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Scaling and Universality of Species Lifetimes

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Natural ecosystems are characterized by striking diversity of form and functions and yet exhibit deep symmetries emerging across scales of space, time and organizational complexity. Empirical and theoretical evidence show that the distribution of local species lifetimes, defined as the timespans between local colonizations and extinctions in a given geographic region, emerges as a universal macroecological pattern characterized by a power-law scaling in time limited by a cut-off determined by the rate of emergence of new species. A synthesis of theory and empirical evidence accounting for the relevant ecological dynamics represents a major goal for community ecology and conservation biology. To that end here we address the relation between species lifetimes and the spatial structure of the ecosystem. We present the analysis of empirical data on species lifetimes from several surveys pertaining to different taxa, properly interpreted to account for the constraints imposed by finite sampling intervals and areas. We show, with a simple theoretical model, that the scaling exponent of the lifetime distribution depends on the underlying spatial interaction network, while the cut-off timescale is imposed by biogeographical constraints related to the size of the ecosystem. In particular, empirical exponents are robustly reproduced once a two-dimensional isotropic matrix is used. We also show how other key macro-ecological patterns, like the species-area relationship, are directly related to the lifetime distribution, which thus proves a powerful and synthetic descriptor of ecosystem dynamics.