Ecology, 84(6), 2003, pp. 1563–1575

VARIABILITY OF LAKES ON THE LANDSCAPE: ROLES OF PHOSPHORUS, FOOD WEBS, AND DISSOLVED ORGANIC CARBON

BEATRIX E. BEISNER,[1] C. LISA DENT,[2] AND STEPHEN R. CARPENTER

Center for Limnology, University of Wisconsin, 680 North Park Street, Madison, Wisconsin 53706-1492 USA

Abstract. In northern temperate lakes, algal abundance or chlorophyll levels are affected by phosphorus loading (P), dissolved organic carbon (DOC), and food web effects from trophic cascades induced by anglers. To investigate how changes in land use and climate might affect future chlorophyll conditions in these lakes, we created a nonlinear model for lake chlorophyll that considers the effects of these factors. Parameters were estimated for northern Wisconsin lakes. We show that resilience of the clear-water state in a single lake is maximized when P inputs are low, DOC is high, and angler pressure is low. We simulated a population of lakes to understand the current distribution of chlorophyll and resilience across lakes in the landscape. Under current conditions of land and lake use in the area, the model indicates that most lakes in the region are resilient clear-water lakes. Low chlorophyll levels, however, do not guarantee resiliency. Resilience shows a bimodal distribution suggesting that, with stochastic shocks or changing conditions, more lakes could shift to a high chlorophyll state that is costly to remediate. We also simulated a limnological comparative study to determine what conclusions would be drawn from a common research method if lacustrine ecosystem dynamics are indeed faithfully generated by our model. We show that phosphorus input will most often appear to be the most significant driver of lake chlorophyll levels, despite the fact that all mechanisms (including DOC and grazing) drive the dynamics. This finding suggests that long-standing debates in limnology about the primary drivers of algal abundance are explainable by differences in research approaches. This work brings together community and ecosystem ecology and shows how their processes can interact to drive higher-order feedbacks.

Key words: chlorophyll; dissolved organic carbon; fishing, food web; lakes; landscape; Northern Highlands Lake District, Wisconsin; phosphorus; resilience; variability.