BOOKS & ARTS

Dirt cheap soil

Precious few societies have taken care of their most fundamental resource.

Dirt: The Erosion of Civilizations
By David R. Montgomery
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Dust in the wind: civilizations collapse when their soil runs out.

Eric A. Davidson

If everyday expressions offer clues to what we value, then the common use of 'dirt-cheap' to describe anything inexpensive speaks poorly of our appreciation for soil. Like water and air, soil is not efficiently traded and priced in the marketplace, and yet we could not live without it. It doesn't take a rocket scientist to figure out that food security and human well-being depend on fertile soil. That expression implies admiration for the intelligence of rocket scientists, and similar praise is due to Earth scientist David Montgomery, whose new book insightfully chronicles the rise of agricultural technology and the concomitant fall of soil depth just about everywhere in the world, from prehistoric to modern times. The topic could not be more timely, as recent large-scale expansion of maize (corn) in the United States and sugar cane in Brazil for biofuel production signals a new era of competition between the energy and food sectors for the globally finite resource of arable land and the remaining good soil.

Montgomery catalogues a tragically recurrent pattern. Starting with the first farmers in the Tigris and Euphrates River basins, across the Mediterranean of the ancient Greeks and Romans, through bronze, iron and industrial ages, repeated in the Americas and in Asia, and up to contemporary practices on industrial mega-farms and smallholder slash-and-burn fields. In each case, agriculture expanded on good land, which fuelled population growth, followed by further agricultural expansion onto marginal land, ultimately leading to soil erosion, declines in agricultural productivity, and often societal collapse and emigration.

Perhaps owing to the repetitive nature of this story, the writing is not as captivating as Jared Diamond's in *Collapse* (Viking, 2004), which similarly charts the interplay between the prosperity and longevity of civilizations and their husbandry of several kinds of inherited natural capital. Equally provocative, however, Montgomery asserts that the rise and fall of many civilizations, generally lasting from 800 to 2,000 years, roughly corresponds to how long it takes for their soils to erode away.

Not all is gloomy. A precious few examples of good soil management are described. Montgomery also cites philosophers, agronomists, and soil scientists from ancient Greece onwards, showing that we have known for a long time how to obtain good crop yields and simultaneously conserve soil. Reasons that such sage advice has seldom been followed include perverse economic incentives and land tenure laws, imposed by govenments that reward mining the soil for short-term profits. Montgomery offers a wealth of interesting examples.

The Lincoln Memorial in Washington DC now stands where colonial ships once sailed in the Potomac River and is built on the sediments washed downstream from former colonial tobacco farms. High prices paid for tobacco in Europe, a plentiful supply of cheap land in the American colonies, and tax revenue for the British government generated from tobacco sales motivated both private and government sectors to seek maximum crop yields rather than promote sound agricultural management. These shocking changes become obvious over many decades and centuries, but soil often slips away at a rate that a farmer may not perceive during a single lifetime.

Further advances in technology will probably increase crop productivity, and some expansion of agricultural land is still possible, but Montgomery argues that soil has become a scarce resource. More than a history lesson of the legacies of past civilizations, the book raises a critical concern for modern times. We are currently losing soil at least 20 times faster, on average, than it is being replaced through natural processes. To meet the demands for food and, more recently, energy, we need Montgomery's scholarly, historical perspective, as well as the ability to project current trends of land management to future scenarios.

In the final chapter, the author offers a vision of organic farming for both large and small farms. Soil conservation can also be promoted without going totally organic, and I doubt that we can feed 7–10 billion people entirely without fertilizers and pesticides. We probably need the proverbial cleverness of rocket scientists to figure out what sustainable agriculture fully entails, but it is clear that soil conservation must be its central tenet.

When I talk to elementary school classes about soil, I start by distinguishing it from dirt. Kids quickly catch on that soil nourishes plants in forests, grassland, farms, and gardens, whereas dirt is soil transported to places where it is unwanted, such as under fingernails, on the living room carpet and in sediments of reservoirs and estuaries. The greatest strength of this book is its persistent and forceful demonstration of a lesson that adult societies have yet to embrace — societies prosper and persist best when they figure out ways to keep their soil where it belongs and not treat it as if it were dirt cheap. ■

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Secret life of plants

The Emerald Planet: How Plants Changed Earth's History
by David Beerling
Oxford University Press: 2007. 304 pp. £14.99

Paul Falkowski

Plants are an inextricable part of the human experience. They provide us with food and fibre, drugs and building materials, fuel and fodder, fragrances and shelter. Although we are literally beholden to plants for our very existence, the geological history of plants and their role in transforming Earth's biology and chemistry is a largely unsung tale.

This book tries to capture the stories for a scientifically literate reader. It is not written, nor intended to be, a popular science blockbuster, but rather an accessible monograph, in the modern sense, that examines basic questions that palaeobiologists and geochemists have addressed for decades. When did oxygen-producing organisms evolve? How did they come from the oceans to invade land? Once on land, how did they transform the rocky world in which they found themselves to create soils and environments conducive to terrestrial animals, such as ourselves?

The author, David Beerling, trained in palaeobiology and geochemistry, tells two stories in parallel. One is the history of Earth and how photosynthetic organisms transformed it. The other is the history of humans who sought to understand Earth's history. Both are eloquently and engagingly merged in a scholarly, yet generally accessible book that bespeaks of the author's love for plants, the geological history of Earth and the history of science.

Traditionally, Earth's biological history has been inferred from fossils. The fossil record of plants extends back to about 420 million years, yet the fossil record of animals is at least 200 million years older, and fossils of marine microorganisms extend back several billion years (although the validity of some of the earliest microfossils has been questioned). So when did oxygen-producing organisms first appear on Earth?

We are not certain; molecular fossils (organic remnants of organisms that are physically lost in the fossil record) suggest that the earliest oxygen-producing microbes — cyanobacteria — evolved about 3 billion years ago. Over the past 50 years, geochemists, armed with mass spectrometers and other sophisticated instruments, have been able to piece together isotopic records of carbon and sulphur, from which the oxidation state of Earth can be inferred. These records suggest that the atmosphere of our planet 'flipped' from a mildly reducing, anaerobic condition to a mildly oxidizing, low-oxygen state about 2.3 billion years ago. Subsequently, cyanobacteria responsible for the generation of oxygen were appropriated via a series of symbiotic associations, and spread throughout the oceans as eukaryotic algae.

One clade among these algae successfully garnered a foothold on land and became the progenitor of all higher plants. This book describes how terrestrial plants transformed the surface of the planet, not only by accelerating the oxidation of the atmosphere (a process pioneered by algae), but by accelerating the weathering of rocks to form soils and release nutrients, thereby transforming the terrestrial landscape.

Beerling provides for the reader a fascinating history of the discovery of fossils and the the inferences drawn from them. For example, he describes how the French palaeontologist, Charles Brongniart, described in 1894 the discovery of a fossil dragonfly with a wingspan of 63 cm. Such an enormous insect cannot fly without extraordinarily high levels of oxygen; indeed, such gigantic insects are taken as support for geochemical models that suggest oxygen concentrations during the Carboniferous period were upwards of 30% or more — about 50% higher than current oxygen level of 21%. The discovery of fossil forests and dinosaur remains in polar regions, such as Greenland and Antarctica, clearly suggest that 200 million years ago these environments were much warmer than today, presumably as a consequence of significantly higher concentrations of CO_2 in Earth's atmosphere.

Beerling argues that the long-term changes in atmospheric oxygen and carbon dioxide are driven not only by tectonics and slow chemical reactions, but by plants. Indeed, he develops a set of examples that explore how the evolution of plants and animals altered the history of Earth as much as geological processes did.

The emerald portion of our blue planet — the largely terrestrial photosynthetic world — owes its existence to the oceanic realm. Perhaps ironically, Beerling virtually ignores the lowly cyanobacteria, without which there would be no higher plants.

Be that as it may, this book is a wonderful example of the nascent field of Earth systems science, in which geologists and biochemists try to document changes in Earth's environment throughout the planet's history, and biologists try to understand how the core metabolic processes of life altered the distribution of elements on the planet's surface. Beerling describes how we came to understand the importance of oxygen in the nineteenth century, yet to this day we still do not fully understand the mechanism by which the energy of the Sun is used to split water to form the gas on which all animal life is dependent. ■

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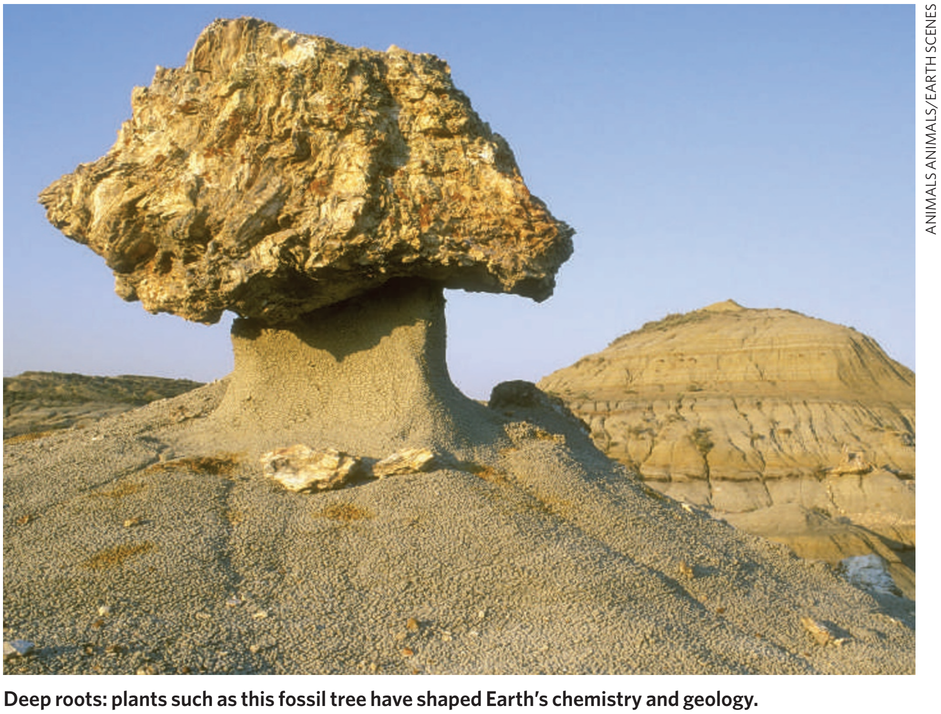
ANIMALS ANIMALS/EARTH SCENES

Deep roots: plants such as this fossil tree have shaped Earth's chemistry and geology.