BOOKS: ECOLOGY

How the Biosphere is Organized

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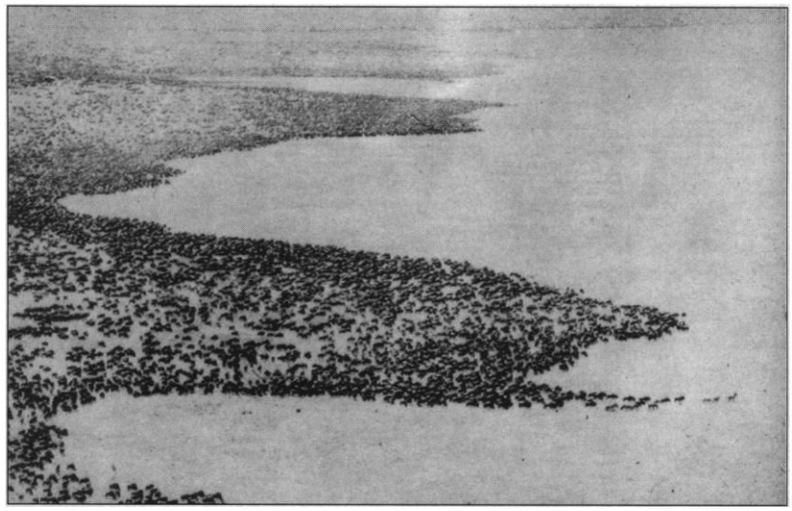
Fragile Dominion
Complexity and the Commons
by Simon Levin
Helix (Perseus), Reading, MA, 1999. 264 pp. $27, C$40. ISBN 0-7382-0111-1.

Why are there roughly 700 species of birds that breed in North America, rather than 7 or 70,000? And why, in comparison, only 200-odd in Britain? For the first question, we are a long way from having the basic understanding that could begin to answer it. For the second, we have an empirical rule and the beginnings of fundamental explanation, but we still have much to learn.

These questions are emblematic of many others in ecology: accessible to a schoolchild, but with no agreed answer as yet. Nor are such questions—about the structure of food webs or about how ecosystems respond to various kinds of disturbance—academic arcana. As human impacts on the environment continue to grow over the coming century and affect even the global climate, the relatively rudimentary state of ecological science prevents us from making reliable predictions about how much biological diversity we can lose before natural systems collapse and deprive us of services upon which we depend. (According to a recent estimate, the true value of such "ecosystem services" exceeds the global total of conventional gross domestic product.)

Simon Levin's book is, in essentials, a lucid and compelling tour through the current intellectual landscape of ecology and environmental science. Levin deliberately follows the structure of the Passover Seder, in which a set of questions derived from a central theme ("Why is this night different from all other nights?") sets the stage. *Fragile Dominion* is organized around six fundamental questions: What patterns exist in nature? What are the relative roles of historical accident versus environment determinism? How do ecosystems assemble themselves? How does evolution, acting on individuals, shape assemblies? What is the relation between an ecosystem's structure and its function? And does evolution favor resilient systems? (The central question these are all derived from is, "Why is this organism different from other organisms?")

Combining specific illustrations with broad synthesis, Levin covers this ground in a way that will engage the nonexpert, yet still provide fresh insights for the professional. For the first two of his six questions, the author argues compellingly that the answer always depends on the temporal and spatial scale at which one looks. Sometimes these scales are set by features intrinsic to the population dynamics of the species, community, or ecosystem itself, and sometimes they are set by extrinsic factors.



Self-organized boundary. Because specific grouping patterns are not so important for the evolutionary reasons that animals gather in groups, the great herds of Serengeti wildebeest exhibit many different shapes and forms.

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A wonderful aerial photograph of wildebeest on the Serengeti—in a herd shaped by thousands of animals each responding only to its local environment and its neighbors—leads into a demonstration that if these patterns are approached on the appropriate spatiotemporal scale, they are as comprehensible as a chemical reaction. But only if approached on the right scale. The implications go far beyond ecology. For example, although rich in achievements of mind-boggling brilliance, today's immunological research focuses mainly on the details of interactions between individual viruses, or other infectious agents, and individual immune system cells; on individual wildebeest, as it were. But a solution to the problem—still unresolved despite 15 years of effort—of why there is so long and so variable an interval between infection with HIV and the onset of AIDS requires, I believe, more attention at the scale of interactions between entire populations of HIV viruses and entire populations of various kinds of immune system cells; at the level of herds of wildebeest, as it were.

Turning to ecosystem assembly, Levin highlights unanswered questions about the characteristics that are likely to favor success for "alien invaders." Again we have basic ecological research intersecting practical problems; here the damage is done by species that are deliberately or accidentally introduced. As globalization shrinks our world, these problems grow in significance.

The later chapters give a clear and balanced account of recent work on how complex systems (ecological or otherwise) might assemble themselves. Levin takes us through a veritable zoo of new ideas, or occasionally new names for old ideas: self-organized criticality, edge of chaos, frequency^{-1} power laws, self-similarity and fractal landscapes, and much else. I think all of this is fun, much of it brings important new insights, and some of it is probably daft. (I do not think the demise of the dinosaurs was a large but self-organized slip on the sandpile of evolution; I think the sand-shovels of external events, such as asteroid impacts, are often decisive.) Nevertheless, Levin is a reliable guide, lucid and skeptical, steering a middle course between the breathless admiration and the sour denigration that characterizes too much writing on these topics.

This is an important book. Sober and scholarly, it lays bare the central problem of our time: So much to learn about the biological treasures that we are heirs to, so little time in which to do it.

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