Concepts & Synthesis

Seasonality and predictability shape temporal species diversity

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Abstract

Temporal environmental fluctuations, such as seasonality, exert strong controls on biodiversity. While the effects of seasonality are well known, the predictability of fluctuations across years may influence seasonality in ways that are less well understood. The ability of a habitat to support unique, non-nested assemblages of species at different times of the year should depend on both seasonality (occurrence of events at specific periods of the year) and predictability (the reliability of event recurrence) of characteristic ecological conditions. Drawing on tools from wavelet analysis and information theory, we develop a framework for quantifying both seasonality and predictability of habitats, and applied this using global long-term rainfall data. Our analysis predicted that temporal beta diversity should be maximized in highly-predictable and highly-seasonal climates, and that low degrees of seasonality, predictability, or both would lower diversity in characteristic ways. Using stream invertebrate communities as a case study, we demonstrated that temporal species diversity, as exhibited by community turnover, was determined by a balance between temporal environmental variability (seasonality) and the reliability of this variability (predictability). Communities in highly-seasonal Mediterranean environments exhibited strong oscillations in community structure, with turnover from one unique community type to another across seasons, whereas communities in aseasonal New Zealand environments fluctuated randomly. Understanding the influence of seasonal and other temporal scales of environmental oscillations on diversity is not complete without a clear understanding of their predictability, and our framework provides tools for examining these trends at a variety of temporal scales, seasonal and beyond. Given the uncertainty of future climates, seasonality and predictability are critical considerations for both basic science and management of ecosystems (e.g. dam operations, bioassessment) spanning gradients of climatic variability.

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