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Quantifying threshold conditions for seaward expansion of tidal marsh shorelines: A transplantation experiment

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1. Introduction

The extent of tidal marshes typically changes by landward erosion or seaward expansion, at rates varying from a few meters per year (e.g. Scheldt estuary, SW Netherlands (Van der Wal *et al.*, 2008)) to several hundreds of meters per year (e.g. Yangtze estuary, China (Yang *et al.*, 2001)). Contrasting stages of marsh development such as gentle sloping marsh-mudflat transition zones that are a sign for an expanding, accreting marsh on the one hand, and eroding cliffs, triggered by waves, tidal currents, and mass movements on the other hand can be found in the field (e.g. Allen (1989), Temmerman (2003)). However, little is known on the threshold environmental conditions that determine the onset of seaward expansion or landward erosion. We hypothesize that seaward expansion by the establishment and survival of plants on initially bare tidal flats depends mainly on sediment dynamics, which should be in direct link with wave exposure. In order to study the impact of sediment dynamics on the expansion by seeds or propagules (rhizomes), a transplantation experiment has been conducted at two sites with contrasting wave exposure along the Scheldt estuary north of Antwerp in 2011.

2. Methods

The two sites chosen for the experiment are Rilland (NL) which lies very close to the shipping channel and Groot Buitenschoor (B) which is protected by a dam from direct wave impact.

Seedlings, individual shoots grown from rhizomes, and adult tussocks extracted from the naturally dominating pioneer vegetation of the brackish intertidal marshes (*Scirpus maritimus*) have been transplanted on 5 distinct levels. In order to take into account a gradient of inundation stress and sediment dynamics, the transplantations were performed along an elevation gradient of 1.2 m, reaching from the bare mudflat at 1.2 m a.m.s.l. (above mean sea level) up into the pioneer vegetation at 2.4 m a.m.s.l. Monitoring of plant growth and survival and of sedimentation and erosion rates with a simplified Surface-Elevation-Table (Cahoon *et al.*, 2002) has taken place from April to September 2011.

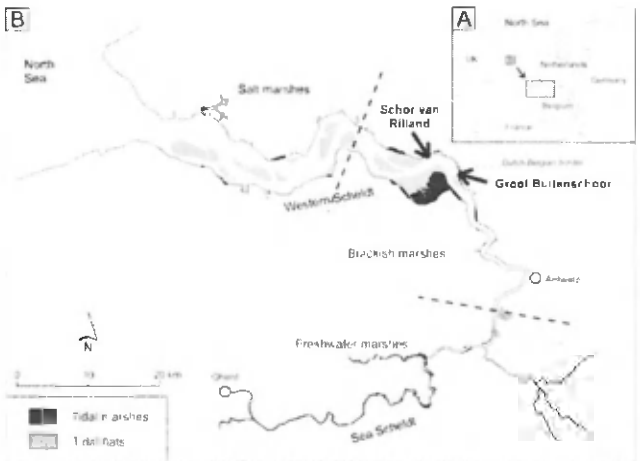

Figure 1. A - General location of the Scheldt estuary; B - Location of field sites in the brackish part of the Scheldt north of Antwerp.

3. Results and discussion

First analyses of the data indicate that neither inundation stress nor the net sedimentation rates had significant impact on the survival of the plants. As a result, survival rates of initially transplanted plants were comparable at both sites (Fig. 2 A). At the sheltered site, however, a clear advantage for clonal propagation of the transplanted plants could be observed (Fig. 2 B). The contrasting wave exposure and their direct and indirect effects could be the reason for this: As direct effect of waves, the plants suffer from physical weakening as they bend forward and backward at each wave event. As indirect effect of the contrasting wave exposal the granulometric composition of the sediment at the two locations differs a lot, with Rilland being mainly sandy (≥ 70 % sand fraction on all levels), whereas silt dominates in Groot Buitenschoor (approx. 50 % on average). This granulometrical contrast leads to a difference of organic matter content (< 3 % at Rilland vs. ≈ 7 % at Groot Buitenschoor) which could thus be an explanation for the better performance of clonal expansion at the sheltered site, simply because more nutrients were available there.

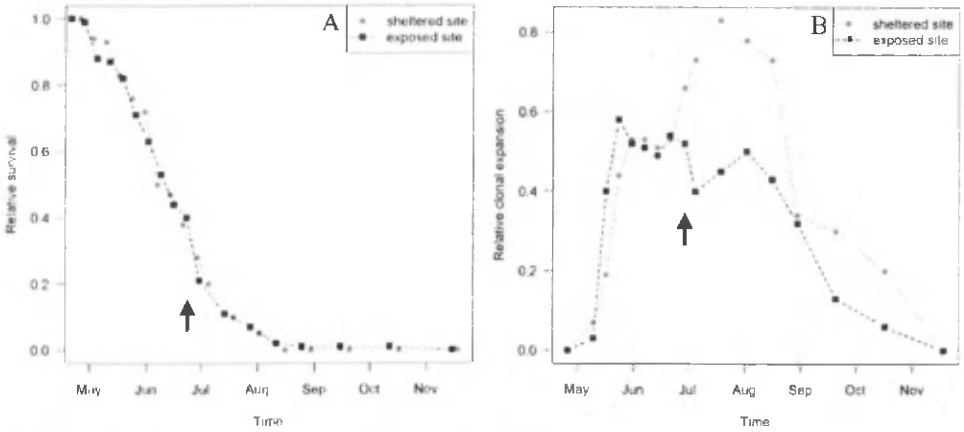

Figure 2. Comparison of plant performance at exposed and sheltered site, all levels combined.
A - Relative mean survival of transplanted shoots; B - Relative mean clonal expansion of shoots.

Moreover, our experiment showed that punctual extreme events such as storms (e.g. June 28th, 2011, indicated with an arrow) destroyed within a few hours plants that had well established on the mudflat over several weeks. Here again, the exposed site suffered more than the sheltered site (see Fig. 2), and plants that had been transplanted into the marsh survived unharmed, which emphasizes the role of wave attenuation and protection of marsh vegetation.

4. Conclusions

Our original hypothesis of direct link between sedimentation dynamics and survival rate cannot be confirmed based on these results. However, it remains to determine whether the *direct* impact of waves limits the survival of plants. In order to do so, the importance of wave action on the plants, as planned in a wave flume experiment at the wave flume of UGent in July 2012, needs to be investigated.

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