Enhanced Forecasting of Biomass-toxicity-water models using Numerical Simulations

Mudassar Abbas, Francesco Giannino, Annalisa Iuorio, Francesco Calabró

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1 Abstract

Numerical techniques are the essential tools to solve the reaction-diffusion models in ecology, addressing the intrinsic complexity arising from nonlinear and coupled systems. Numerical methods provide efficient spatial and temporal resolution to explain the vegetation patterns. The emergence of vegetation patterns is significantly influenced by plant-soil feedback which alters the soil properties, shapes nutrient availability, influences plant interactions, and develops mutualistic relationships with soil microbes. Understanding these feedback processes is essential to manage and conserve ecosystems, predict responses to environmental change, and implement appropriate land management strategies. The formation of vegetation patterns has been the focus of significant study and debate over the years, and it has been linked to two main mechanisms: the depletion of water in the center of vegetation patches and the production of toxicity by litter decomposition in soil. In this study, we investigate the role of water depletion and autotoxicity in the formation of spatial patterns. We compare various reaction-diffusion PDE models that describe the dynamics of plant biomass under water scarcity and the presence of toxicity caused by the decomposition of litter. We incorporated logistic and exponential growth functions to capture different growth patterns, along with mortality and inhibitor terms to simulate the component's individual death rates and inhibitory effects. Using appropriate numerical techniques, we solved six alternative reaction-diffusion PDE models that we proposed, and MATLAB was used for the simulations.