Scaling behaviour in resilient social-ecological systems governance

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Abstract

Recent work on human-environment systems has generated a variety of models for studying systemic collapses of social cooperation and/or ecological resources. Several factors underlie the stability of regimes in such systems, such as social network topology or how accessible resources are to harvesters. However, these models have typically focussed on a single scale of analysis and do not account for the fundamentally multiscale nature of socio-ecological dynamics, which connect the behaviours of individuals to large-scale Earth system dynamics. In this work, we address this gap by studying how the size of a socio-ecological system (SES) affects its dynamics. In particular, we extend prior SES multilayer network models and introduce a coarse graining scheme that enables the systematic study of scaling trends. Our results show two opposing effects as system size increases: The first promotes socially cooperative resource conservation behaviour due to the increasing separation of distant resource nodes. The second privileges defectors as their ability to avoid punishment increases with their seperation. We evaluate the interplay and impact of these scaling effects. Our findings provide a mechanistic explanation for frequently observed dynamics in SESs and offer insights into how risk management strategies need to be adjusted for SESs at different scales..

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