The effect of bank slope types on reed species distribution patterns along marsh edges

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Introduction

Reed species form the natural vegetation of estuarine river banks in Germany. Protected by the European Habitats Directive these habitats exhibit high levels of productivity. Moreover, they provide valuable ecosystem services such as river bank protection acting as ecosystem engineers by trapping sediments. Marsh reeds are prone to hydrodynamics. Therefore, natural disturbances like storms and ice drift, but especially anthropogenic disturbances by shipping waves are an important factor shaping the distribution of these species along marsh edges. Due to unequal hydrodynamic energy in the river channel, differences in the distribution patterns of reed species along slip-off and cutbank slopes can be expected. For example, *Phragmites australis* can be observed on lower elevations where hydrodynamics are less intense (Fig. 1d) compared to sites of higher disturbance (Fig. 1c). Seeking adequate parameters for modelling reed species distributions under estuarine conditions to further assess climate change effects, we tested the effects of bank slope types on the distribution pattern of three different reed species.

Figure 1:
a) overview of the study area
b) orthophoto of a section of the study site with the two bank types
c) picture of a typical cutbank slope
d) picture of a typical slip-off slope

Methods

Presence data of the three reed species *Schoenoplectus tabernaemontani* (Sc), *Bolboschoenus maritimus* (Bo), and *Phragmites australis* (Ph) were extracted from reed type maps from 2006 provided by the Water- and Shipping Office Hamburg. Additionally, laserscan data for these maps of altitude above sea level were supplied. Bank types and relative elevations above mean tidal high water level were generated by GIS analyses. We performed an analysis of covariance (ANCOVA) with the elevation in relation to mean tidal high water level as response variable and species and bank types as categorical predictors. River kilometers as a proxy for longitudinal (tidal) gradient were included as the linear predictor. Moreover, all possible two- and three-way interactions were tested. Homoscedasticity and normal distribution of residuals were visually checked using diagnostic plots. Since a non-orthogonal design had to be applied due to unequal sample sizes within categories (Tab. 1), ANCOVAS were run with all possible sequences of predictors entering the models to check for consistency of results. All model results were consistent.

Table 1: Number of samples within the categories reed species and bank types

		Reed species Sc	Bo	Ph	Sum
Bank type	slip-off slope	29	98	27	154
	cutbank slope	14	56	10	80
	Sum	43	154	37	234

Table 2: ANCOVA results of the relative elevation of presence points of species tested against species, bank type and river kilometer; d.f.= degree of freedom, SS=sum of squares, MS=mean square, *F*=F-Value, *p*=p-value

Sources	d.f.	SS	MS	*F*	*p*
reed species	2	5.35	2.68	18.31	0.000
bank type	1	1.67	1.67	11.43	0.001
longitudinal gradient	1	8.61	8.61	58.90	0.000
reed species : bank type	2	1.71	0.85	5.83	0.003
bank type : longitudinal gradient	1	0.83	0.83	5.69	0.018
Residuals	223	32.60	0.15		

Results and Conclusion

The results show a significant interaction in the elevational distribution for the different species in relation to the bank types (Tab. 2). For the slip-off slope, *P. australis co-occurs* with *S. tabernaemontani* and *B. maritimus* on the same relative elevations (Fig. 2). In contrast, a clear zonation pattern can be identified for the cutbank slope. Here, *P. australis* grows only at higher elevations while *B. maritimus* and *S. tabernaemontani* occur at similar or even lower elevations compared to the slip-off slope. These patterns suggest that *P. australis* is highly prone to mechanical disturbances by hydrodynamics.
We can conclude that the interaction between reed species and bank types is an important parameter to be included into modelling reed species distributions. Cutbank slopes show often a typical zonation of reed species along the vertical gradient (Fig. 1c) whereas on slip-off slopes, where low disturbance rate allow vigour growth of *P. australis,* the pioneer types *S. tabernaemontani* and *B. maritimus* are often outcompeted by *P. australis.*

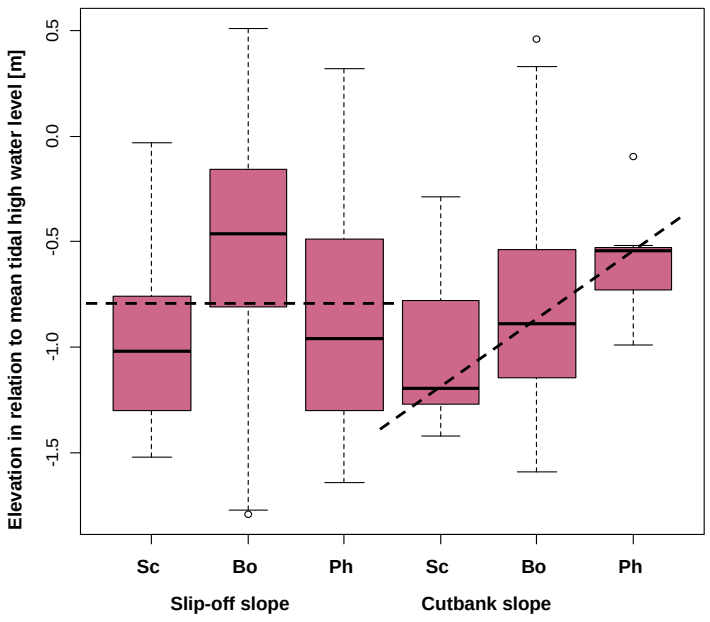

Figure 2: Boxplots of relative elevations to mean tidal high water level showing the present points for the reed species of the two bank types; the dashed lines represent the relative elevational position of the species to each other.

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