Problems of scale in ecology

John Lawton

A Hierarchical Concept of Ecosystems. By R. V. O'Neill, D. L. DeAngelis, J. B. Waide and T. F. H. Allen. *Princeton University Press:1986. Pp. 253. Hbk $45, £29.70; pbk $14.50, £9.60.*

ECOLOGISTS have been slow to wrestle with the importance of spatial and temporal scales in population, community and ecosystem processes. By way of illustration, imagine a coral reef, and the myriads of jewel-like fish that call it home. How important are interspecific interactions between the fish in determining "community structure" — which species live where, when and in what abundance?

Study a single patch of coral a few metres square for a few weeks, and fish may appear to come and go at random: evidence of pattern or structure is hard to find because the spatial scale of observations is too small. Fish communities may, instead, be structured over much larger scales, set by patterns of larval recruitment from the plankton over several kilometres of reef. Or, with a different question in mind, it may be very difficult indeed to link detailed behavioural studies of interactions between fish, over time-scales of minutes or hours, to population dynamic processes taking months or years. Finally, the scuba-diver interested in fish behaviour takes the coral for granted as part of the habitat. Yet corals build and die over decades: how are fish behaviour (involving the fastest time- and the smallest spatial-scales) and coral dynamics (with long time- and huge spatial-scales) to be combined into realistic models of the reef ecosystem?

A Hierarchical Concept of Ecosystems tries to address such questions: they may seem obvious, but they have received far too little attention from ecologists. More often than not, field workers arbitrarily select a scale of observations that "seems right", and theoreticians are mute about space and time. But as O'Neill and his colleagues show, these are risky strategies. Theories and observations appropriate for one kind of ecology do not easily translate to larger and longer or smaller and faster spatial and temporal scales. Instead, the natural world can profitably and more correctly be viewed as a multi-layered system, hierarchical in space and time. One virtue of this approach is that a number of apparent conflicts are immediately resolved. For example, assemblages of species (communities) may indeed be regarded as more or less separate entities, each with its own rich biology, much as H. A. Gleason suggested over 50 years ago, whilst entire ecosystems may function holistically, fixing energy and cycling nitrogen irrespective of the species involved. Neither point of view is more "correct" than the other. Similarly, populations and communities of organisms may well be equilibrium systems, with population sizes regulated by food or space, embedded in an ecosystem undergoing long-term, very slow changes far from equilibrium. Again the "correct" picture depends upon your perspective and what questions you ask.

The general message of this book is therefore valuable and well put. Its strength lies in the exposition of hierarchy as a way of thinking, in repeatedly drawing attention to the pitfalls of ignoring scale, and in reinterpreting existing data, disagreements and conflicts in the light of the new perspective. In contrast, I found the development of a formal theory of hierarchy, useful for ecologists, more disappointing. The ideas are more qualitative than quantitative, and starting to accumulate their own jargon: it remains to be seen whether ecologists will find the term "holon" useful, and whether holons can be identified, measured and studied in any objective way. Nor do many clear and new predictions emerge from the book. There are some, for example specific predictions about patterns of nutrient loss from stressed laboratory ecosystems ("microcosms"), and much more general and important ideas about overall control of the dynamics of populations, or other ecosystem components, interacting in nested hierarchies of slow and fast time-scales. I was disappointed not to find more, but recognize that at this stage in the game more rigorous theory and predictions are hard to come by.

The construction of theoretical models of ecological processes as spatial and temporal hierarchies, and attempts to match, test and refine the models against the real world, will undoubtedly be one of the growth industries in ecology over the next decade. *A Hierarchical Concept of Ecosystems* is a good point of departure for this venture, which could prove to be an exciting and unpredictable journey. □

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Even cognitions

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Odd Perceptions. By Richard L. Gregory. *Methuen, London and New York: 1986. Pp. 230. £16.95, $19.95.*

EDITORS of journals usually confine their published remarks to matters of policy. Not so Richard Gregory in his editorials in the journal *Perception*, which have appeared over the past 15 years. These essays reflect the ideas that were exciting him as the deadline for publication descended, and a selection of them has now been collected together under the title *Odd Perceptions*.

Many of the pieces have been amended, extended or amalgamated, and the variety of subject matter is vast: from Bacon to exploratories, from eclipses to ESP, from gnomons to von Neumann, from wind-up frogs to Wittgenstein. They are grouped under three headings — amusing, musing and using (alas, there is no fourth musical section!).

Oddly enough, it is not perception that binds the essays together, but the history of science and its associated methods. At times, the history is confined to individual achievements (such as Kepler's law of planetary motion or Turing's approach to machine intelligence), at others it is addressed to a particular problem (mirror reflections or consciousness, for example). All of these issues tend to be reduced to problems of cognition: how ideas about physical processes develop, and how cognitive processes can be modelled.

According to Gregory, these two types of problem are closely related: his thesis, presented in more detail in *Mind in Science* (Weidenfeld & Nicolson, 1981), is that theories of mental processes draw upon the current solutions to technical problems. The methods that work with physical systems should, he considers, be applied to biological ones. Again, oddly enough, very little is said about machine vision, even though the approach he adumbrates has had some of its greatest successes in image interpretation. Gregory's cognitive approach to perception (as outlined in his chapter on illusions) was developed without the benefit of these solutions, and so it would have been instructive to learn whether his theory has been revised accordingly. Perception is conceived of as a process generating and testing hypotheses — much as scientists do with respect to physical phenomena — until a resolution of the problem is found. How the hypotheses are generated is one of the many deep mysteries we are left with; indeed, one of the pleasures of this book is that it does not set out to provide the answers, but to frame appropriate questions, and to place them in historical perspective.

The essays are served with a liberal mixture of autobiographical anecdote, wit and word-play. They stand as a tribute to Richard Gregory's enthusiasm for perception — the process and the journal. □

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