11th Conference on Dynamical Systems Applied
to Biology and Natural Sciences DSABNS 2020
Trento, Italy, February 4-7, 2020

SPATIAL SELF-ORGANISATION ENABLES SPECIES COEXISTENCE IN A MODEL FOR SAVANNA ECOSYSTEMS

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The savanna biome is characterised by a continuous vegetation cover, comprised of herbaceous and woody plants. The coexistence of species in arid savannas, where water availability is the main limiting resource for plant growth, provides an apparent contradiction to the classical principle of competitive exclusion. Previous theoretical work using nonspatial models has focussed on the development of an understanding of coexistence mechanisms through the consideration of resource niche separation and ecosystem disturbances, but has ignored effects of spatial interactions.

In this talk, we propose that a spatial self-organisation principle, caused by a positive feedback between local vegetation growth and water redistribution, is sufficient for species coexistence in savanna ecosystems. We present a spatiotemporal ecohydrological PDE model, based on the Klausmeier reaction-advection-diffusion system for vegetation patterns, to suggest two mechanisms that enable species coexistence. Firstly, a stability analysis of the system's single-species patterns, performed through a calculation of their essential spectra, provides an insight into the onset of coexistence states. We show that a stable solution branch in which both species coexist bifurcates off the single-species solution branch as the single-species state loses its stability to the introduction of a second species. We present a comprehensive existence and stability analysis to establish key conditions, including a balance between the species' local competitive abilities and their colonisation abilities, for species coexistence in the model. Secondly, we show that coexistence can also occur as a metastable state. Such a long transient behaviour is caused by the small growth rate of perturbations to a spatially uniform coexistence equilibrium, whose size is controlled by the average fitness difference between both species, a measure of the species' competitiveness in a spatially uniform setting.

 ISBN: 978-989-98750-7-4