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BOOK REVIEWS

Underground: How Creatures of Mud and Dirt Shape Our World by Yvonne Baskin. *Island Press, Washington, D.C. ISBN 1597260037. $26.95. 237 pp.*

People are fascinated by life in the soil. It appeals to soil scientists and the general public. Starting in the mid-1970s, there are now several primary journals solely devoted to soil biology (e.g., *Applied Soil Ecology, Biology and Fertility of Soils, European Journal of Soil Biology, Soil Biology & Biochemistry*). In addition, some soil science journals have sections on soil biology; also, *Soil Science* has published several well-cited soil (micro) biology papers. It has impact too; since the late 1970s, *Soil Biology & Biochemistry* tops the impact factor rankings in most years. The number of papers on soil biology is increasing each year, and soil biology has become one of the fastest growing branches at the soil science tree.

This book is the latest addition to a range of publications that aim to popularize soil biology. It is written by the successful science writer and journalist, Yvonne Baskin. Her recent books include "*The Work of Nature: How the Diversity of Life Sustains Us*" (1998) with a chapter on soils, and "*A Plague of Rats and Rubbervines—The Growing Threat of Species Invasions*" (2002). Her new book is an outgrowth of a SCOPE (the Scientific Committee on Problems of the Environment) project called *Soil and Sediment Biodiversity and Ecosystem Functioning*. The project ran between 1996 and 2002 from Colorado State University.

The book has nine chapters, and each chapter deals with research or a problem in a particular area (e.g., polar desert of Antarctica, vanishing wetlands of the Mississippi river basin) and on a type of soil life (e.g., fungus, nematodes). The red thread in this book is soil biology in relation to an ecological or environmental issue; the chapters can be read independently. The introductory chapter (nicely named Opening the Black Box) illustrates the importance of soil biology. Baskin stresses that little effort has been devoted to life underground, and she quotes the much used figure that only 5% of the species in most key groups of soil animals have been identified. Her opening message is that creatures of mud and soil shape the world more powerfully than most of us imagine. The subsequent seven chapters are meant to illustrate this.

In the second chapter, she follows a team of scientists investigating the miniscule life in permafrost soils of Antarctica. Initially, it was believed that these soils were sterile, but the team found several species of nematodes that are the most diverse and abundant animals on the planet—four of every five animals are nematodes! Worldwide, some 25,000 nematode species have been named, and anywhere from an estimated half a million to 100 million more nematodes species are still waiting to be discovered. Fluctuations and changes in the nematode population of the study site and the sensitivity of these creatures to environmental changes may help ecologists answer questions that are the key to reducing the human footprint in more complex ecosystems. How that should be done remains unclear.

The third chapter deals with natural ecosystems in the Great Smoky Mountains National Park—a hot spot of temperate biodiversity, and the park is a United Nations World Heritage Site. Air pollution, invasive species such as pigs and insects, and an increasing number of human visitors bring changes to these ecosystems. Biologists investigate these changes and look at the relation between above and belowground biodiversity and whether changes in the soil community affect the plant community. No conclusions are reached in this chapter, but as Ms. Baskin puts it, "As both soil degradation and threats to biodiversity accelerate, learning who is there and who matters most is vital."

No soil biology book without earthworms; the next chapter (The Power of Ecosystem Engineers) is a fascinating story on this so well-loved bioturbators. There are no native worms in North America, so all were imported—most of them accidentally in ship ballast from Europe or on the root balls from imported plants; they swiftly spread across the soils of the United States of America. Earthworms often have a

favorable effect on the soils, but this chapter describes an ecological disaster caused by two *Lumbricus* species. The story is as follows. In a forested area in northern Minnesota, fishermen dump leftover worms before heading home. These worms invade the forest and eat the forest floor which dramatically affects the vegetation. The result is a distinctive pattern of worm invasion and vegetation changes, radiating from boat landings and fishing resorts. The worm invasion went unnoticed because foresters seldom recognize changes in soil organisms, whereas soil scientists often do not know what the plant community should look like. Earthworm invasion not only dramatically changed the vegetation but also caused higher soil bulk densities and reduced nitrogen (N) availability (more leaching and gaseous losses).

The next story is about the ecological changes in the seabed of the English Channel. Fishing practices such as bottom trawling and dredging in combination with a range of environmental factors caused changes in the seabed ecology. Trawling might be comparable to plowing a field, and apparently, much of the seabed life is severely reduced. More than 80% of all decomposition and nutrient cycling that take place on the earth occur in sediments on the continental shelf and slopes of up to 1.5 km deep. Destructive fishing greatly reduces or eliminates bioturbators that might have major effects. It is predicted that if the seabed is regularly plowed, life in the water above will eventually be diminished.

Chapter 6 also deals with environmental problems in coastal waters. Hypoxic areas in the Gulf of the Mississippi are related to excessive inorganic fertilizer use on cropland and the cutting of wetland forests in the upper catchment of the river. Wetlands are important not only for flood control, water purification, and wildlife habitat but also for removing nitrate through denitrification. Less wetlands mean more nitrates downstream. The annual N influx to the gulf has tripled since the 1950s, paralleling the increase in hypoxia. Reducing the influx means more wetlands that in turn will increase denitrification and higher amounts of nitrous oxide—a noxious greenhouse gas. Baskin discusses these relationships eloquently and shows the important role of the tiny denitrifiers.

In the next chapter, Baskin takes us to the temperate rain forests, of which 90% had been cut by 1990, and the deforestation rates are far greater than that of tropical rain forests. In the Canadian forest zone, experiments called "new forestry" are conducted in which blocks of trees are left behind in clear-cut areas. The idea is that soil life in such uncleared areas is maintained, and ensuring the survival of a diverse soil food web, particularly fungi, is critical to the recovery of the forests.

Chapter 8 focuses on the grazed areas in Yellowstone National Park which, on average, produce twice as much biomass as ungrazed grasses. Bison and elks are responsible for this doubling in biomass, and in grazed grasslands, there is twice as much plant available N and denser growth. Clipped grasses pulse sugar and carbon-based substances from their roots into the soil which spurs an enormous growth in microbial biomass; this leads to increased mineralization and higher N availability by which the plants recover quickly from the grazing. So plants are capable of manipulating the rhizosphere in response to stress (grazing). Experiments have shown that grazers can have positive, negative, and neutral effects that are related to the inherent soil fertility, but this is not treated in this chapter.

The last chapter deals with "restoration efforts" of land previously under intensive agriculture. This is relevant, with a shrinking area under agriculture in Western Europe. However, many such restoration efforts have failed, and Ms Baskin visits scientists in the United Kingdom and the Netherlands who work on natural vegetation and soil life. Patience is needed for such research because it could take more than a century for plant communities on former croplands to begin to resemble those on unplowed land. The key for restoration seems to be in type, diversity, and abundance of the soil community; she quotes "…if the engine room of the soil isn't fixed, eventually your restoration will just collapse." Researchers try to find the "tactical knock" that accelerates the development of soil communities, and experiments focus on topsoil additions of multitrophic interactions. It all seems a bit empirical, but some good understanding of the food web is gained.

So, for the content of the book, here is a critique. The book presents seven case studies or stories, mostly from North America, in which the author passionately describes the use and function of soil communities in various environmental and ecological contexts. Most stories are convincing, but it seems that despite advancements in food web approaches, part of soil

biological research is still "a counting the number" type of science. As a result, the sentence "we don't know yet" passes by in most chapters, leaving the book short of conclusive. As in all branches of soil science, there is still an awful lot of work to do in soil biology, but genetic sequencing of samples (not species) will speed up understanding (Gewin, 2006) and make soil biology a more mature branch. It is almost impossible to identify and count all species and explore their roles in the food web. That is why sequencing of samples seems promising, certainly more rapid and fancy. A chapter on such techniques would have been welcome.

The text is very readable, but a bit long winded at times which take tension out of the stories. It is clear that Ms Baskin is an experienced writer who can capture the essence of a problem and build a story around it. However, she is not a soil scientist. In most parts of the book and in the subtitle, she uses *dirt* where she means soil. That is, in my opinion, an unforgivable sin.

Baskin's writing style is one of great enthusiasm, brilliance at times, passion, and intelligence; however, such a writing style does not agree with the fact that the book has a fairly negative outlook. In every story, the importance and relevance of soil life is illustrated (rarely quantified but that is not her responsibility), and doom scenarios are sketched when soil life is further lost or diminished. In addition, she shows that restoration of soil life is complex and sometimes very difficult and impossible. There is little about the elasticity or resiliency of soil life, maybe because we know little about it or maybe because it did not fit her overall story. A good journalist listens with care and always reveals both sides of a story. Toward the end of the book, she is so adulated by the subject that she falls into a well-known trap when writing that the fertility of soils in the tropics can be renewed by underground communities that maintain crop production, increase food security, and reduce pressures to clear more tropical forests. In her slightly chemophobic North American perspective, she misappropriates the use of inorganic fertilizers. That is not uncommon for someone from Western Europe or North America, but it is unscientific to think that food production in tropical regions could be increased without inorganic fertilizers. Of course, we know that soil animals are useful and essential too, but they cannot maintain—let alone increase—crop production on low fertility soils in tropical regions. Optimizing what is there and combining it with external inputs are the way to do it, and that is well described in the seminal work of Woomer and Swift (1994). That book is somewhat dated now but still a compulsory reading for tropical soil biologists.

The book is meant for the American market (most case studies are from the United States of America, where dirt and soil is sometimes used interchangeably), and units in this book are nonmetric (Fahrenheit, inches, acres, miles, etc.). I can comfortably read a book with the occasional sin and nonmetric unit, but I would like to see a little bit more about the role of soil. Several chapters focus on the interaction between plants and soil life or animals and plants and soil life. However, there is virtually nothing about the interaction between soil life and the soil itself. How does soil life differ between different soils; how does soil life affect crop production [not only plant species community]; how come some soils produce high yield with very little diversity and vice versa; what is the effect of such basic properties as texture, moisture, and pH on spatial distribution of soil animals, and many others—simple questions to which the answers are only partly known but which would make simulative reading. The book serves another purpose, but the lack of treating these issues highlights a fairly common problem in soil biology—too little attention on soils, their properties, and distribution. I know most soil biologist argue that there is too little attention on soil biology by other soil scientists.

This is not the first book that aims to popularize soil biology and ecology, and because she has not referred to any of them, I presume she has not read them. One of the first—I am not talking about Darwin here—is by E.B. Balfour entitled "*The Living Soil*" (1943) written in the middle of the Second World War (Balfour, 1943). He describes the interrelationships between soil vitality and the health of plants, animals, and humans. There are interesting sections not only on the direct and circumstantial evidence of the role of soil microflora in the nutrition of higher plants but also on soils and human health and illnesses. In the late 1950s, Sir John Russell wrote "*The World of the Soil*" which ran through several editions (Russell, 1963). Russell, a famous soil scientist from the United Kingdom (he wrote the first seven editions of *Soil Conditions and Plant Growth*), describes the invisible and visible inhabitants of

the soil and relates it to human's control of the soil (agriculture, food production). Europe came out of the war hungry, and the need to increase agricultural production was a major challenge for soil science. Russell recognized the role of soil animals in all these. A more ecological approach was taken by Farb (1957) who described the living organisms in the soils under forests, grassland, and deserts; the book starts with the infamous quote, "The soil is the placenta of life." A recent but less extensive effort in popularizing soil biology is the "*Soil Biology Primer*" by Tugel et al. (2000). It is downloadable from the internet.

The book by Baskin fits in the tradition of popular soil biology books. It is not too long, consisting of 194 text pages, and the rest are bibliography (approximately 300 references on 30 pages); it also contains a useful index. It complements recent scientific publications on the living soil (e.g., Doelman and Eijsackers, 2004; Gobat et al., 2004), which are more useful as a reference or as teaching books. I should mention here that the book by Gobat et al. (2004) is a very good introductory textbook on soil biology. It would be nice if Baskin's book were to be accompanied with an equally readable book about other soil properties or processes or about the use and management of soils in different societies. There is tradition in popularizing soil biology; the time is ripe to start the same with other topical soil science subjects. Baskin's book provides the method on how that should be done—let a science writer or journalist join you during your laboratory and field work or computer days and explain why the work you are doing is of interest. There is no reason to believe that synchrotron work, zinc speciation, or pedotransfer rules could not yield readable stories of interest to the general public. Admittedly, nitrous oxide or digital soil mapping are not as alive and creeping as earthworms or nematodes, but understanding their significance may equally increase the appreciation of soils for the welfare of human beings.

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