

THRESHOLDS AND STABILITY OF ALTERNATIVE REGIMES IN SHALLOW PRAIRIE-PARKLAND LAKES OF NORTH AMERICA¹

Kyle D. Zimmer,² Mark. A. Hanson³, Brian R. Herwig⁴, and Melissa L. Konsti^{5, 6}

Numerous studies have demonstrated alternative regimes in shallow lake ecosystems around the world, with 1 state dominated by submerged macrophytes and the other by phytoplankton. However, the stability of each regime, and thresholds where lakes shift to the alternative regime, are poorly known. We used a cross-sectional analysis of 72 shallow lakes in Minnesota, USA, over 2 years to assess the frequency of regime shifts and to estimate corresponding phytoplankton and macrophyte abundance thresholds. Thresholds were low and varied among lakes, likely due to differences in lake depths. Upper bounds on confidence intervals for thresholds were 29 $\mu\text{g L}^{-1}$ chlorophyll *a* for phytoplankton and 398 g sample^{-1} for macrophytes. Lakes crossing 1 or both of these bounds shifted regimes between years, as evidenced by greater changes in macrophyte and phytoplankton abundance relative to all other lakes. Thirty-three lakes were dominated by macrophytes and 17 lakes were dominated by phytoplankton in both years, while 22 sites shifted regimes. Benthivore biomass was intermediate in shifting lakes relative to clear and turbid lakes, and change in biomass was higher in shifting and turbid lakes relative to clear lakes. This suggests a threshold at moderate benthivore abundance. Our results indicated that shallow lakes may switch regimes at relatively low levels of phytoplankton and macrophyte abundance, and that natural changes in abundance of benthivorous fish may be an important trigger. Specific thresholds were variable among lakes, perhaps due to other important influences, indicating that lakes will be best managed on a case by case basis.

¹ Abstract of a paper submitted to *Ecosystems*

² Department of Biology, University of St. Thomas, St. Paul, Minnesota, 55105

³ Minnesota Department of Natural Resources, Wetland Wildlife Populations and Research Group, Bemidji, Minnesota, 56601

⁴ Minnesota Department of Natural Resources, Fisheries Research, Bemidji, Minnesota, 56601

⁵ Department of Biological Sciences, North Dakota State University, Fargo, North Dakota, 58105

⁶ Present address: Minnesota Department of Natural Resources, Fisheries Management, Lanesboro, Minnesota, 55949