Poster submission CS3 Summer School

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Informing Seagrass Restoration With Mathematical Modelling

Alongside efforts to protect aquatic ecosystems, efforts are also underway to restore degraded habitats and establish new ones in currently barren areas. Mathematical models describing the dynamics of key species can inform decision-making, particularly given the high costs and logistical challenges of underwater restoration. This study focuses on restoration efforts involving seagrasses such as *Posidonia oceanica* and *Cymodocea nodosa*. Seagrasses, as both primary producers and ecosystem engineers, play a crucial role in aquatic ecosystems, as well as being key carbon sinks. These plants form extensive meadows which often display heterogeneous structures at the seascape level, attributed to self-organisation to optimise resources and better dissipate wave energy. We apply a model that incorporates not only growth and mortality but also facilitation, competition, and spatial interactions[1], enabling it to capture the emergence of spatially heterogeneous patterns. Many seagrass planting methods aim to stabilize sediment and locally reduce mortality, particularly from currents and wave action that can dislodge shoots before they develop strong root systems. This is introduced into the model by modifying the baseline mortality ω_0 with a spatially dependent field $\omega(x)$, representing localized reductions in mortality due to stabilizing structures.

The enhancing structure is modelled by this field as a local reduction of the mortality. We study how this modifies the existing solutions and the bifurcation diagrams, using numerical integration and solution continuation methods. We focus particularly on identifying the thresholds that must be surpassed for a structure to develop, since this is a key piece of information for practical applications. The plant distribution is also relevant for optimising the initial chances of success of the restoration and maximising the growth rate. The available biomass to plant is a strong limiting factor for underwater restoration, and more so in the case of seagrasses, due to both biological particularities and their protected status. Studying the best shape is thus key to make good use of this limited resource. This is heavily influenced by the spatial and nonlinear effects.

[1] Ruiz-Reynés, D., Martín, L., Hernández-García, E., Knobloch, E., and Gomila, D., Patterns, localized structures and fronts in a reduced model of clonal plant growth, Physica D: Nonlinear Phenomena 414 (2020) 132723