The Impacts of Stochasticity in a Freshwater Ecosystem Model with Alternative Stable States

Freshwater ecosystems are impacted by disturbances including stochasticity (natural fluctuations in population sizes) and nutrient input, which can push a clear, healthy lake into a cloudy, algae-dominated state. At certain nutrient levels, these two states can both persist as alternative stable states, where it can be hard to reverse a transition from one state to the other. To study the impacts of disturbance on freshwater ecosystems, we used the mathematical model of fish populations from Scheffer (1989), where a pike-dominated state is a clear lake and a bream-dominated state is a cloudy lake. We added stochasticity into the model, which we estimated from population data of pike and bream in various lakes. We ran our model at various levels of stochasticity and nutrient levels and quantified the population dynamics, such as proportion of time spent at each state and the time between transitions. We found that with the addition of stochasticity, bream populations never reached the high populations at the cloudy state that were calculated by the model without stochasticity, and that the model with stochasticity actually spent more time at the clear state than the cloudy state. At high nutrient levels, the model without stochasticity stayed in the algae-dominated cloudy state, but the model with stochasticity frequently transitioned from the cloudy state to the clear state. Our results suggest that stochasticity may mitigate the length of time spent at the cloudy, unfavorable state, as well as decrease the severity of the cloudy algae-dominated state.

Keywords: freshwater ecosystem, alternative stable states, stochasticity, mathematical model, pike and bream