

The Biochar Solution: Carbon Farming and Climate Change

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when the evidence available at the time is not robust if the consequences of inaction are likely to be catastrophic. Would informed consent (p. 137) be as appropriate for environmental risks and benefits as it is in biomedical ethics, especially when intergenerational ethics are involved?

Elliot has covered a broad range of literature on hormesis and related fields but primarily at a single-species (*Homo sapiens*) level. The word *pollution* in the title (suggesting hormesis) deserves scrutiny at higher levels of biological organization—even though the value of this concept is not clearly shown. I applaud the author's efforts to bring about consilience (literally “leaping together”) between societal values and policy-relevant environmental research. However, synthesis requires a great deal of time, and its importance is difficult to communicate to the news media and the general public, since, at present, environmental literacy in both groups is inadequate to address a complex subject such as hormesis. Knowing about the problem is a superb first step, but it is not enough.

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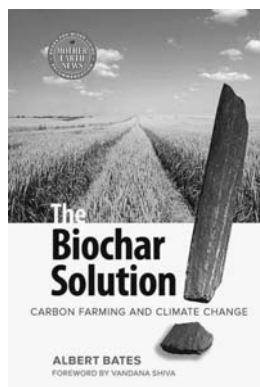
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ADAPTATION THAT CONTRIBUTES TO MITIGATION

The Biochar Solution: Carbon Farming and Climate Change. Albert K. Bates. New Society Publishers, 2010. 208 pp., \$17.95 (ISBN 9780865716773 paper).

Climate change mitigation and adaptation are major topics in related international negotiations to save the human enterprise from barreling full speed through a still unknown tipping point into irreversible global heating. Last October, *BioScience* offered a special section on biological carbon sequestration with a range of arboricultural and agricultural options. One option that was mentioned but not analyzed in depth is *biochar*, which is charred organic matter that could be used for agricultural soil enhancement or bioremediation. *BioScience* contributor Rattan Lal (2010) considers biochar a viable but not major component of mitigation through the sequestration of carbon



in soil (the major terrestrial sink), partially because the science of biochar is still in its infancy. Not cited in his article were Lehmann and Joseph's (2009) book on the state of the science and Bruges's (2009) more popular volume.

A month after *BioScience's* special section, *The Biochar Solution: Carbon Farming and Climate Change* was published. This book is an overview, intended for a more general audience, with an impressive summary of much of the pertinent science and a careful inclusion of biochar in the call for greater adaptation and sustainability in farming practices. Although he always considers mitigation, author Albert K. Bates is more concerned with adaptations that will contribute to both mitigation and improved food security (something Lal is also concerned about) within a more organic,

biodynamic, and permanent agricultural landscape.

The Biochar Solution is divided into five sections, after a foreword by Vandana Shiva, longtime critic of the current global political economic system that is the root cause of climate change. She cautions us to avoid a fixation on biochar-only solutions and to embrace ethically and ecologically sound changes in agriculture in order to contribute to a more just and sustainable global society. Bates gives consideration to her warning by maintaining objectivity as he outlines the origins of the current scientific interest in biochar, examines some of modern agriculture's failings, surveys options and especially technologies for capturing carbon with biochar, examines more sustainable traditional agricultural systems and how these are being used to heal degraded agroecosystems, and finally discusses the politics surrounding biochar and the creation of carbon-neutral and carbon-negative communities.

The first section (Losing the Recipe) is a broad mix of quick reviews of agricultural origins and includes a discussion of the major twentieth-century figure of Amazonian dark earth (ADE) research, Dutchman Wim Sombroek, who organized the now-international effort to study ADE. This section also covers the first Europeans' experiences in Amazonia, during which they were impressed by the healthy, well-fed native populations in a region now known for its poor soils. Bates is a great fan of Gaspar de Carvajal, the first European chronicler of the Amazon River, but does not use enough caution when retelling his tales—something I've learned over the last two decades but failed to pass on to Bates when he interviewed me a few years ago.

Nonetheless, modern archaeological work is confirming that there is enough ADE to have supported very large populations along the major whitewater rivers, such as the Madeira and the Amazon, and that these ADE

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sites were quickly reforested when the indigenous peoples were decimated by disease, slavery, and European-inspired warfare, leaving the “empty” forests that so impressed the first European naturalists. When modern populations (including Confederate Southerners) started new settlements, they soon learned to seek out the ADE, because it permitted abundant harvests of sugarcane and other export crops. Bates then shows us the first modern scientific analyses of ADE at the end of the nineteenth and beginning of the twentieth centuries, which were forgotten until Sombroek organized the ADE research effort in the 1990s.

The second section (Agriculture and Climate) identifies some of the technologies that led to soil degradation and fueled the collapse of numerous early civilizations, starting with the earliest hearth of food production systems in the Near East. One of the author’s strengths is his grasp of technologies and how they can contribute to the degradation or conservation of soils. His review of the development of plows is excellent. Needless to say, the plow is not responsible for the degradation of millions of hectares of once-fertile soil or for the desertification of once-habitable regions. Rather, human use and misuse of technology and, more recently, the idea that soils can be considered factories needing only inorganic inputs (e.g., fertilizers, pesticides) instead of being recognized as living systems is driving degradation worldwide. In turn, degradation is driving further land-use change to supply food and fiber to populations that have no awareness of the unsustainability of the current human enterprise.

The fact that land-use change drives global climate change, which was also later proven by modern research, was illustrated by the effect of the decimation of Native Americans by European conquest. The resulting reforestation sequestered so much carbon so quickly that it caused the Little Ice Age, which affected Europe and North America (Nevle and Bird 2008). Bates uses this new research to

suggest—I think correctly—that Native American agricultural practices, including ADE creation, contributed to ecosystem resilience in such a way as to favor this rapid reforestation—something that is extremely unlikely to recur after the soil degradation caused by modern industrial agriculture.

In the third section (Capturing Carbon), Bates reviews appropriate soil science and different ideas for carbon farming; he discusses how ruminants play a part, even though they are often demonized by climate mitigation activists; he then focuses on technologies, his specialty. Bates explains composting, how compost “tea” activates biochar (which may be the secret for using biochar to create dark earths), and how to make biochar. Numerous inventors are developing multipurpose stoves that make biochar, which would allow a family to cook a meal, a farmer to generate energy, or an industry to produce chemical byproducts while also generating energy. Although the stoves designed for poor rural farmers in the developing world perfectly satisfy Vandana Shiva’s aspirations, those intended for industry fuel her worries about capitalist enterprises using this technology in the carbon market. Nevertheless, a full range of farming technologies is available, and as with the plow, our future depends on its use and misuse.

The fourth section (Gardening the Earth) delves into alternatives to modern industrial agriculture. Bates examines Mayan *milpas* and Aztec *chinampas*, both of which have served as models for small-scale alternative agrotechnologies. He examines trees, different arboriculture practices, and strategies for greening deserts, including the Sahara. In each case, he identifies those goals to restore degraded ecosystems as also being ideal plans for climate change mitigation and adaptation.

Today, numerous forms of technology are touted for climate change mitigation and adaptation; all are worthy of close examination, as was pointed out by Emily Boyd (2010) when she compared proposals presented in the

BioScience special section. In the final section of the book (At the Turning Point), a clear analogy for the tipping points that climate and biodiversity scientists are so worried about today, the author takes a look at one group of biochar critics called Biofuelwatch, but he fails to clearly explain their origins or how they relate to Shiva’s warnings at the beginning of the book. He does, however, present the International Biochar Initiative as a new advocacy group that is answering Biofuelwatch’s criticisms point by point. Bates focuses on carbon trading and how biochar may become a component of projects that seek to sequester carbon, both in rural communities in underdeveloped countries and in agricultural enterprises in the developed world. Finally, he examines carbon-negative communities that are springing up throughout the world and how they serve as models for what we need to do in the face of climate change.

Bates cites British historian Arnold Toynbee, who affirmed that “Civilizations die from suicide, not by murder.” For those of us who accompany the international negotiations—even if we are not in the working groups and plenary sessions—this is what we are seeing. Whether biochar really is part of the solution to climate change mitigation and adaptation remains to be seen, but Bates shows quite clearly that it can contribute to nurturing the soil to support food security, both in alternative agricultural schemes in the developed world and in small-scale agriculture of all kinds in the underdeveloped world. This is adaptation that contributes to mitigation.

For those who are not scientists directly involved with biochar, this is a book worth reading. It presents the science that got biochar rolling, the technologies already available, and how to use it to enhance food security and restore degraded agroecosystems. It is well designed for international agricultural aid staff, nongovernmental organization activists, and agricultural extensionists. Anyone interested in climate change mitigation and adaptation will gain something

from this book, because Bates is careful to point out that mitigation and adaptation will only succeed if global society decides to change the ways it thinks about population and consumption.

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FISHY VERTEBRATES

Do Fish Sleep? Fascinating Answers to Questions about Fishes. Judith S. Weis. Rutgers University Press, 2011. 240 pp., illus. \$21.95 (ISBN 9780813549415 paper).

Did you know that fishes can live in waters with temperatures between the freezing point of salt water and over 110 degrees Fahrenheit? The characteristics of fishes relating to function, form, behavior, and ecology vary across similarly spectacular ranges, and with over 30,000 described species of fishes (representing more than half

of all known vertebrates), how can this evolutionary exuberance be conveyed to a nonspecialist audience? *Do Fish Sleep? Fascinating Answers to Questions about Fishes* is the answer. Estuarine ecologist Judith S. Weis aims at communicating such diversity in her new book with an interdisciplinary view of how the natural history of fishes intertwines with human lives. Structured as 112 questions in eleven chapters, the book follows the model of the Rutgers University series *Animal Q&A: Fascinating Answers to Questions about Animals*. The editors describe the series as “covering everything from basic biology to complex behavior.” Although covering everything poses a practically impossible task for any author, Weis addresses a rich range of fish-related topics from the perspectives of biology, economics, conservation, health, and culture.



For the sake of coherence, I will use the term *fishes* for aquatic fish-like nontetrapod vertebrates (jawless; cartilaginous; and bony fishes, including lobbed-fin and ray-finned fishes). This grouping is strictly based on ecological premises, which seem to be the implicit criterion followed by Weis (more on this below). The book could be divided into two main parts. In the first six chapters, Weis responds to questions about evolution (How did fishes evolve?), form and function (How do fishes swim? Do fishes smell?), life habits and behavior (Do fishes build nests? And of course, do fish sleep?), and ecology (How do fishes interact with plants?), as well as

to questions about their natural enemies, such as diseases, parasites, and predators.

In the second part of her book, Weis surveys nonbiological connections between fishes and human culture, economy, and health. The aesthetic and recreational lure (pun intended) of fishes is addressed with questions relative to home aquaria (Which fishes adapt well and live peacefully in a home fish tank?), swimming (What are the advantages and disadvantages of snorkeling and scuba diving?), and fishing (What is ice fishing?). Particularly refreshing are the notes on the fish theme throughout art, children's literature, and religion.

Commercial fishing, including history of the industry, targeted species, and fishing gear, is also reviewed. Weis explains how unregulated fisheries not only affect fish populations and ecosystems but also the economy. Aside from depicting this somber reality, the author includes examples of what has been done and what could be done to improve the situation. Understandably, the depth with which different topics are presented varies across chapters. Weis is at her best when writing about issues related to her own professional interests, such as estuaries, salt marshes, and the effect of mercury and other pollutants on fishes.

A major challenge in communicating science to nonspecialists is how to avoid taking for granted those concepts and ways of thinking inherent to a scientific specialty. Weis passes this test with honors, showing a special talent for explaining complex subjects in a clear and succinct way and without excessive use of jargon. Using a few select examples, Weis successfully conveys a full range of variation. One shortcoming throughout the text, though, is a lack of consistency regarding how fish species are referred to. Given the general ubiquity of common names, a consistent addition of the scientific name after the common name would have improved clarity and facilitated further research on those species.

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