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# Towards detecting signatures of resilience in soils

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Resilience of ecological systems has been a topic of much debate over the past two decades. There are a number of different definitions of such resilience, but a consensus is that if early warning signs of system change can be detected in response to environmental perturbations, this may allow management interventions to prevent collapse to a potentially undesirable alternative. Amongst the candidates suggested as potential signals are 'critical slowing-down', signified by changes in generic properties pertaining to the system, such as increased autocorrelation and variance in data relating to the response to perturbation. Demonstrations of such signals have tended to be confined to computer simulations, due to difficulties in measuring signals in real systems resulting from issues of temporal and spatial scales. For the first time, we have found experimental evidence of critical slowing-down in a complex ecosystem, using soil as an exemplar. We studied the effects of controlled perturbations in microcosms upon a system-level function (respiration in response to repeated dry:wet cycles) in soils taken from 67 sites across England and Wales, representing a wide spectrum of land management and soil types. We detected changes in the variance and autocorrelation of the respiratory response to increasing number of dry:wet cycles, enabling us to demonstrate three classes of behaviour in soil: (1) Those with low variance and no auto-correlation with respect to increasing cycle number – consistent with Dakos et al.'s "resilient" definition; (2) those with increasing variance and high auto-correlation with respect to increasing cycle number – consistent with Dakos' "non-resilient" definition; (3) those with increasing variance but no auto-correlation with respect to increasing cycle number, which we posit are beginning to lose resilience. The implications of this work include a potential means to establish the extent to which soils in temperate managed systems are close to crossing into alternative stable states, and that this type of approach may be able to provide a test system for wider ecological theory.