Ecology, 75(7), 1994, pp. 2127–2138

PREDICTIVE INDICES OF ECOSYSTEM RESILIENCE IN MODELS OF NORTH TEMPERATE LAKES[1]

KATHRYN L. COTTINGHAM AND STEPHEN R. CARPENTER
Center for Limnology, University of Wisconsin, 680 North Park Street, Madison, Wisconsin 53706 USA

Abstract. Predictive indicators of the rate of ecosystem recovery after a perturbation (resilience) could be valuable tools for ecological studies that need to anticipate system response to perturbation. We used a simulation model of summer phosphorus cycling in north temperate lakes to (1) evaluate whether resilience decreases with increasing food web length and increases with increasing nutrient loading and (2) test the correspondence between two potential indicators of resilience (nutrient turnover rate, NTR, and the dominant eigenvalue, λ_{max}) and postperturbation measurements of recovery rate. We determined λ_{max} and NTR for reference simulations of planktivore- and piscivore-dominated food webs at three baseline phosphorus loading rates (0.1, 1.0, and 2.0 $\mu g \cdot L^{-1} \cdot d^{-1}$), then measured recovery rates from simulated pulses of available phosphorus. The planktivore-dominated (short) food web was more resilient at baseline phosphorus loading rates of 0.1 and 1.0 $\mu g \cdot L^{-1} \cdot d^{-1}$. However, the piscivore-dominated (long) food web was more resilient at the highest baseline phosphorus loading rate (2.0 $\mu g \cdot L^{-1} \cdot d^{-1}$), apparently because the additional nutrients were incorporated into biota more rapidly. Recovery rates predicted from NTR (but not from λ_{max}) were consistent with measured recovery rates. NTR appears to be a useful predictor of lake ecosystem recovery from nutrient pulses, particularly because it can be estimated relatively easily. Field tests comparing preperturbation estimates of NTR and postperturbation recovery rates are necessary to further validate this approach.

Key words: ecosystem; eigenvalue; food web; lake; nutrient loading; nutrient turnover rate; phosphorus cycling; pulse perturbations; resilience; simulation model.