Density fluctuation as a measure of the tipping point in Ising-type ecosystems

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Abstract

A tipping point is a critical transition point where a system is impending to collapse under a slight disturbance. Based on sequential time-series data, such transition can be captured by early warning signals like critical slowing down. However, sequential time-series data is limited for most macro-ecosystems, which brings the challenge for practical application. Here we report that density fluctuation, a purely spatial metric, robustly indicates the tipping point of Ising-type ecosystems. Ricker model and an agroecosystem, both of which have been proved to fall in Ising universality class, are used as prototypes to illustrate how density fluctuation captures the tipping point from instantaneous spatial configurations. The agroecosystem demonstrates experimental evidence that the existence of an Ising-type tipping point depends on the dynamics properties of the system. In addition to detecting tipping points, early warning signals were able to infer ecological processes from spatial patterns of the agroecosystem. As spatially high-resolution data are becoming increasingly available, density fluctuation offers a novel perspective on anticipating tipping points and identifying ecological processes from spatial patterns.

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