Paleo-thresholds: What the past can tell us about abrupt changes in ecosystems

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Abstract

High-resolution paleoecological datasets offer a unique opportunity to study abrupt shifts in ecological community structure and function, including the nature of precursor conditions and the extent to which they may be sustained over long periods of time. Here we evaluated an abrupt change in diatom species composition from a sediment core from Foy Lake (Montana, USA) for predictors of a regime shift. We used univariate indicators (e.g. increasing variance) and multivariate analysis (e.g. Fisher Information) to evaluate whether a warning signal is apparent prior to the abrupt shift in species composition brought about by regional climate change. We found that some, but not all, of the univariate indicators for some species show a warning prior to the shift. However, both multivariate metrics (Fisher Information and multivariate time series modeling) showed evidence of a ~2000 year transition period prior to the abrupt shift. This suggests that within a complex system an abrupt transition can be the product of a long-term reorganization. Most quantitative research on regime shifts in complex ecosystems has focused on shifts that occur during periods of human observation; these analyses lead to an understanding of how fast variables (e.g. nutrient loading) erode resilience, but don’t address how slow variables (e.g. climate) change ecosystem state. Here we show that paleoecological records can reveal the duration of transitions between alternative states in a system that is impacted by both fast and slow variables. In addition, paleoecological records provide a valuable resource for testing tools of threshold detection and prediction.

Keywords: Regime shift, Resilience, Threshold

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