MODELS AND EXPLANATION IN ECOLOGY

Gregory J. Cooper, *The Science of the Struggle for Existence: On the Foundations of Ecology.* Cambridge: Cambridge University Press, 2003, Pp. xvi + 319. USD 60.00 HB.

By Mark Colyvan

Ecology is a very young science and it is yet to attract the philosophical attention it deserves. But those interested in mining this area will be richly rewarded. All the usual philosophy of science issues are to be found here, along side some fascinating philosophical issues peculiar to ecology. Some of the latter issues include whether ecology has laws and what role(s) mathematical models play in ecological theory. Such issues promise to shed new light on more traditional topics in philosophy of science, such as the nature of explanation and the relationship between explanation and laws of nature. Moreover, the central issues in the philosophy of ecology are also issues for ecology itself, with many ecologists actively and explicitly pursuing the philosophical questions relating to their discipline.

In light of this, Greg Cooper's book *The Science of the Struggle for Existence* will be welcomed by ecologists and philosophers of science alike. This book is perhaps the first philosophically-focussed treatise on ecology by someone with expertise in contemporary philosophy of science. Cooper clearly lays out the central problems in the philosophy of ecology and does so in historically- and ecologically-informed ways. He does a wonderful job of presenting the issues in an engaging fashion, always keeping in mind the needs and interests of ecology. Cooper knows his ecology as well as his philosophy of science and he shows how each can make significant contributions to the other. This is philosophy of science as it should be. But Cooper is not content to merely lay bare the issues in the philosophy of ecology; he also advances his own carefully-reasoned and often provocative proposals for solving the problems under discussion.

The book begins with an overview of some of the philosophical issues that arise in ecology and an introduction to the central task: to defend a particular definition of 'ecology'. The definition Cooper defends is due to Ernst Haekel, according to which "ecology is the study of all those complex interactions referred to by Darwin as the conditions of the struggle for existence." (Haekel, quoted in Cooper, pp. 4–5). At times this unifying thread of the book is a little strained and by and large the task of defining 'ecology' I found less interesting than the issues addressed along the way. But Cooper, also stresses the importance of these other issues in their own right and, indeed, the book can be looked upon as a sustained and systematic treatment of the major philosophical issues arising in ecology.

The second chapter gives a very nice historical overview of ecology, highlighting the various foundational philosophical debates that seem to have plagued the discipline right from the start. The third and subsequent chapters set about clarifying, and eventually providing solutions to, the problems raised in chapter two. The third chapter tackles the question of whether there needs to be a balance of nature. The rest of the book, in effect, tackles a series of questions relating to the possibility of general ecological knowledge.

> If each ecological circumstance is a unique constellation of causal factors shaped by its own idiosyncratic historical context, then it is hard to see how a genuine theoretical understanding of ecological phenomena is even possible. Untangling this foundational debate requires a sharper philosophical image of the pursuit of ecological generality than we currently have. What kinds of general knowledge do ecologists seek? How are these epistemic goals embodied in various methodological practices of the discipline? How does ecological complexity shape the process? What are the prospects for uncovering genuine laws in ecology? (p. 96)

Crucial here is understanding the status of mathematical models, such as the logistic equation and the Lotka-Volterra predator–prey equations. On the one hand, these equations ignore a great deal of important detail and so are clearly somewhat simplistic idealisations and not to be treated too seriously. On the other hand, building, modifying, and testing such models is a major part of standard methodology in population ecology and these models are often taken to be explanatory. Cooper presents the problem as an inconsistent triad (p. 178):

1. There are no laws in ecology
2. There are genuine theoretical explanations in ecology
3. If there are genuine theoretical explanations in ecology then there must be ecological laws.

Cooper accepts (1) and (2), in large part because he takes these to be accepted by most ecologists. He thus rejects (3), the traditional philosophical account of the relationship between laws and explanation. He takes an instrumental attitude towards mathematical models—they are not laws but tools capable of explaining. Although Cooper's move here is very interesting and well worth exploring, I think he is a bit quick to give up on laws in ecology. For a start, not all ecologists accept that there are no laws in ecology (see P. Turchin, 'Does Population Ecology have General Laws?' *Oikos*, 94(2001): 17–26). And those who do accept that ecology is without laws, seem to be driven by somewhat idealised and untenable conceptions of the role of laws elsewhere in science (see M. Colyvan and L. Ginzburg, 'Laws of Nature and Laws of Ecology' *Oikos*, 101(2003): 649–653).

The reasons for denying the existence of laws in ecology is not always entirely clear. Often appeals are made to lack of generality and lack of predictive success, but the complicated nature of ecology seems to feature especially prominently in this debate—ecology is just too complex to have laws, or so the thought goes. But we are in danger of setting the bar too high for lawhood here. It may well be true that ecology is too complex to submit to general laws, but it's not obviously true, and it's certainly not something we can determine *a priori*. After all, we take celestial mechanics to be law governed, even though every massive body in the universe interacts with every other massive object. It doesn't get much more complicated than that! While it is true that populations are affected by a great deal around them—the weather, predators, parasites, resources, and so on—considerations elsewhere in science show that complexity alone does not disqualify a discipline from being law governed. The complexity might "wash out", so to speak (see M. Strevens, *Bigger than Chaos*, Cambridge, Mass., 2003), or much of the complexity might be properly ignored in many situations (as we can properly ignore the gravitational influence of Antares on the earth when we consider the Earth's orbit around the sun).

A case can be made for rejecting (1) in Cooper's inconsistent triad, while hanging on to (2) and (3). There is a very natural way to think of a highly simplistic and idealised equation like Malthus's equation, $N(t) = N_0 R^t$ (where, N is the population abundance, t is time, N_0 is the initial abundance, and R is the growth rate), as a fundamental law of ecology. After all, this equation can be thought of as analogous to Newton's first law. Both describe what the system in question does in the absence of disturbing influences. In the ecological case, Malthus's law tells us that populations tend to grow exponentially unless interfered with. Interference can come in the form of density dependence, predators, and so on. Of course there always are disturbing influences, so no population grows exponentially for any significant period of time. But why should this disqualify Malthus's equation from being a law? After all, no massive body in the universe moves with uniform motion, but this does not disqualify Newton's first law. If it's good enough for celestial mechanics, it's good enough for ecology. Malthus's equation can thus be thought of as a fundamental law of population growth—it describes the default case from which departures are to be explained. We are then faced with the project of identifying the "ecological forces" that result in such departures from exponential growth. We have some plausible candidates here: density dependence, predator–prey interactions, and the maternal effect. (See L. Ginzburg and M. Colyvan, *Ecological Orbits: How Planets Move and Populations Grow*, New York, 2004). If this is right, then ecology may yet have simple laws.

While I don't always agree with Cooper's positive proposals, I do agree that these proposals are always worthy of serious consideration. And most importantly, I agree with Cooper on the significance of the underlying issues.

As I see it, the lasting value of *The Science of the Struggle for Existence* is in its thoughtful articulation of some of the most interesting philosophical problems relating to the study of ecology. This is an important book and one that will set the agenda for some time in the philosophy of ecology.

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