needlessly poisoned communities of beneficial organisms and groundwater. Each of these factors, taken alone, reduces the "fertility capital" stored in soil. Taken together, soil scientists warn, the synergistic and cumulative effects of the changes unknowingly begun in soils may effect our life on the planet.

Perhaps we will heed the advice of the sustainable agriculture movement and change to less damaging ways of guiding the natural sources of fertility and growth. Researchers such as Wes Jackson at the Land Institute in Kansas have been seeking to model agricultural systems on ecological principles. Some farmers have switched to minimum tillage and introduced cover and "green manure" crops to their rotations to mimic natural systems and protect the resource base. Fine tuning of new and more selective pesticides may allow farmers continued control of specific, unwanted insects and plants without damaging groundwater or populations of beneficial insects, plants and soil microorganisms.

The soil remains mysterious, despite our best attempts to know and manage it. Some of the "new" practices promoted by sustainable agriculture advocates are as old as farming itself. Although we can demonstrate their beneficial effects, we can't always say why they work. Crop rotations are a good example: we know that rotating crops causes about a ten percent improvement in yields. Corn, soybeans, sunflowers, sugar beets, cotton, sorghum and barley show the benefit of rotations. Fertility levels, soil tilth, soil moisture and pest control have been studied with an eye to explaining the "rotation factor", but answers remain a mystery of the soil itself. Soil is wild to the extent that it is unknown territory and undisturbed by human activity or, in other words, self-regulating. Despite our efforts to explore and manage the soil, much remains inexplicable. What's more, most soil ecosystems are self-regulating and likely to remain beyond our control. Our primary impacts on soil ecosystems are inadvertent and damaging.

How have other cultures related to soils and the principles of fertility contained in it? Some people personalize the principle and conceive of "little people who live under the hill", like the

"sidhe" or Iroquois' "jungies", who guard fertility and remind humans of their responsibilities. Storied little people and mythic talking animals link cultural and natural worlds. They carry warnings of duty and messages of thankfulness.

Roy Rappaport's account of the lives of the Tsembaga of New Guinea.2. details their handling of the concept of fertility. The Tsembaga regard spirits to be significant components of their environment. In the lower lying parts of their territory, a special class of spirits dwells, which is also associated with the lower portions of the body. These spirits are designated as "something

out of which something else has grown". There are different kinds of fertility spirits; one, which is not human, typically dwells in a wide place in the stream. This spirit may bring death. Another type, which once was human, is the cold, wet, soft spirits of rot. The Tsembaga believe they embody the necessary conditions for growing things. Spirits of the low ground are involved in the cycle of fertility, growth and death in which all living things participate. Fertility and growth on one hand and death and dissolution on the other are linked in the persons of these spirits. Through them, the Tsembaga acknowledge that life both terminates and arises out of the soil.

No one knows what the Adena and Hopewell people of Ohio and Illinois meant by the gigantic earth sculptures they created several thousand years ago. One, a snake with an egg in its mouth, seems to indicate a spiritual impulse. Other sculptures are remarkable for sheer size: an earthen and stone block wall from six to fifteen feet high, a mile in length, surrounding forty acres of hilltop. Much has been said about the sacredness of the earth to native people, but in this case the native people used the earth itself for their designs and effigies.

Although we don't know what the Adena meant by their sculptures, modern artists and environmentalists have turned again to earthworks to express themselves. Near Ottawa, Illinois, artist Michael Heiser has incorporated large earth sculptures into a mine reclamation project. On the two hundred acre site, Heiser designed five mounds or "Effigy Tumuli", in the shape of a water strider, frog, catfish, turtle and snake. He acknowledges his debt to earlier moundbuilders and clearly wishes to integrate artistic and environmental concerns in the work.

Many artists have celebrated the fertility and beauty of soils in landscapes, but the science and aesthetics of soils rarely find common ground. In a remarkable interview, "My Friend, the Soil", teacher and soil scientist Hans Jenny reveals a feeling for soil that combines aesthetic, scientific and mystic appreciation of the medium..3. Jenny says

> [S]oil appeals to my senses. I like to dig in it and work it with my hands. I enjoy doing the soil texture feel test with my fingers or kneading a clay soil, which is a short step from ceramics or sculpture. Soil has a pleasant smell. I like to sit on the bare, sun-drenched ground and take in the fragrance of the soil. ...Soil profile art...resembles abstract art. ...Soil speaks to us through the colors and sculptures of its profile, thereby revealing its personality; we acknowledge it by giving the soil a name.

Jenny reveals that he has become an advocate for the preservation of natural, undisturbed soils set aside as "benchmarks for assessing man-induced soil changes and for preserving unique segments of landscapes...for teaching and research." While acknowledging that we cannot live without sacrificing plant and animal lives and that land must be cleared for our sustenance, he raises fundamental questions about soils, "What does nature have in mind, what is her goal of soil evolution?", and answers in a way that links the evolution of soils with the evolution of species. He suggests a close link between the processes that make soil and the processes that make humans, in ways that arts may best express.

Wild soils? Tame soils? Though we have done our best, but more often our worst, to domesticate soils, they still lie outside our reason. Any farmer who's pulled a hedgerow out knows the ground beneath will be darker and richer with humus for a few years, until the less worked soils are mixed with the tilled. The clearing of forests and three hundred years of cultivation of Northeastern soils have depleted the soils' humus. Much of the original topsoil is gone, and the loss of the natural nutrient base is masked by the addition of industrial fertilizers. Reduced water infiltration rates and diminished holding capacities push the water regime toward a "boom and bust" cycle and increased flooding *and* droughts.

Ecological models of nature categorize sources of primary production and describe ecosystem energy flows. Both the quantity and quality of nature's bounty rest heavily on the productive capacity of shallow water areas (wetlands, estuaries) and a thin layer of living topsoil.

In 1789, Abner Barlow and his ox tilled up a little ground in Lot Number 2 of the Village of Canandaigua to plant the first wheat in Western New York. Though his plot of ground had been cleared by the Seneca, the land outside the village was covered by huge oak, chestnut, maple, white pine and beech forests. Beneath these trees, the native soils were mineral mixtures formed, transported, laid down and shaped by the glaciers. In ten thousand years between the last glacial retreat and Abner's plow, perhaps ten more inches of soil had formed from fractured bedrock and accumulated vegetable matter. Now, the silt loam Abner tilled has disappeared beneath lawns, houses and pavement. When he tilled the ground, was it wild? Covered with domestic structures, is it tame? Abner Barlow and ten generations since have gone down into the ground. From the viewpoint of one who goes back to the ground, the soil's wild enough, however well it is known.

The Soil Scientist Digs a Hole

> "You can go places with a spade you can't with a backhoe."

He starts it off with his foot, driving the blade deep and wrenching out clods of soil. He wears cotton work pants, easily dirtied and washed, and leather work boots sufficient to protect his ankles. The spade has a long, narrow blade with a curved, sharp bit. He lifts it as high as his shoulder for each short, chopping stroke, coming down hard to split out the peds and blocks of soil, laying them in order on the grass beside the hole so that they form the text of his lecture. His task is a dissection. He brushes away crumbs of soil and peels back a sliver of clay with the sharp blade. It curls away like a wood shaving or a layer of skin. In the exposed bank you see thin layers of red oxide trapped in bands of grey silt. He cuts through horizons, shows us mineralization and paths of water leaching through the soil, light shapes like prisms in the earth. The violence of his stroke is matched by his calm voice explaining the materials and their actions and origins in local landscapes. He digs through thousands of years in a few feet of soil, then pauses to catch his breath. While he stands in his hole gazing out over the land, you almost remember silts and clays filtering down through impounded water, water rushing under ice, washing sands and gravels into stratified beds, glacial advance and retreat, outwash and deposition, great calves of ice spawned in the drainages. His gaze passes through time and matter. After a while, you begin to wonder about the importance of these human beings clustered around the hole, all of us looking intently in, or following his gaze out to the landscape, nodding our heads gravely in agreement.

Notes

1. Edward Hyams, *Soil and Civilization*, New York: Harper & Row, 1976.

2. Rappaport, Roy A., *Pigs for the Ancestors*, New Haven, Conn.: Yale University Press, 1968.

3. Jenny, Hans and Kevin Stuart, "My Friend, the Soil", *Journal of Soil and Water Conservation*, May-June, 1984, pp. 158-161.
