On the Brink

Rivers in Time: The Search for Clues to Earth's Mass Extinctions. Peter D. Ward. Columbia University Press, New York, 2000. 315 pp., illus. $29.95 (ISBN 0-231-11862-7 hard cover).

Peter D. Ward, professor of geological sciences at the University of Washington, has spent much of his career writing science books about evolutionary matters for the intelligent layperson. This latest endeavor returns us to one of his earlier themes—mass extinction.The author freely admits that *Rivers in Time* is essentially an updated version of his 1994 book, *The End of Evolution: On Mass Extinctions and the Preservation of Biodiversity.* If you read that first edition, you may not find that much worth rereading in this volume. If, however, this is the first time you've embarked upon the subject of mass extinction and you would like a good précis, this book is one of the best written and most evenhanded treatments you could find.

Researchers generally agree that there were five mass extinctions during the Phanerozoic, which began over 500 million years ago, at or near the ends of the Ordovician, Devonian, Permian, Triassic, and Cretaceous periods. The author tackles the last three, with the extinctions at the end of the Triassic an addition to this updated version. This is not a fact-filled book, which is both good and bad. The good: If you are looking for a readable overview of the more recent mass extinctions, this one is worth the read. Ward predigests facts and figures, leaving the reader with a readable summary of what is known of these mass extinctions. He also weaves into the summary a good historical perspective on our ideas about mass extinction. This is not all. He also provides a first-person narrative of his visits to some of the important places where these extinctions have been studied. Sometimes, however, he fails to make it clear to the reader that he is a paleontological tourist, not an expert on these areas; moreover, and unfortunately, many of the photographs are reproduced poorly in the text, though that is ultimately the fault of the publisher, not the author.

The bad part about this not being a fact-filled book is that one cannot use it as a reference volume for mass extinction. There is not a single table or figure illustrating the facts surrounding these major biotic upheavals. Although the absence of these data may well enhance the readability of the book, it severely restricts the audience. Thus, I would recommend it to a student in my undergraduate evolution course who knows little of the earth's past history, but not to anyone interested in the underlying factual basis for these extinctions.

As I stated before, I feel that Ward's account of mass extinctions is evenhanded. As we all are, the author is sometimes subject to biases, notably in the way he has summarized data. For example, in both his first and most recent editions, he notes (p. 173) that "contrary to popular opinion, however, mammals did poorly; in the Hell Creek region only 1 of 28 mammals species survived. In all of North America, the survival rate of the mammals was only 20 percent." The author confuses true extinction with high turnover rates that can result from pseudoextinction. In fact, in the Hell Creek area, 12 of 27 species (44 percent) of mammals either survived or had a descendant that survived. The author's oversimplification masks a very important biological pattern—namely, marsupials fared very badly in North America, dropping from 11 to 1 species, while prospering in South America. The author and I do not always see eye-to-eye on the primacy of some causes of extinctions (e.g., bolide impact at the Cretaceous–Tertiary [K/T] boundary and its corollaries), so the account I just gave of Ward's oversimplification might be dismissed as my bias. Let us examine another example from the author's research.

Ammonites are probably second only to dinosaurs as a poster child for the terminal Cretaceous extinctions. Arguably one of the most definitive studies of ammonites was done by the author and Charles Marshall in1996 ("Sudden and Gradual Molluscan Extinctions in the Latest Cretaceous of Western European Tethys," *Science* 274: 1360–1363). About this article, Ward says in his book (pp. 168–169), "We used a new statistical technique to show that the ammonites certainly died out suddenly at the end of the Cretaceous."

One might quibble with this statement because it was based mostly on research in Zumaya, Spain, and thus we don't know the facts from other areas. Even more interesting, what the authors conclude in this article is that, of 28 species of ammonites, 6 became extinct well before the K/T boundary, another 3 to 10 either disappeared before (possibly from a major regression) or survived until the K/T boundary, and the remaining 12 species probably survived until the K/T boundary. I will leave it to the reader to decide whether the results of this study jibe with the author's claim in his book that these extinctions were sudden. In fairness, I must note that immediately following his discussion of ammonite extinction, the author explains how the abundant rudist clams became extinct well before the end of the Cretaceous.

My major concern is not that the book contains some factual lapses, but that the reader of such books as Ward's may become overly impressed by high percentages of extinction—which in many instances are estimates—and fail to realize that the loss of major parts of a global biota (e.g., dinosaurs and ammonites) have tremendous implications for future evolution. As many authors have noted, without dinosaur extinction by whatever cause, mammals, including ourselves, would not have come to dominate many of the niches occupied by terrestrial vertebrates. Ward shows that one particular result of the terminal Cretaceous extinctions, the appearance of modern humans, has started us on another round of mass extinctions.

Here, I believe, the author does an admirable job of weaving past mass extinctions into what is sometimes called the sixth mass extinction. This message is important, because the events of deep time that have shaped our planet are too often unknown by most people, even some biologists. The author presents the connection.

Ward ends with a supposition with which I cannot agree, namely that "humanity is functionally extinction-proof." He may well be correct that our survival may be augmented by "integration with machine intelligence" or that we may serve as midwife to machine intelligence. But extinction is so much the norm that different kinds of estimates of percentage extinction since the beginning of life on this planet all converge on 99+ percent. I think it is both arrogant and dangerous to believe that because we think we understand extinction (when we do not) that we will somehow escape it. We may even be aiding and abetting it.

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FARMING AROUND THE WORLD

Exploring Agrodiveristy. Harold Brookfield. Columbia University Press, New York, 2001. 348 pp., illus. $35.00 (ISBN 0-231-102321 hardcover).

Harold Brookfield has long been involved in the United Nations University international project on people, land management, and environmental change. The author's work has taken him to diverse areas where he could observe farming practices and agrobiodiversity among small farmers. He has also conducted research with other investigators to enrich his collection of case studies. Included in his book are analyses of farming practices in Africa, Asia Pacific regions, and Central and South America.

The author defines agrobiodiversity as "the many ways in which farmers use the natural diversity of the environment for production, including not only their choice of crops but also their management of land, water, and biota as a whole" (p. 42). Thus, the prime focus of the book is on the production of crops, including tree crops.

As an example, the author reports that in Borneo, more than 95 botanical species of plants (including 200 varieties) are cultivated. Seventy-four of the species are used as food and three are cultivated as cash crops. Such crop variety is unusual: Worldwide, about 15 species of crop plants provide the world with approximately 90 percent of its food.

Also in Borneo, Brookfield reports, Kalimantan farmers are struggling to hold onto their land against the spread of oil palm plantations and commercial development. In other locations, rubber trees are being planted on farmland, thus pressuring the small native farmers in the region.

Early in his book, Brookfield suggests that the problem of soil erosion and land degradation is not as severe as many soil scientists in the world have reported (pp. 80–96). Other investigators disagree with his perspective (Lal and Stewart 1990). On sloping land under tropical rainfall, as much as 400 tons per hectare per year ($t \cdot ha^{-1} \cdot yr^{-1}$) of soil can be lost. Under arid conditions with relatively strong winds, as much as 5600 $t \cdot ha^{-1} \cdot yr^{-1}$ of soil have been reported lost (Gupta and Raina 1996). Indeed, during the summer of 2001, the National Aeronautic Association photographed an enormous cloud of soil being blown from the African continent toward the South and North American continents.

In addition, large amounts of eroded soil are found in streams and rivers. Reportedly, every year two billion tons of soil are transported down the Yellow River of China (Zhang et al. 1997). Soil scientists, including Myers (1993), estimate that approximately 75 billion tons per year are lost primarily from agricultural lands worldwide. Moreover, soil erosion is intensifying in many developing countries because fuelwood is in short supply and people are burning crop residues for fuel, which leaves the soil unprotected, thereby increasing erosion.

Later in the book, the author reports that land degradation is "serious and may well have become more widespread in recent decades" (p. 175). He notes that this degradation is causing crop productivity to decline. This assessment disagrees with his earlier analysis.

The benefits and risks of the Green Revolution from 1960 to 1985 are thoroughly and fairly discussed. Rice and wheat are discussed as models of the revolution. The wheat and rice germ plasm with short-stem characteristics enabled these crops to tolerate heavy applications of nitrogen and other fertilizers. The Green Revolution technologies were based primarily on fossil energy, which was used to produce fertilizers and pesticides and to power irrigation pumps; in regions where these inputs could be afforded, technology helped increase rice and wheat yields two- to fourfold.

In analyzing some of the problems and risks associated with the Green Revolution, Brookfield stresses the loss of the genetic diversity of rice and wheat varieties that had been maintained by farmers before the Green Revolution. This loss of diversity continues to be of concern to not only farmers but also to scientists throughout the world because of new plant pathogen and insect pest problems.

Also cited is the experience of farmers in Java, Indonesia, in the early 1980s, who were provided with an abundance of pesticides, fertilizers, and other inputs to raise rice. As pesticide use increased, so did populations of the destructive brown plant hopper, and eventually rice yields in Java began to decline. When the president of Indonesia consulted Dr. I. N. Oka of the Bogor Food Institute, Dr. Oka recommended that 57 of 64 pesticides be banned; that, to decrease hopper populations, rice not be planted for one three-month period during the year; and that a policy of protecting natural enemy populations of pests in rice be implemented, so farmers could treat against pests only when necessary and in dosages that would protect the natural enemies of the pests. In combination, these strategies led to a 65 percent reduction in pesticide use and an increase in rice yields of 12 percent. Dr. Oka's basic goal, to increase diversity in the rice production system, was achieved.

Recent trends in crop production are not encouraging, as Brookfield suggests. The high costs of inputs (fertilizers, pesticides, and crop seeds) place severe economic stress on small farmers. Although crop yields per hectare are still increasing, they are increasing more slowly than in the past because of shortages of cropland, land degradation, declines in irrigation, and declines in the per capita use of fertilizer. Moreover, the Food and Agricultural Organization (FAO 1961–1999) reports that grain production per capita has been declining since 1983.The decline in per capita availability of these basic foods—grains make up about 80 percent of the world's food—has led to increasing incidence of malnourishment. For example, the World Health Organization recently reported that more than three billion people—more than ever before—are malnourished.

The author is sincerely concerned about agricultural practices and is especially interested in how farmers might initiate changes to protect and conserve their resources. I recommend his final chapter, entitled "Science, Farmers, and Politics," because it gives the reader much to ponder.

Brookfield is to be commended for gathering information and producing a well-documented and indexed reference on agrobiodiversity. Agriculturists, agronomists, geographers, biologists, ecologists, plant breeders, agricultural engineers, anthropologists, and others interested in a world outlook on agrobiodiversity will find an interesting perspective on the topic in this book.

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