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Sea Level Rise and Sediment Supply Explain Large-Scale Patterns of Saltmarsh Expansion and Erosion

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Abstract : Salt marshes are valued for their role in coastal flood protection, carbon storage, and for supporting biodiverse ecosystems. As a biogeomorphic landscape, marshes evolve through the complex interactions between sea level rise, sediment supply and wave/current forcing, as well as and socio-economic factors. Climate change and direct human modification could lead to a global decline marsh extent if left unchecked. Whilst the processes of saltmarsh erosion and expansion are well understood, empirical evidence on the key drivers of long-term lateral marsh dynamics is lacking. In a GIS, saltmarsh areal extent in 25 estuaries across Great Britain was calculated from historical maps and aerial photographs, at intervals of approximately 30 years between 1846 and 2016. Data on the key perceived drivers of lateral marsh change (namely sea level rise rates, suspended sediment concentration, bedload sediment flux rates, and frequency of both river flood and storm events) were collated from national monitoring centres. Continuous datasets did not extend beyond 1970, therefore predictor variables that best explained rate change of marsh extent between 1970 and 2016 was calculated using a Partial Least Squares Regression model. Information about the spread of Spartina anglica (an invasive marsh plant responsible for marsh expansion around the globe) and coastal engineering works that may have impacted on marsh extent, were also recorded from historical documents and their impacts assessed on long-term, large-scale marsh extent change. Results showed that salt marshes in the northern regions of Great Britain expanded an average of 2.0 ha/yr, whilst marshes in the south eroded an average of -5.3 ha/yr. Spartina invasion and coastal engineering works could not explain these trends since a trend of either expansion or erosion preceded these events. Results from the Partial Least Squares Regression model indicated that the rate of relative sea level rise (RSLR) and availability of suspended sediment concentration (SSC) best explained the patterns of marsh change. RSLR increased from 1.6 to 2.8 mm/yr, as SSC decreased from 404.2 to 78.56 mg/l along the north-to-south gradient of Great Britain, resulting in the shift from marsh expansion to erosion. Regional differences in RSLR and SSC are due to isostatic rebound since deglaciation, and tidal amplitudes respectively. Marshes exposed to low RSLR and high SSC likely leads to sediment accumulation at the coast suitable for colonisation by marsh plants and thus lateral expansion. In contrast, high RSLR with are likely not offset deposition under low SSC, thus average water depth at the marsh edge increases, allowing larger wind-waves to trigger marsh erosion. Current global declines in sediment flux to the coast are likely to diminish the resilience of salt marshes to RSLR. Monitoring and managing suspended sediment supply is not common-place, but may be critical to mitigating coastal impacts from climate change.

Keywords : lateral saltmarsh dynamics, sea level rise, sediment supply, wave forcing
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