Flee the toxins: autotoxicity-induced traveling vegetation spots in a biomass-water-toxicity model

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Abstract

In recent years it has become increasingly clear that one factor that can serve as an indicator to critical climate changes, and how resilient a given ecosystem is to such changes, is the dynamics of vegetation. This realization has made the understanding of the underlying mechanisms regulating these dynamics extremely important to explore. Motivated by this direction of investigation, a new ecological theory has recently emerged, which identifies the toxic compounds that are produced by the decomposition of organic material as an essential element in the behaviour of local vegetation. The introduction of a new model component modeling biomass autotoxicity induces novel spatiotemporal behaviour of vegetation patterns. In particular, autotoxicity is seen to induce movement and deformation of spot patterns. Our aim is to analytically quantify this novel phenomenon, by considering the model reduced to one spatial dimension. We use geometric singular perturbation theory to obtain an explicit expression for the corresponding asymmetric traveling pulse solution, by constructing a homoclinic orbit in the associated 5-dimensional dynamical system. We find that both the plant's sensitivity to toxins and the toxin decay rate significantly influence the behaviour and shape of the biomass pulse.