Study may help predict extinction tipping point for species

September 8 2010

What if there were a way to predict when a species was about to become extinct -- in time to do something about it?

Findings from a study by John M. Drake, associate professor in the University of Georgia Odum School of Ecology, and Blaine D. Griffen, assistant professor at the University of South Carolina, may eventually lead to such an outcome—and that is only the start. Their study also has implications for understanding drastic, even catastrophic, changes in many other kinds of complex systems, from the human brain to entire ecosystems.

The paper, "Early warning signals of extinction in deteriorating environments," published in the early online edition of the journal *Nature*, describes a study of the fluctuations in experimental populations of water fleas (Daphnia magna) undergoing environmental stress until they reach a tipping point beyond which they do not remain viable. The study is unique in its careful comparison of these stressed populations with other, healthy populations in the context of new theories about dynamic systems undergoing transitions at a tipping point, particularly a phenomenon known as "critical slowing down."

"This is the first experimental demonstration of critical slowing down in a biological system," said Drake. He explained that critical slowing down is a term used to describe a pattern in data that has previously been observed in physics and the Earth sciences, but until now has been only a theoretical possibility in biology. It describes the decreasing rate of recovery from small disturbances to a system as it approaches a tipping point. When a system is close to a tipping point, it can take a long time to recover from even a very small disturbance. "The theory was originally used to describe drastic changes in other kinds of systems—everything from epileptic seizures to regime shifts in the earth's climate system," Drake said. "But these attributions of CSD primarily have been after-the-fact explanations of anomalous observations without clear controls."

This also is the first time the theory has been applied to extinction.

The experiment featured populations of water fleas that were assigned to either deteriorating environments (in this case, declining levels of food) or stable environments (the control group). The experiment lasted for 416 days, when the last population in the deteriorating environment group became extinct. Depending upon the amount of food they received, populations in the deteriorating environment group reached the population viability tipping point after approximately 300 days. Populations in the control group never reached it; those populations persisted.

The researchers next looked at a variety of statistical indicators, early warning signals that could detect the onset of CSD and thereby predict the approach to a tipping point. They compared the indicators with the timing of the decrease in food and with the achievement of the tipping point, mathematically referred to as a "transcritical bifurcation." They found that each of the indicators—some more strongly than others—showed evidence of the approaching tipping point well before it was reached.

According to Drake, what is even more important is the generality such statistical indicators are expected to exhibit. That is, although precise quantitative models are required to predict most natural phenomena—in any domain of science—with any degree of accuracy, the theory of critical slowing down applies qualitatively anytime a bifurcation is in the vicinity. "You don't have to know the underlying equations to use the theory," Drake said, "and this is important in biology, where the dynamics are typically sufficiently complex that we often do not know which equations to use. In fact, we may never come to such a complete understanding, given the range of biodiversity out there and the fact that species are evolving all the time."

Drake pointed out that potential applications, such as predicting extinctions based on evidence of CSD, are still in the future. "This is the first step in the fundamental research that would underlie such an application," he said. "We have shown that CSD can happen in populations—that is all. The real world is a lot 'noisier' than the lab. Using early warning signals to predict approaching tipping points could eventually be a powerful tool for conservation planning, though, and for better understanding a host of other kinds of systems as well."

John Gittleman, dean of the Odum School of Ecology, agreed. "This study fits into one of the core missions of the Odum School by developing a predictive science of ecology," he said. "We now have clear, predictive research programs dealing with extinction, conservation, and disease, all critically important areas for a more robust science of ecology."

Provided by University of Georgia

Citation: Study may help predict extinction tipping point for species (2010, September 8) retrieved 19 April 2024 from https://phys.org/news/2010-09-extinction-species.html