RATE-DEPENDENT CRITICAL PHENOMENA IN ECOSYSTEMS

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Nowadays, populations are faced with unprecedented rates of global climate change, habitat fragmentation and destruction causing an accelerating conversion of their living conditions. Critical transitions in ecosystems often called regime shifts lead to sudden shifts in the dominance of species or even to species' extinction and decline of biodiversity. Many regime shifts are explained as transitions between alternative stable states caused (1) by certain bifurcations when certain parameters or external forcing cross critical thresholds, (2) by fluctuations, (3) by extreme events or by (4) by rate-dependent transitions. We address here several of the aforementioned mechanism and show their relevance for ecosystems. Firstly, we discuss rate-dependent critical transitions (4) which do not require the existence of alternative states but instead, the system performs a large excursion away from its usual behaviour when external environmental conditions change too fast. During this excursion, it can embrace dangerous, unexpected states. We demonstrate that predator-prey systems can either exhibit a population collapse or an unexpected large peak in population density if the rate of environmental change crosses a certain critical rate. Whether a system will track its usual state or will tip with the consequence of either a possible extinction of a species or a large population outbreak like, e.g., a harmful algal bloom depends crucially on the time scale relations between the ecological timescale and the time scale of environmental change. Secondly, we demonstrate another rate-dependent phenomenon, in which a system can cross the basin boundary of an ecosystem changing from a desirable to an undesirable coexistent stable state. In particular, we show how the interplay between bifurcation-induced regime shifts (1) and rate-dependent basin boundary crossings due to extreme events (3) can lead to population outbreak or collapse. Again, the relationship between the different timescales in the system like the intrinsic timescale of the ecosystem dynamics and the timescale of environmental change plays a decisive role in the possibly counterintuitive outcomes after the impact of an extreme event.