Part 2 of the book is devoted to the history of moas at human hands and is fascinating reading for anyone regardless of field of interest. This section is complete, covering sites, hunting strategies, processing technology, and chronology and extinction. Anderson's conclusions are carefully formulated from evidence, not from hopes and fears. Moa relationships are still in doubt; mass-kill episodes probably did not occur, but individualized hunting may have been wasteful; moa-hunting began about 900 years ago and had ceased by 400 years ago, and it is unlikely that moas survived much longer than that. Anderson brings us his story from the standpoint of an anthropologist, and I would have liked more on the relationships between moas and plants, a topic covered nicely by Atkinson and Greenwood in the *New Zealand Journal of Ecology* volume. But this beautifully produced book will stand as a new landmark in the study of these bizarre New Zealand giants. It will occupy a prominent place on my bookshelves.

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Reptilians Past

Dinosaur Tracks. TONY THULBORN. Chapman and Hall, New York, 1990. xvi, 410 pp., illus. $85.

Dinosaurs, Spitfires, and Sea Dragons. CHRISTOPHER MCGOWAN. Harvard University Press, Cambridge, MA, 1991. xii, 365 pp., illus. $29.95. Revision of *The Successful Dragons: A Natural History of Extinct Reptiles* (1983).

Two prominent and productive vertebrate paleontologists here weigh in with good, readable books about very different aspects of dinosaurs and other extinct beasts. Though both books are curiously lacking in phylogenetic perspective, both are highly competent in scholarship and presentation and (in different ways) deserve the attention they are likely to receive.

Dinosaur tracks have been studied for over two centuries (though their makers were not at first correctly recognized), and over the years a vast literature on them has accumulated, very ably reviewed by Thulborn. Through history, many paleontologists have tended to look down their noses at footprints and other trace fossils, often underestimating what they have to tell us. The traditional work was mostly descriptions of tracks or sites: find 'em, collect 'em, draw 'em, measure 'em, name 'em, file 'em, forget 'em. The most adventurous work was usually in trying to guess the identity of the track-maker, often with (to our eyes) implausible or even hilarious anatomical and functional reconstructions. Few paid much attention to the sedimentary or biological context of trackways until the 1950s and 1960s, when workers such as Donald Baird, Frank Peabody, Georges DeMathieu, and Hartmut Haubold began to look more intently at their meaning. Baird in particular established rigorous methods for analyzing tracks, properly noting that these were not anatomical structures but records of transitory behavior. And, he added, there is no point wasting much time on badly preserved tracks, as so many taxonomizers have done.

Many younger workers, notably Martin Lockley, Paul Olsen, James Farlow, and Thulborn himself, have been instrumental in adopting new approaches to trackways. Many of these have been experimental, involving recent animals and a variety of actual substrates. And a lot of new work has overturned traditional identifications of track-makers and views about their locomotion. In 1986, at the First International Symposium on Dinosaur Tracks and Traces, Wann Langston and Adolf Seilacher led a strong new emphasis on the sedimentological context of tracks, noting the importance of the composition and competence of the substrate in influencing footprint form and warning how easily one can be misled by underprints, or "ghost tracks," in reconstructing the identity of track-makers and their behavior. This emphasis should spur a lot of new work.

Thulborn's emphasis in this book is mainly the basics of fossil footprints: what they are, how they are collected and described, and how their makers have been assigned to them. He is particularly good reviewing the recent literature on dinosaur speeds and gaits. His command of the vast literature is especially impressive, typically strong and unusual in coverage.

Dinosaurs, Spitfires, and Sea Dragons is a great engaging exploration of the functional morphology, physiology, and structural mechanics of extinct reptiles, plus the obligatory chapter on extinction. McGowan nicely covers ground probably familiar to most specialists, but with a strong emphasis on the lessons that living animals can teach us about fossil ones. He is especially effective exploring the analogies between large living herbivores, such as giraffes and elephants, and giants of the past. The question of dinosaurian physiology, often simplified as "warm- vs. cold-bloodedness," is given a thorough going-over: the treatment here will enlighten, but not confuse, even the typical undergraduate. Of course there are minor gripes. I would have been perhaps less conservative in conclusions about dinosaur physiology, and I think that perhaps uniformitarian analogies to recent forms are accepted rather too casually at times. But there is more than just good heuristic discussion here. Students and professionals alike will benefit from this book.

In omitting the phylogenetic perspective these two books surprisingly fail to take advantage of what is the greatest advance in our knowledge about dinosaurs during the past decade: clarification of their evolutionary relationships. It is not simply that new phylogenies of major dinosaur groups have been advanced and (more or less) established; more important, the usefulness of phylogenies in answering more complex evolutionary questions has proven so great that no paleontological study is complete without rooting hypotheses in phylogeny. So it is curious that, for example, Thulborn divides track types into "small ornithopods," "iguanodonts," and "hadrosaurs," when these are really nested sets of the same group, and ponders the question whether fossil tracks belong to theropods or birds, when in fact birds *are* theropods. Discussions of track-makers and of the evolution of locomotory types should be coordinated with this kind of knowledge. McGowan leaves questions of phylogeny and what it can tell us about the evolution of function and physiology almost entirely out of his book. And this is a real tragedy. How can one consider the problems of the great size of brachiosaurs, the evolution of the bizarre skull crests in duckbills, or the elegant flight of *Pteranodon* without exploring the evolutionarily intermediate stages represented by other groups in a phylogeny?

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A Repopulation

After the Ice Age. The Return of Life to Glaciated North America. E. C. PIELOU. University of Chicago Press, Chicago, IL, 1991. x, 366 pp., illus. $24.95.

As the most recent period of geologic history, the Quaternary (Ice Age) is potentially the best known. That is especially true of the most recent deglacial hemicycle that spanned the past 20,000 years. In glaciated North America the ground is littered with fresh (and sometimes frozen) evidence of events just past; and most living things in the region have their histories intimately

entwined with environments generated by glacial retreat. Carbon dating (based on the 5700-year half-life of ^{14}C) has been applied with considerable precision to innumerable sites and landscapes of late Pleistocene and Holocene age since the method was discovered four decades ago.

Paradoxically, this plethora of Quaternary data causes most textbooks to give an oversimplified view of that period. The opposite product that many of us specialists help produce is a kaleidoscopic compendium, largely refractory to any but other specialists. In view of these circumstances, the present volume, clearly and coherently written by a single author, comes as a refreshing summer breeze from the north. E. C. Pielou, a resident of British Columbia, is best known for her outstanding books on quantitative methods in ecology and on northern evergreens and has received major awards in botany and ecology. Although this book is partly a new departure from her prior publications, the author clearly enjoys crafting together the details of such diverse subjects as glacial geology, geomorphology, paleontology, and the sytematics and biogeography of living organisms. She does not spare the details, yet they are succinctly summarized and enlivened by some 200 sketches ranging from Ice Age vistas to diatoms, larvae, plants, fishes, dung beetles, beaver dams, and mammoth teeth.

This book is a historical quest to recreate the peregrinations of organisms that now occupy the formerly glaciated land. No great underlying principles are revealed, unless it be the extraordinary complexity and contingency of life. Interpretations are inductive, and the author threads her way cautiously through many weak inferences and multiple hypotheses. Nevertheless, as she observes (p. 62), "When all is said and done, . . . the post-glacial history of the biosphere in Canada and northern United States is now fairly well known because it is based on an enormous amount of evidence."

Northward distribution of trees over glacial terrain has been particularly well studied. Origin from different refugia, unique modes of spreading, and varied soil and moisture requirements cause each species to follow its own destiny, thus producing a shifting set of "non-analogue" communities. The pattern of movement in the west is quite different from the pattern in the east. For example, the eastern white pine moved northward early, whereas the western lodgepole pine made a surprisingly late northward move, until its trek was assisted by evolution of lighter wing loading for its wind-borne seeds. Once a particular species is established, it is not easily displaced until fire or some other catastrophe breaks the logjam. Such "ecological inertia" implies that even today many communities may not exist in equilibrium with the climate and the cohabitants of their environment. For this reason the author advocates (p. 101) the view that "disequilibrium in ecological communities is much commoner than equilibrium."

Naturally there is a chapter on "The great wave of extinctions" among large mammals, which the author sees (p. 251) as "one of the most noteworthy, and most puzzling, events in ecological history." This chapter encapsulates the dilemma that characterizes the extinction debate: *neither side is right*. "The numerous 'environmental' theories put forward . . . all fail in being too farfetched or too 'particular.' . . . . Moreover, they all seem to overlook the fact that tremendous environmental changes occurred during the Wisconsin glaciation as well as at the end of it. The overkill theory has fatal objections, too." Pielou concludes (p. 266), with some frustration, that "the great wave of extinctions at the end of the Pleistocene has yet to be convincingly explained."

This splendid history of American lifeways in the recent past is published just when our society has reached a peak of anxiety over the future of our environment. And so the obvious question is whether this book provides a recipe or two that can help us plan more wisely. Certainly there are no grand pronouncements about global change. The processes and perspectives deciphered here are so intricate, and in many instances so heartily debated, that even simple applications must remain open to discussion. One can assert, however, that knowledge is better than ignorance, and that this book presents a valuable new synthesis of facts and ideas about climate, geography, and life during the past 20,000 years. More important, the book conveys an intimate appreciation of the rich variety of nature through time. As we, and other survivors of the late Pleistocene, struggle onward, this knowledge of life past may encourage us to protect life future.

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Tropical Sites

Four Neotropical Rainforests. ALWYN H. GENTRY, Ed. Yale University Press, New Haven, CT, 1991. xvi, 627 pp., illus. $57.50. From a symposium, Columbus, OH, Aug. 1987.

In his foreword to the 1985 reprinting of Thomas Belt's *The Naturalist in Nicaragua*, first published in 1874, Daniel Janzen wrote, "Just as Belt exposed some of the outlines of tropical biology, today we have by comparison an army of workers observing and recording natural history of the tropics. But Belt was working amidst an ocean of nature, while all that remains to us are small and rapidly shrinking ponds." Four of those "ponds" are the subject of this book, which presents the results of a symposium held at the Association of Tropical Biology's annual meeting in 1987. The four neotropical rainforest sites represented are La Selva, Costa Rica; Barro Colorado Island (BCI), Panama; Cocha Cashu field station in Manu National Park, Peru; and the Minimum Critical Size of Ecosystems (MCSE) study site near Manaus, Brazil.

The book is divided into six parts dealing with site histories, floristics, birds, mammals, amphibians and reptiles, and forest dynamics. Each of the latter five sections contains a chapter on each site and a chapter presenting an overview and summary of the topic. Thirty-six authors, including 26 housed in non-tropical institutions, have contributed to the work.

The four rainforest sites differ strikingly in their size, accessibility, degree of human disturbance, soil conditions, and history of study. La Selva is small (1500 hectares), disturbed, and easily accessible, whereas Cocha Cashu lies in a vast region of undisturbed forest and is least accessible. The soil at three of the sites is relatively rich, whereas that at MCSE is poor. BCI is the longest-established site (dating from the early 1920s) and MCSE the most recent (1979). To date, BCI and La Selva have been the most intensively studied sites and MCSE the least. The former two sites have large infrastructures, substantial annual budgets (over $1 million at BCI), and laboratories for technically sophisticated research. In contrast, Cocha Cashu with its magnificent forest and intact fauna consists of three simple buildings and has an annual operating budget of less than $5000, slightly more than the cost of one polymerase chain reaction machine. Hundreds to thousands of published studies have been done at La Selva