Does alternative stable states theory and catastrophic shift theory apply for bare intertidal flats and vegetated marshes?

Wang Chen and Stijn Temmerman

Universiteit Antwerpen

Ecosystem management research group, Department of Biology, University of Antwerp, Belgium

E-mail: Chen.Wang@student.ua.ac.be

Introduction

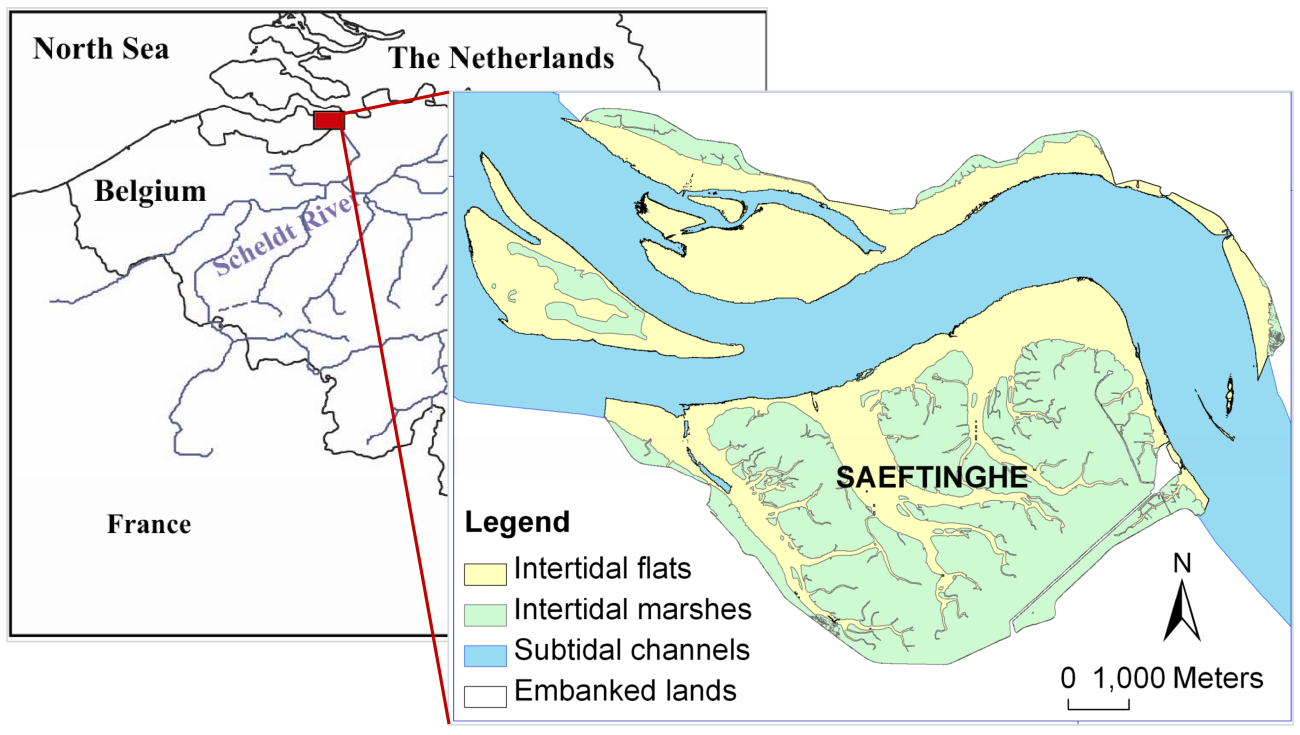
Theory: Sudden large shifts may occur in ecosystems between alternative stable states due to positive feedbacks.

Hypothesis: Tidal flats and marshes behave as alternative stable landscape states with abrupt shifts.

Study area: Western scheldt estuary with semi-diurnal tidal regime and the local mean tidal range of 4.88m.

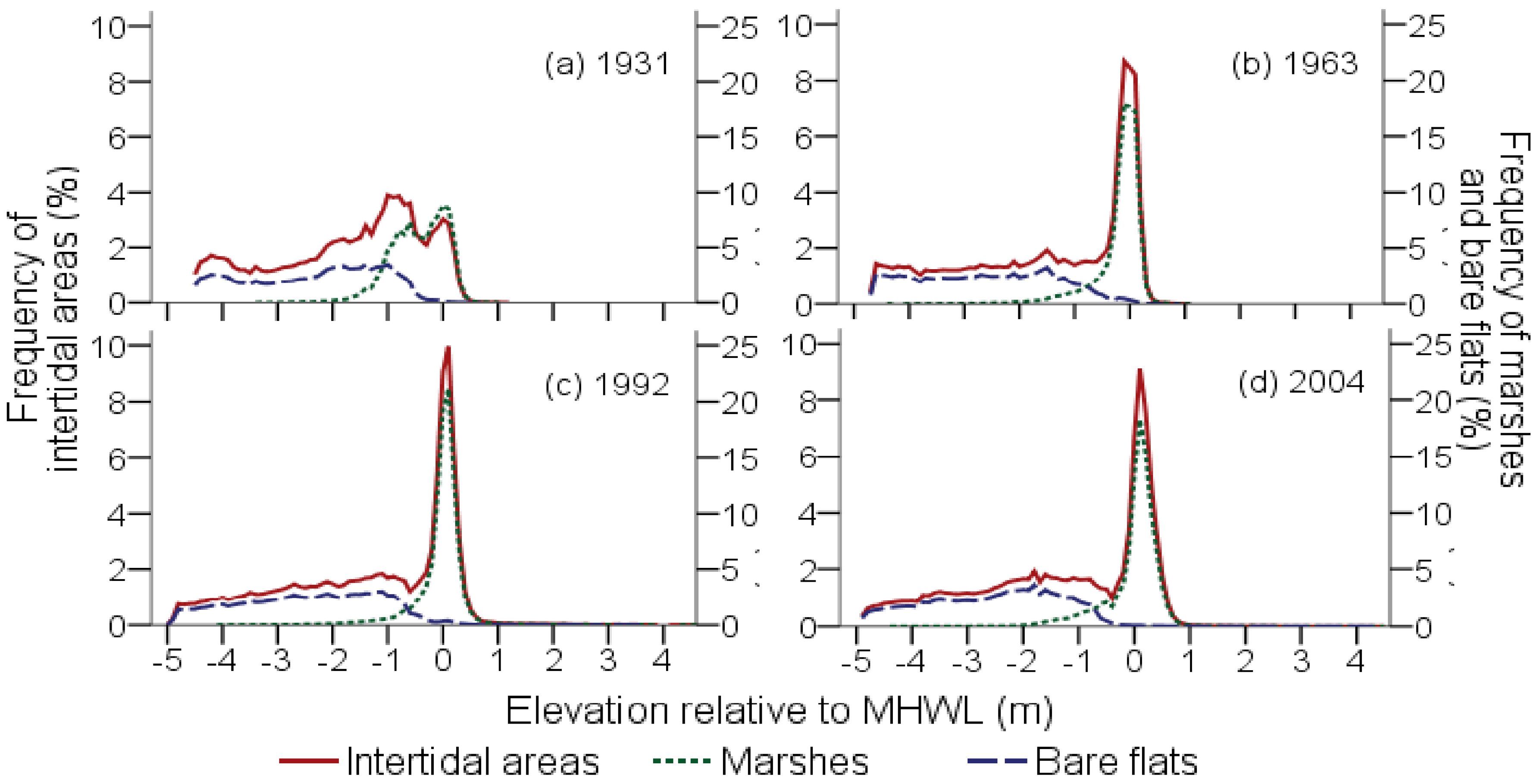
Methods: GIS analysis of historical records of intertidal elevation surveys (DTM), vegetation maps and aerial pictures.

DTM (Year)	Vegetation map (Year)	Five-year mean high water level (m NAP)
1931	1935	2.36
1963	1959	2.53
1992	1988	2.70
2004	2004	2.76



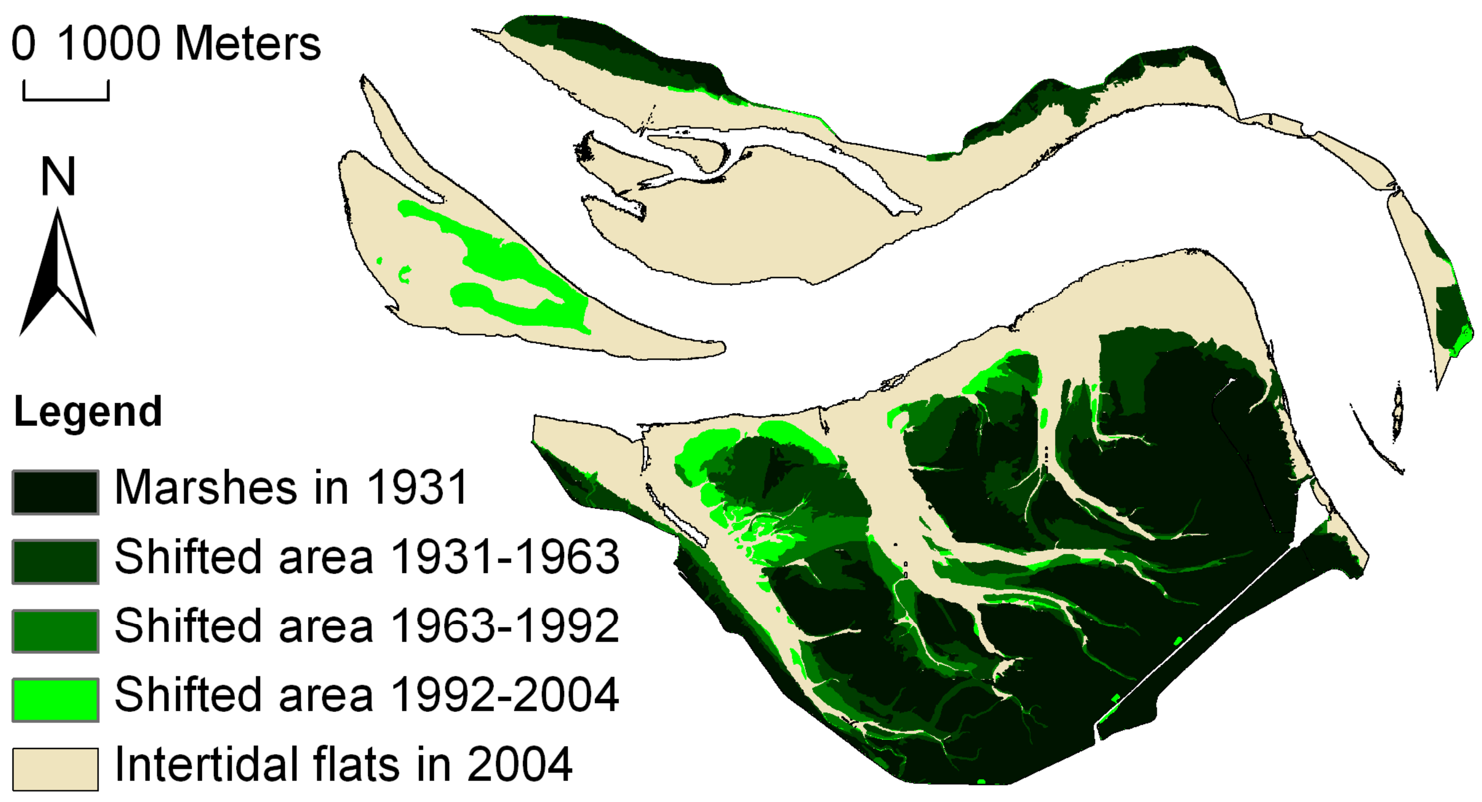
Bimodal distribution of intertidal elevations

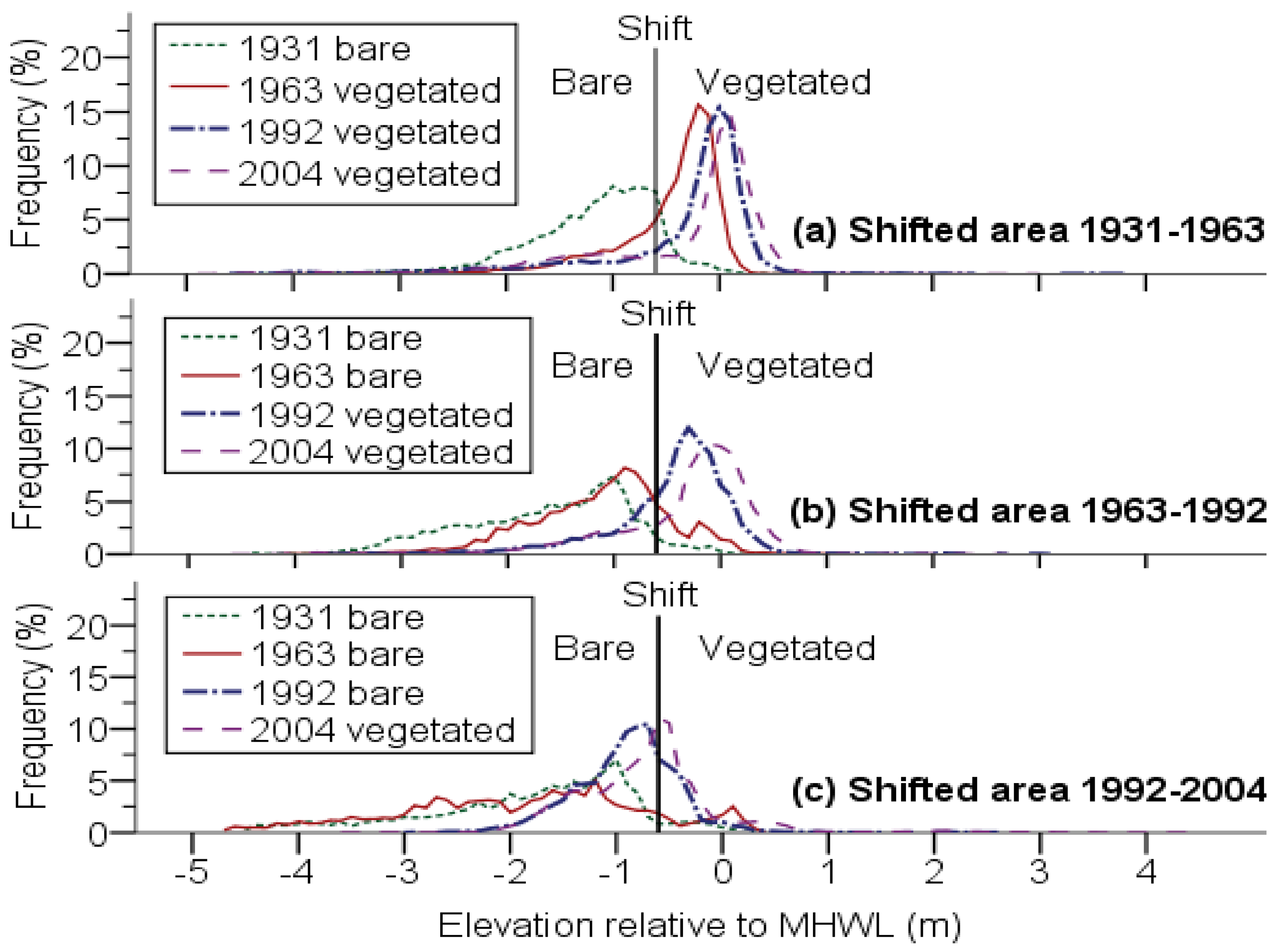
Vegetated intertidal marshes lie within a small range of high elevations, while bare intertidal flats dominate a broader range of lower elevations. The intermediate elevations are less frequent.



Rapid elevation shifts from bare flats to vegetated marshes

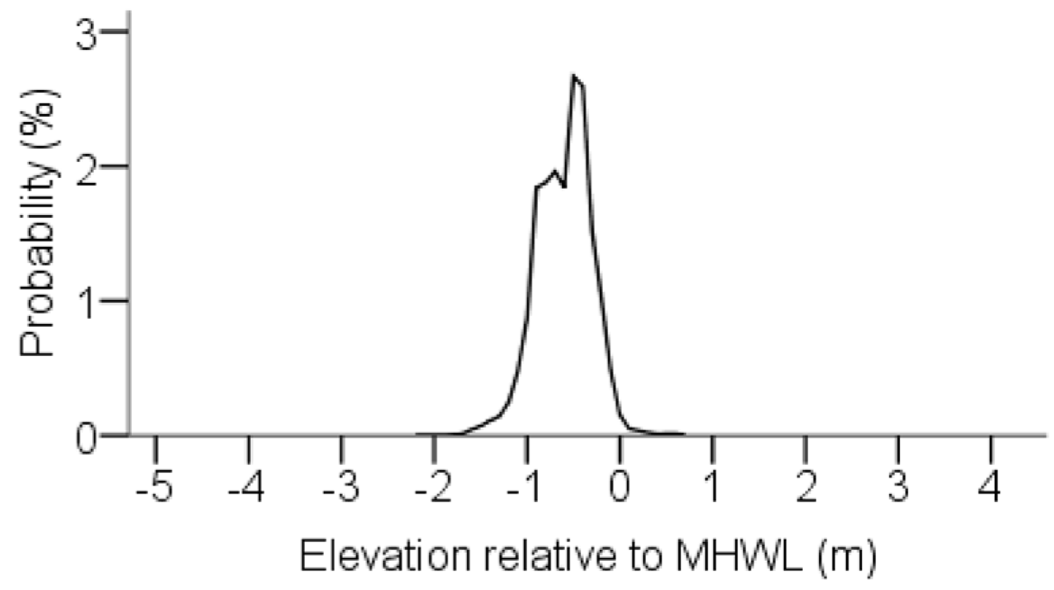
The change from bare to vegetated state was always associated with a much more rapid increase of the peak of the elevation distribution and when it exceeded a threshold value.



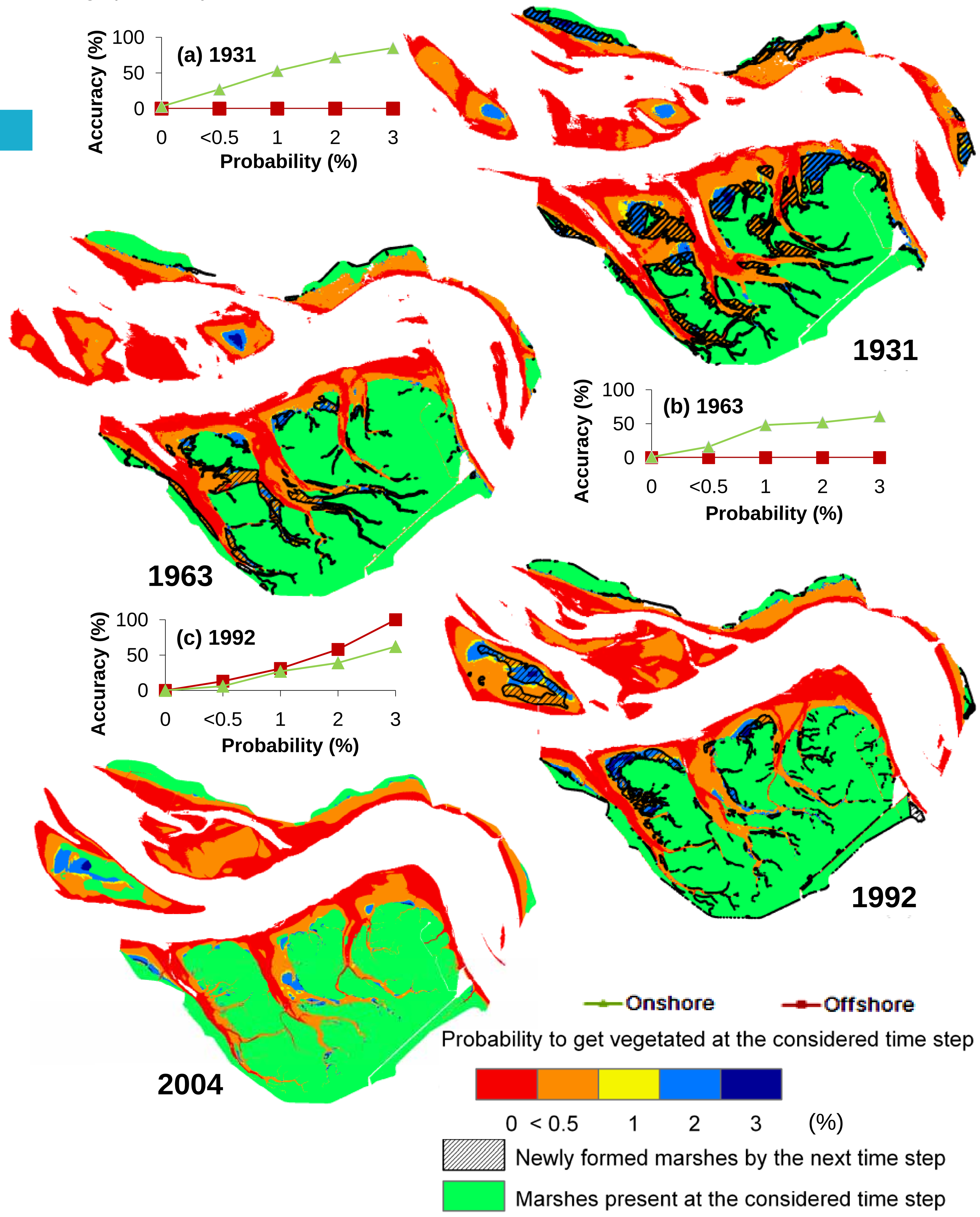


Predicting shifts from bare to vegetated based on threshold elevation

Pioneer patches are considered to initiate the shift from bare to vegetated state. The probability for establishment of pioneer vegetation, proxy of the shift, was calculated based on the data of 2004.



The probability map of getting vegetated was then generated for the four time steps. The accuracy was assessed with the map of newly formed marshes by the following time step. A high probability on the onshore flats mostly results in a shift to vegetation by the next time step.



Conclusion

Our study provided empirical evidences for the rapid non-linear shifts between low-lying bare flats and higher-elevated vegetated marshes in a macro-tidal intertidal ecosystem.

1) The elevation distribution is bimodal, with a high occurrence of low-elevated bare flats and high-elevated vegetated marshes, but low occurrence of intermediate elevations.

2) The elevation shift from bare flats to vegetated marshes is relatively rapid.

3) The shift can be predicted as soon as a threshold elevation is exceeded.