DEVELOPMENT OF A MECHANISTIC POPULATION MODEL FOR TIDAL REEDS

Jana Gevers [1], Boris Schröder [1,2]

[1] University of Potsdam, Institute of Earth and Environmental Sciences, Potsdam, Germany; [2] Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany

Introduction

Natural river bank vegetation at tidal waterways provides important ecosystem functions and services. It offers habitat, filtrates solid and dissolved substances from the water and serves as erosion control for riverbanks. In many rivers, agriculture, hydraulic engineering and water management threaten the structure, species composition and functionality of tidal reeds. Global warming might entail additional risks, such as changes in water levels and a higher frequency of extreme events. In our study we use process based, spatially explicit modelling for analysing the ecological processes determining distributional patterns. Through this we want to assess the impact of environmental changes on tidal reeds' distribution in the river Elbe in Germany, focussing on *Phragmites australis*.

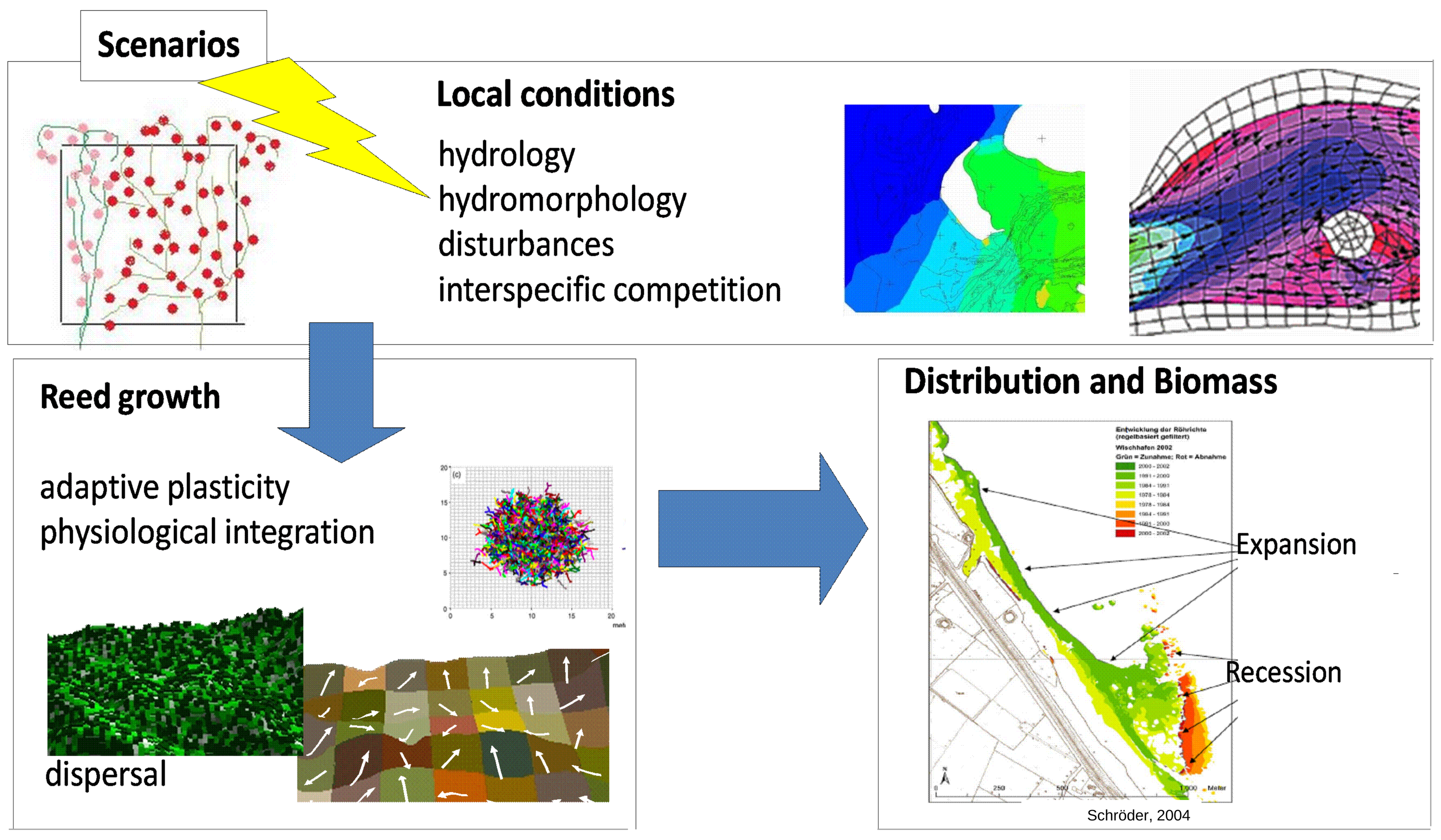


Figure 1: Conceptual model

General questions

- How does reed distribution develop with global warming-induced changes in process dynamics?
- Which processes influence the spatiotemporal population dynamics and distribution of *P. australis*?
- What is the relationship between habitat variability, ramet growth and stable patterns of reeds' distribution?

Hypotheses

- Changes in water level, salinity, erosion and flooding will have an impact on the lateral and longitudinal zoning of tidal reeds and therewith on the distribution of *P. australis.*
- Clonal plant specific growth forms like adaptive plasticity and physiological integration influence population dynamics and can not be neglected.

Methods

Study site

The river Elbe is one of the major rivers of central Europe and an important waterway for Germany and the Czech Republic. The river section north of Hamburg (Figure 2) is influenced by the tide. The tide has an impact on water levels, flow directions and salinity.
The area near Wischhafen serves as one of the reference areas in this study. It contains the typical vegetation of the natural environment as well as gradients in most of the relevant habitat parameters.

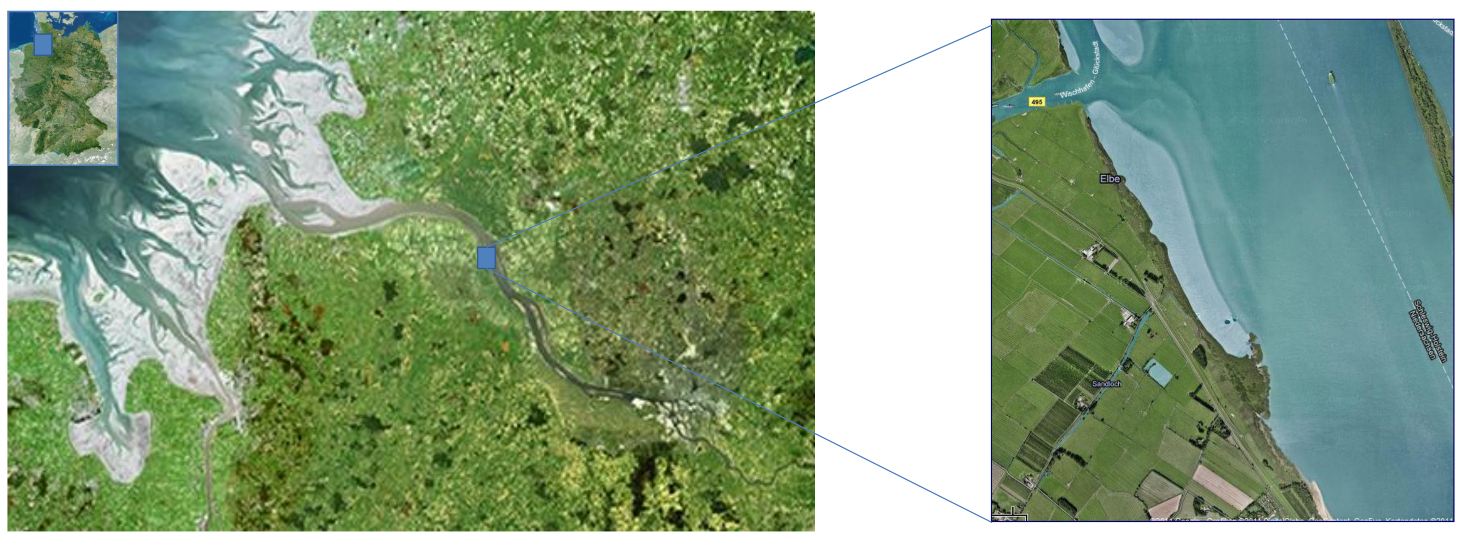


Figure 2: Study site and reference area (http://maps. google.de)

Modelling

- Process based modelling offers the possibility to incorporate processes and the transient dynamic of a system
- Potential population processes to be included into the model are dispersal, competition, foraging and clonal integration
- Potentially important habitat factors represent processes related to stress factors such as salinity, competition and disturbances
- Scenarios will be implemented by changes in the landscape model

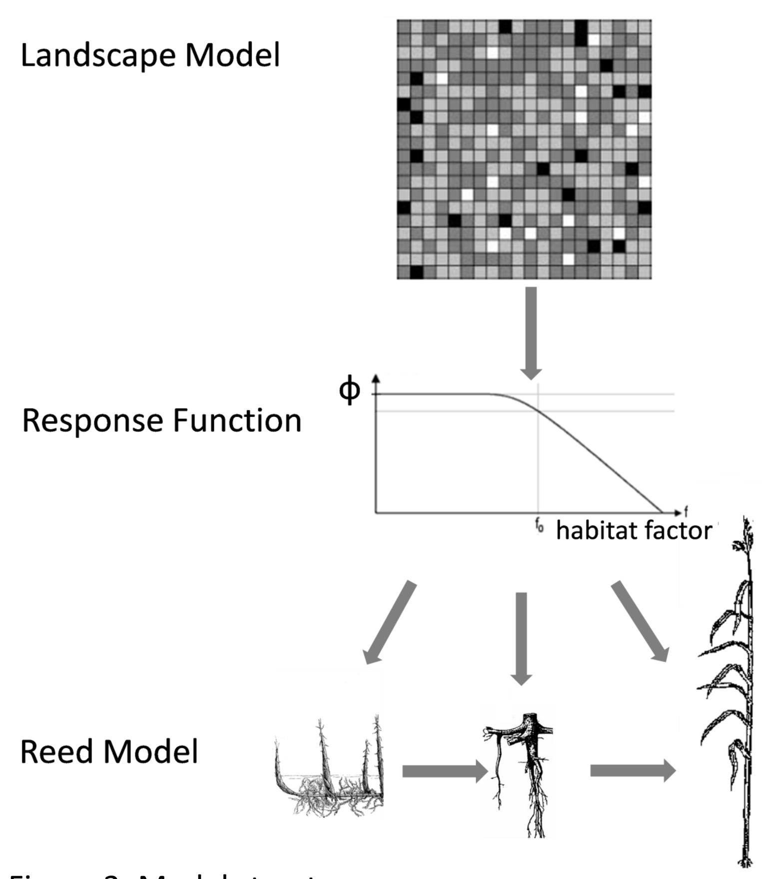


Figure 3: Model structure

First steps

- Finding key processes and sensitive parameters on biomass and distribution of *P. australis* with the help of a grid based model based on the study of Wortmann et al. (1998)[1] by gradually adding more detailed processes and mechanisms
- Landscape model: low and high quality habitat cells in differing amounts and with random configuration (Figure 3)
- Reed model: density and habitat dependent growth and mortality of rhizomes, roots and above ground biomass; dispersal is implemented by rhizome expansion into neighbouring cells (Figure 4)
- Introduction of clonal integration (the support of ramets by neighbouring ramets): implemented by artificially improving habitat quality around good habitat cells
  - Yields to homogenisation of the habitat
- Introduction of foraging (ability of clonal plants to adapt their growths on local habitat conditions): realised by reducing the expansion into low-quality habitats in favour for the expansion into good-quality habitats
  - Yields to more effective rhizome expansion

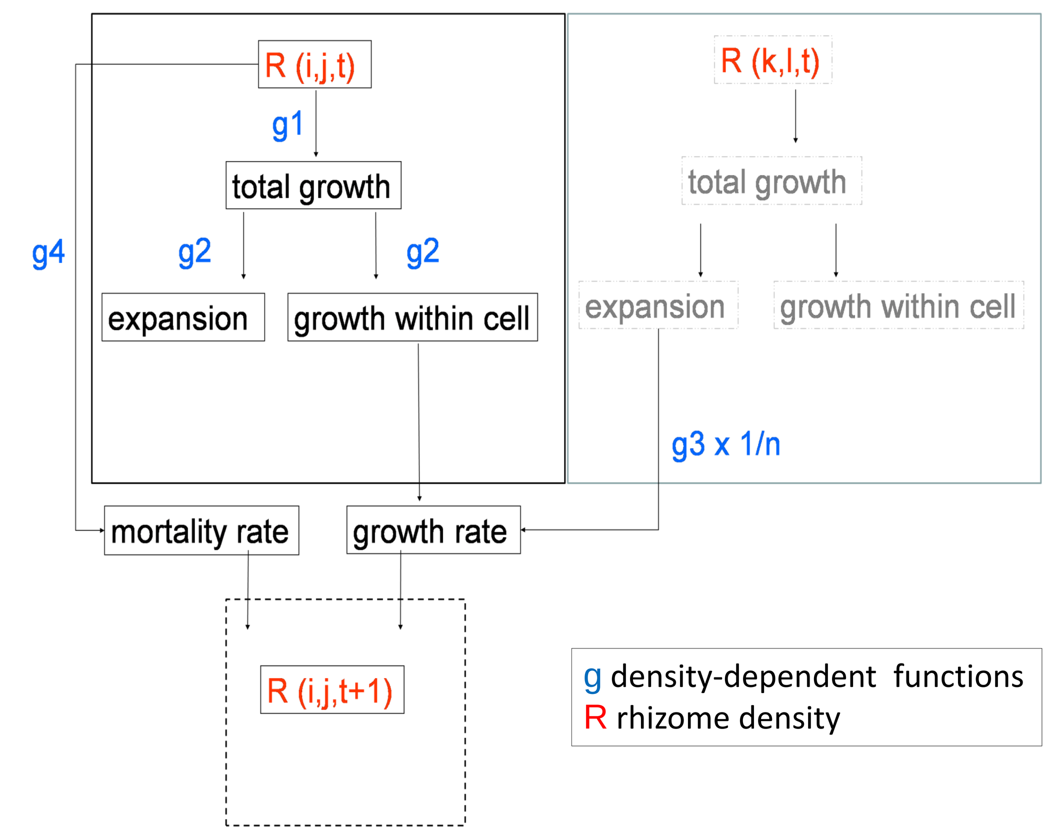


Figure 4: Flow chart for rhizome growth in the reed model

First Results

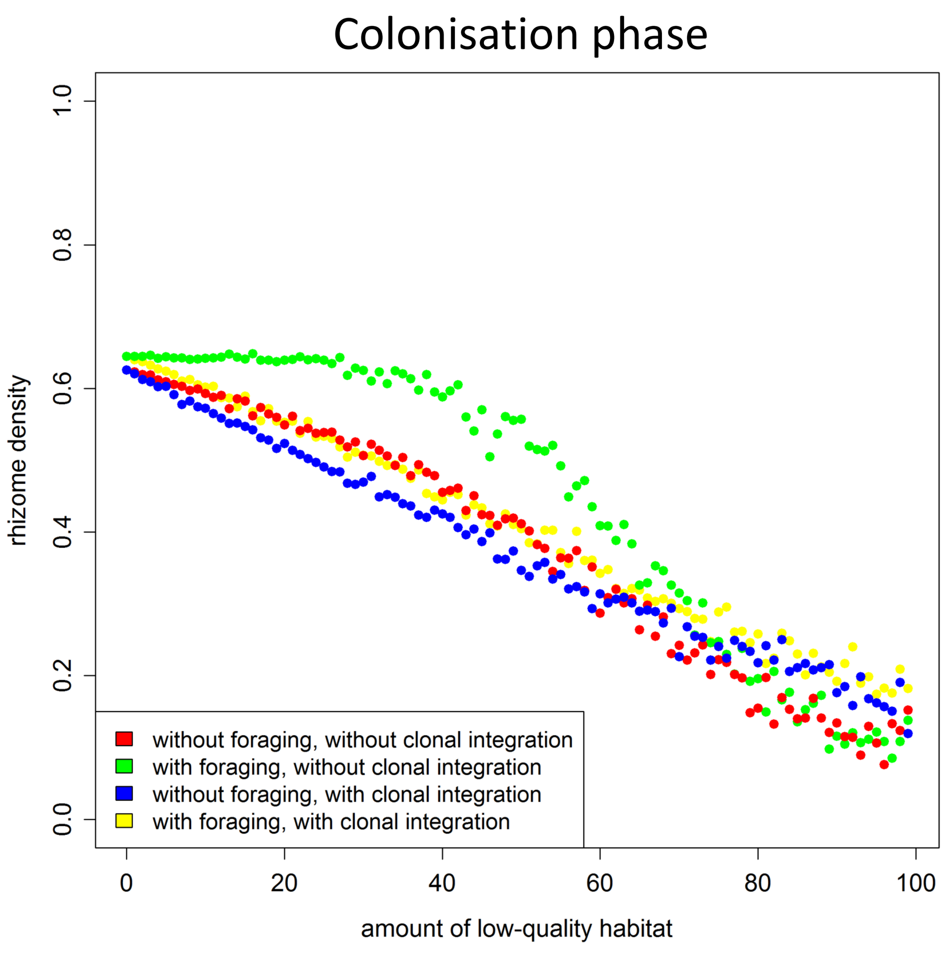


Figure 5: Rhizome density with changing habitat quality and with different combinations of clonal growth forms

Colonisation phase, first year (Figure 5)

High habitat quality
higher rhizome biomass with foraging
Dominating processes: directional rhizome dispersal, more rhizomes in good habitats
Low habitat quality
highest biomass with clonal integration
Dominating process: bypassing of low-quality habitats, dispersal into remote habitats

Stationary phase, from year four (Figure 6)

High habitat quality
lower above ground biomass with clonal integration
Dominating process: loss from support of ramets in low-quality habitats
Low habitat quality
highest biomass with clonal integration
Dominating process: bypassing of low-quality habitats, dispersal into remote habitats

→ the effect of the two forms of clonal growth highly depends on habitat quality

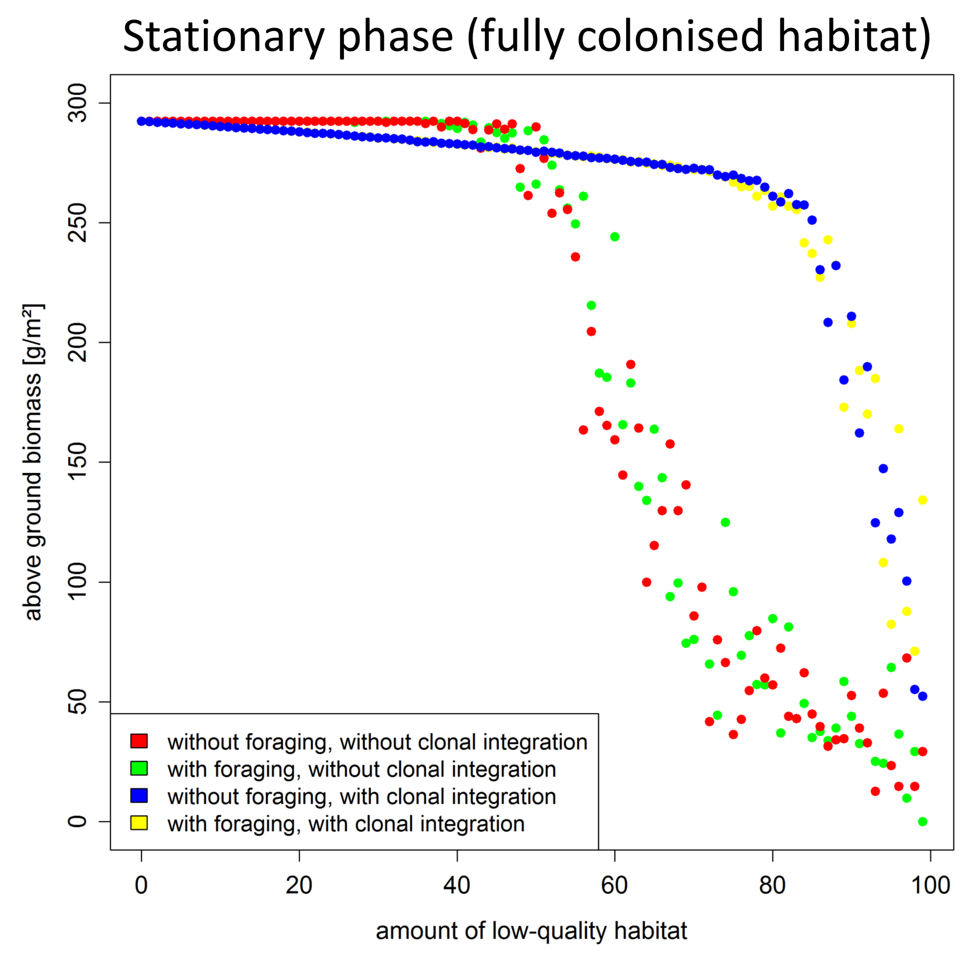
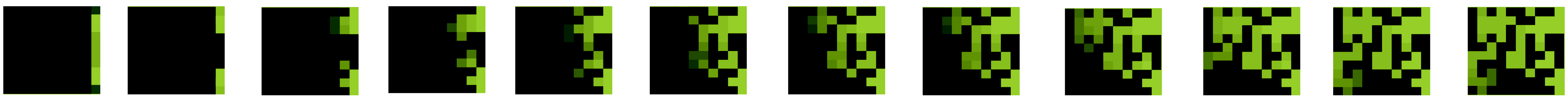


Figure 6: Above ground biomass with changing habitat quality and with different combinations of clonal growth forms

Conclusion

- The integration of clonal growth forms into the model of Wortmann et al. (1998) is a first step to analyze the effect of clonal growth forms on the dispersal and distribution of *P. australis*.
- By including different habitat parameters into the model this integration can furthermore provide first ideas on what the key processes in different habitats might be..
- To reasonably integrate clonal growth forms and realistically simulate habitat variability more detailed process based modelling is needed; e.g. by applying individual based models May et al. (2009)[2].



References: [1] Wortmann J, Hearne JW, Adams JB (1998) Evaluating the effects of freshwater inflow on the distribution of estuarine macrophytes, *Ecological Modelling*, **106**, 213–232.
[2] May F, Grimm V, Jeltsch F (2009) Reversed effects of grazing on plant diversity: the role of below-ground competition and size symmetry. Oikos 118:1830–1843.

Jana Gevers, Mail: jgevers@uni-potsdam.de, Phone: 0331 9772518

KLIWAS Climate · Water · Navigation