
Delayed behavioral shifts undermine the sustainability of social-ecological systems.

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Abstract

Natural habitat destruction and fragmentation generate a time-delayed loss of species and associated ecosystem services. As social-ecological systems (SESs) depend on a range of ecosystem services, lagged ecological dynamics may affect their long-term sustainability. Here, we investigate the role of consumption changes for sustainability, under a time-delayed ecological feedback on agricultural production. We use a stylized model that couples the dynamics of biodiversity, technology, human demography and compliance with a social norm prescribing sustainable consumption. Compliance with the sustainable norm reduces both the consumption footprint and the vulnerability of SESs to transient overshoot-and-collapse population crises. We show that the timing and interaction between social, demographic and ecological feedbacks govern the transient and long-term dynamics of the system. A sufficient level of social pressure (e.g. disapproval) applied on the unsustainable consumers leads to the stable coexistence of unsustainable and sustainable or mixed equilibria, where both defectors and conformers coexist. Under bistability conditions, increasing extinction debts reduces the resilience of the system, thus favouring abrupt regime shifts towards unsustainable pathways. Given recent evidence of large extinction debts, such results call for farsightedness and a better understanding of time delays when studying the sustainability of coupled SESs.

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