Tipping points and Transient Responses to Global Stressors Determine the Carbon Storage Capacity in Seagrass Ecosystems

Antoine Le Vilain*[1,2], Elisa Thebault[2], and Vasilis Dakos[1]

[1]Institut des Sciences de l'Evolution de Montpellier – Centre de Coopération Internationale en Recherche Agronomique pour le Développement, Ecole Pratique des Hautes Etudes, Institut de recherche pour le développement [IRD] : UR226, Centre National de la Recherche Scientifique, Université de Montpellier – France

[2]Institut d'écologie et des sciences de l'environnement de Paris – Institut de Recherche pour le Développement, Sorbonne Universite, Université Paris-Est Créteil Val-de-Marne - Paris 12, Centre National de la Recherche Scientifique, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement – France

Résumé

Seagrass ecosystems are key carbon sinks in the biosphere and, hence, promising nature-based solutions for climate change mitigation. The carbon stocked in these ecosystems – along with mangroves and salt marshes – has been coined as "blue carbon" for its aquatic origin. Unfortunately, they are also experiencing major anthropogenic pressures that can lead to seagrass degradation or even result in difficult-to-reverse abrupt shifts (i.e. tipping point responses) to complete cover loss. Although the possibility of tipping point responses in seagrass ecological dynamics has been addressed, the potential cascading effect of tipping points on biogeochemical dynamics, shifting seagrass ecosystems from carbon sinks to carbon sources remains largely unexplored. Such cascades from the ecological to the biogeochemical dynamics can be driven by direct anthropogenic physical damage, eutrophication and warming. Here, we developed a mechanistic stoichiometric model coupling ecological and biogeochemical dynamics to assess the effects of global change stressors on carbon storage in seagrass ecosystems. After parameterising our model for Mediterranean Posidonia meadows, we explored stress scenarios with different intensities and change rates to anthropogenic damage, eutrophication and warming. Our findings underscore the importance of considering transient dynamics to fully grasp the complexity of these ecosystems as rapid changes in environmental conditions lead to rate-induced tipping points in carbon storage capabilities. They also highlight the pivotal role of time lags between ecological and biogeochemical processes for understanding the dynamics of carbon storage capacity of dead matte and in the restoration of seagrass ecosystems as a Nature-Based Solution for climate mitigation.

Mots-Clés: blue carbon, environmental change, seagrass, tipping point, time lag, transient dynamics

*Intervenant