Measuring the relative resilience of sub-arctic lakes to global change

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Abstract

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Ecosystems at high altitudes and latitudes are expected to be particularly vulnerable to the effects of global change. We assessed the responses of littoral invertebrate communities to changing abiotic conditions in subarctic Swedish lakes with long-term data (1988–2010) and compared the responses of subarctic lakes with those of more southern, hemiboreal lakes. We used a complex systems approach, based on multivariate time-series modelling, and identified dominant and distinct temporal frequencies in the data; that is, we tracked community change at distinct temporal scales. We determined the distribution of functional feeding groups of invertebrates within and across temporal scales. Within and cross-scale distributions of functions have been considered to confer resilience to ecosystems, despite changing environmental conditions.

Two patterns of temporal change within the invertebrate communities were identified that were consistent across the lakes. The first pattern was one of monotonic change associated with changing abiotic lake conditions. The second was one of showing fluctuation patterns largely unrelated to gradual environmental change. Thus, two dominant and distinct temporal frequencies (temporal scales) were present in all lakes analysed. Although the contribution of individual feeding groups varied between subarctic and hemiboreal lakes, they shared overall similar functional attributes (richness, evenness, diversity) and redundancies of functions within and between the observed temporal scales. This highlights similar resilience characteristics in subarctic and hemiboreal lakes.

The effects of global change can be particularly strong at a single scale in ecosystems. Over time, this can cause monotonic change in communities and eventually lead to a loss of important ecosystem services upon reaching a critical threshold. Dynamics at other spatial or temporal scales can be unrelated to environmental change. The relative ‘intactness’ of these scales that are unaffected by global change and the persistence of functions at those scales may safeguard the whole system from the potential loss of functions at the scale at which global change impacts can be substantial. Thus, an understanding of scale-specific processes provides managers with a realistic assessment of vulnerabilities and the relative resilience of ecosystems to environmental change. Explicit consideration of ‘intact’ and ‘affected’ scales in analyses of global change impacts provides opportunities to tailor more specific management plans.

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