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Species competition and dispersal drive vegetation dynamics in tidal salt marshes

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Salt marshes are among the most common morphological features found in tidal landscapes and provide ecosystem services of utmost importance.

The ability of salt marshes to counteract changes in external forcings depends on the complex dynamic interactions between physical and biological processes. In particular, salt-marsh evolution, both in the horizontal and vertical directions, is critically affected by the presence of halophytic vegetation that colonizes the marsh platform.

Despite their importance, however, modeling vegetation dynamics in intertidal marshes remains a major challenge both at the theoretical and practical/numerical levels. Improving our current understandings of the mechanisms driving halophytes zonation is of critical importance to enhance projections of salt-marsh response to changes in climate and relative sea level.

Here we present a new bi-dimensional, spatially explicit ecological model aimed to simulate the spatial dynamics of halophytic vegetation in tidal saline wetlands. Vegetation dynamics are treated differently compared to previous models, which employed relatively simple deterministic or probabilistic mechanisms, dictated only by the ability of different species to adapt to different topographic elevations. In our model, in contrast, spatial vegetation dynamics depend not only on the local habitat quality but also on spatially explicit mechanisms of dispersal and competition among multiple, potentially interacting species. The temporal evolution of vegetation biomass at each site depends on death and colonization processes, both local and resulting from dispersal. These processes are modulated for each species by the habitat quality of the considered site.

Results indicate that our model can predict realistic diversity and species-richness patterns. More importantly, the model is also able to effectively reproduce the outcome of classical ecological experiments, in which a species is transplanted to an area outside its optimal niche. A direct comparison clearly shows how previous models not accounting for dispersal and interspecific competitions are unable to reproduce such dynamics.

Coupled with a hydro- and morphodynamic module, our model can contribute to improving our

ability to model salt marsh evolution numerically and allow for cost-effective ecological community-level studies, providing useful insights on the ecomorphodynamics of marsh landscapes that are of interest to the community of coastal scientists and managers as a whole.