

Evidence of alternate attractors from a whole-ecosystem regime shift experiment

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Abstract Ecosystems sometimes shift between different states or dynamic regimes. Theory attributes these shifts to multiple ecosystem attractors. However, documenting multiple ecosystem attractors is difficult, particularly at spatial and temporal scales relevant to ecosystem management. We manipulated the fish community of a lake with the goal of causing trophic cascades and shifting the food web from a planktivore-dominated state to an alternate piscivore-dominated state. We evaluated evidence that the shifts in the fish community comprise alternate attractors using two complementary approaches. First, we calculated phase space trajectories to visualize the shift between attractors. Second, we computed generalized autoregressive conditional heteroskedasticity (GARCH) models and the Brock–Dechert–Scheinkman (BDS) test for linearity. The reconstructed phase space trajectories show the system departing a point attractor, entering a limit cycle, and then shifting to a new point attractor. The GARCH and BDS

results indicate that linear explanations are not sufficient to explain the observed patterns. The results provide evidence for alternate attractors based on high-frequency time series of field measurements.

Keywords Alternate ecosystem attractors · Regime shift · Trophic triangle · Ecosystem experiment · Bifurcation · Nonlinearity · GARCH · BDS test · Phase space

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