Ecologists need 'efficient theory' to make sense of all the data

July 17 2014

Ecologists are awash with data and have the tools to find patterns in it, but understanding those patterns requires the extra struggle to come up with simple, typically mathematical approaches that the 16 co-authors of a new report in *BioScience* term "efficient theory."

That half of the 16 authors have SFI connections is no accident, says External Professor Pablo Marquet, lead author of the paper. In the late 90s, SFI and University of New Mexico researchers developed a theory of biological scaling laws based on fractal geometry—and in the process "spawned a lot of criticism," Marquet says, much of it focused on the nature of theory and whether mathematical theory was even desirable in the age of Big Data. In 2006, a small group—including the biological scaling researchers—met in Chile and decided they had to clear up those issues.

"The complexity of the world is such that big data without big theory is scary, actually," Marquet says. Efficient theory, he says, addresses the challenge by building on robust foundations called first principles (basic, well-tested, core principles about the world), a small number of additional assumptions, and usually, though not always, mathematical descriptions of the world. Mathematics, he says, makes a theory not only simpler to describe but also easier to communicate, hence speeding up scientific progress.

Despite the emphasis on mathematical precision, ecologists should also think of theory as an approximation to the real world, the authors argue.

In physics, for example, Newtonian mechanics describes well how marbles, cars, and planets interact, but it doesn't work so well for atoms, the domain of quantum mechanics. And that's as it should be: no theory is perfect, and researchers should look for discrepancies with data and use those to refine a theory, not reject it completely. "We want to find the simplicity in the complexity," Marquet says

That simplicity isn't just academic. We need efficient theory, Marquet says, "to cope with complex and wicked environmental problems. Without a predictive theory of the biosphere and ourselves, we are doomed."

More information: Pablo A. Marquet, Andrew P. Allen, James H. Brown, Jennifer A. Dunne, Brian J. Enquist, James F. Gillooly, Patricia A. Gowaty, Jessica L. Green, John Harte, Steve P. Hubbell, James O'Dwyer, Jordan G. Okie, Annette Ostling, Mark Ritchie, David Storch, and Geoffrey B. West. "On Theory in *Ecology*." *BioScience* first published online July 16, 2014. DOI: 10.1093/biosci/biu098

Provided by Santa Fe Institute