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ESTIMATING COMMUNITY STABILITY AND ECOLOGICAL INTERACTIONS FROM TIME-SERIES DATA

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Abstract. Natural ecological communities are continuously buffeted by a varying environment, often making it difficult to measure the stability of communities using concepts requiring the existence of an equilibrium point. Instead of an equilibrium point, the equilibrial state of communities subject to environmental stochasticity is a stationary distribution, which is characterized by means, variances, and other statistical moments. Here, we derive three properties of stochastic multispecies communities that measure different characteristics associated with community stability. These properties can be estimated from multispecies time-series data using first-order multivariate autoregressive (MAR(1)) models. We demonstrate how to estimate the parameters of MAR(1) models and obtain confidence intervals for both parameters and the measures of stability. We also address the problem of estimation when there is observation (measurement) error. To illustrate these methods, we compare the stability of the planktonic communities in three lakes in which nutrient loading and planktivorous fish abundance were experimentally manipulated. MAR(1) models and the statistical methods we present can be used to identify dynamically important interactions between species and to test hypotheses about stability and other dynamical properties of naturally varying ecological communities. Thus, they can be used to integrate theoretical and empirical studies of community dynamics.

Key words: community matrix; community stability; multivariate autoregressive process; reactivity; resilience; stationary distribution; stochastic population model; time-series analysis; vector autoregressive process.