Species competition and dispersal drive vegetation dynamics in tidal salt marshes

Enrico Bertuzzo[1,2], Alvise Finotello[1,2], Andrea D'Alpaos[2,3], and Marco Marani[2,4]

[1] Dept. of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Venice, IT
[2] Center for Lagoon Hydrodynamics and Morphodynamics, University of Padova, Padova, IT
[3] Dept. of Geosciences, University of Padova, Padova, IT
[4] Dept. of Civil, Environmental, and Architectural Engineering, University of Padova, Padova, IT

enrico.bertuzzo@unive.it
@enricobertuzzo

Sharing is encouraged

A Minimalist Model of Salt-Marsh Vegetation Dynamics Driven by Species Competition and Dispersal

Alvise Finotello[1,2]*, Andrea D'Alpaos[2,3], Marco Marani[2,4] and Enrico Bertuzzo[1,2]*

[1]Department of Environmental Sciences, Informatics, and Statistics, Ca' Foscari University of Venice, Venice, Italy

[2]Center for Lagoon Hydrodynamics and Morphodynamics, University of Padova, Padova, Italy

[3]Department of Geosciences, University of Padova, Padova, Italy

[4]Department of Civil, Environmental, and Architectural Engineering, University of Padova, Padova, Italy
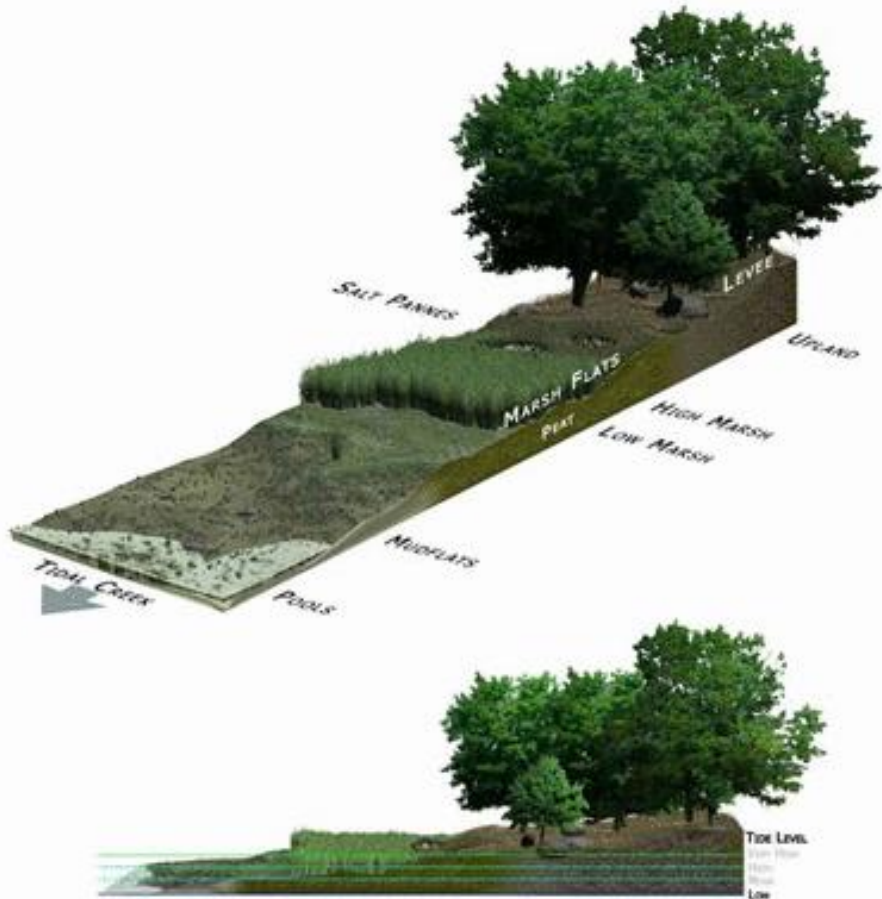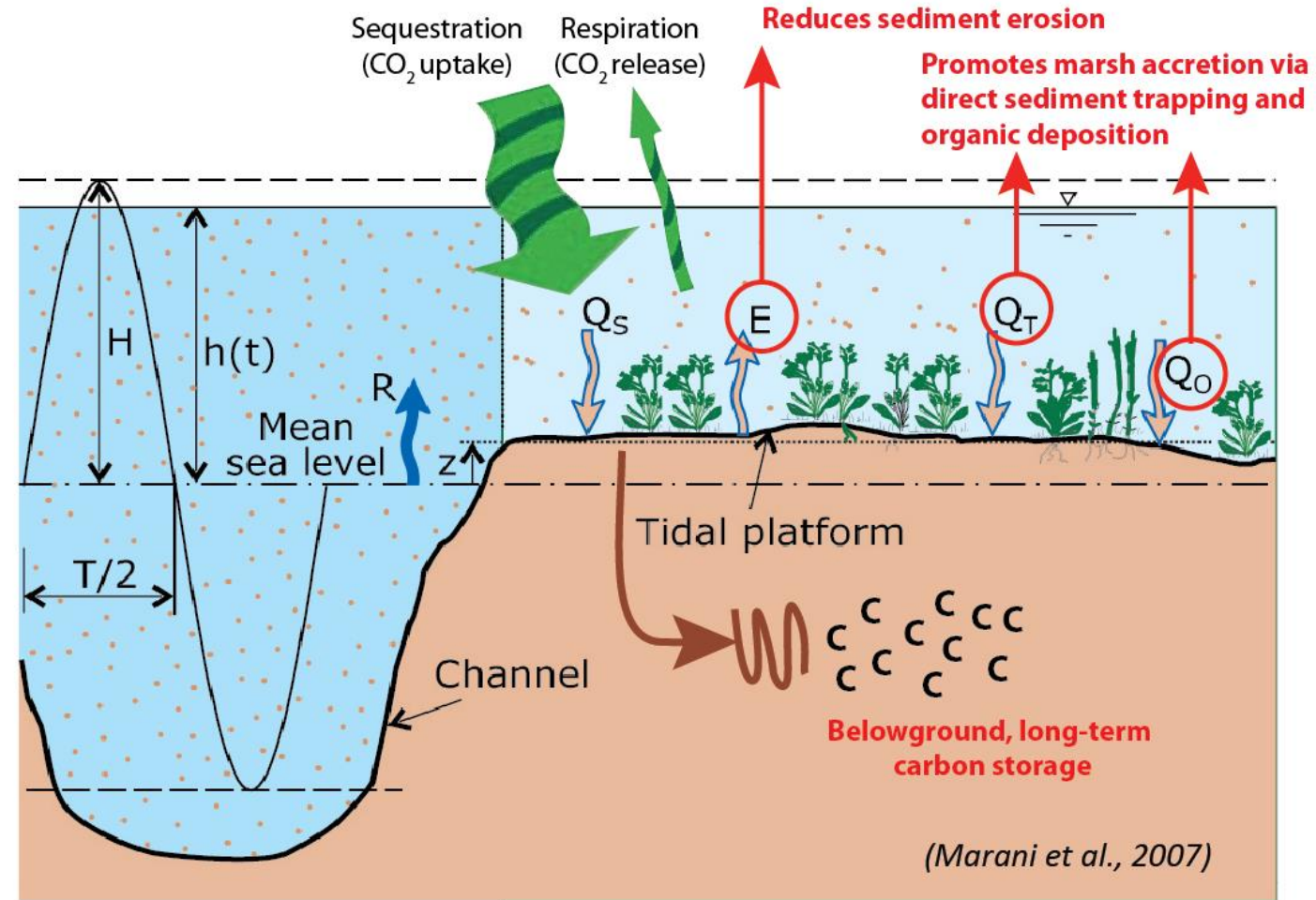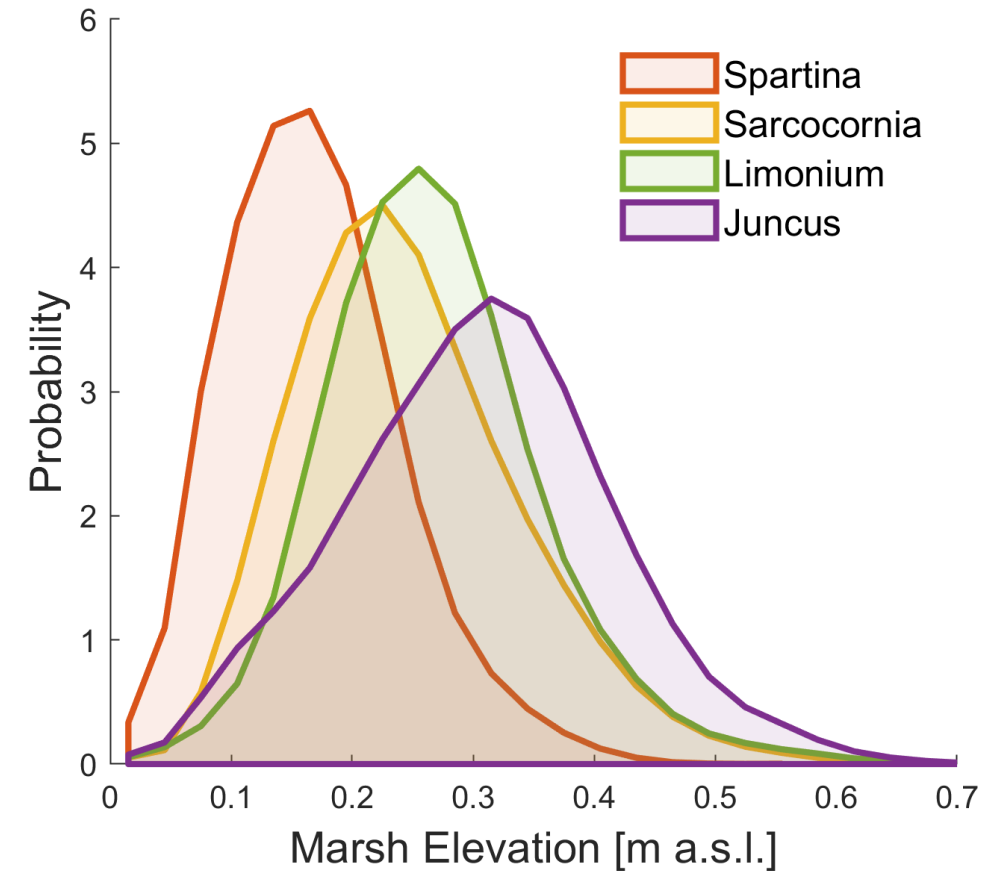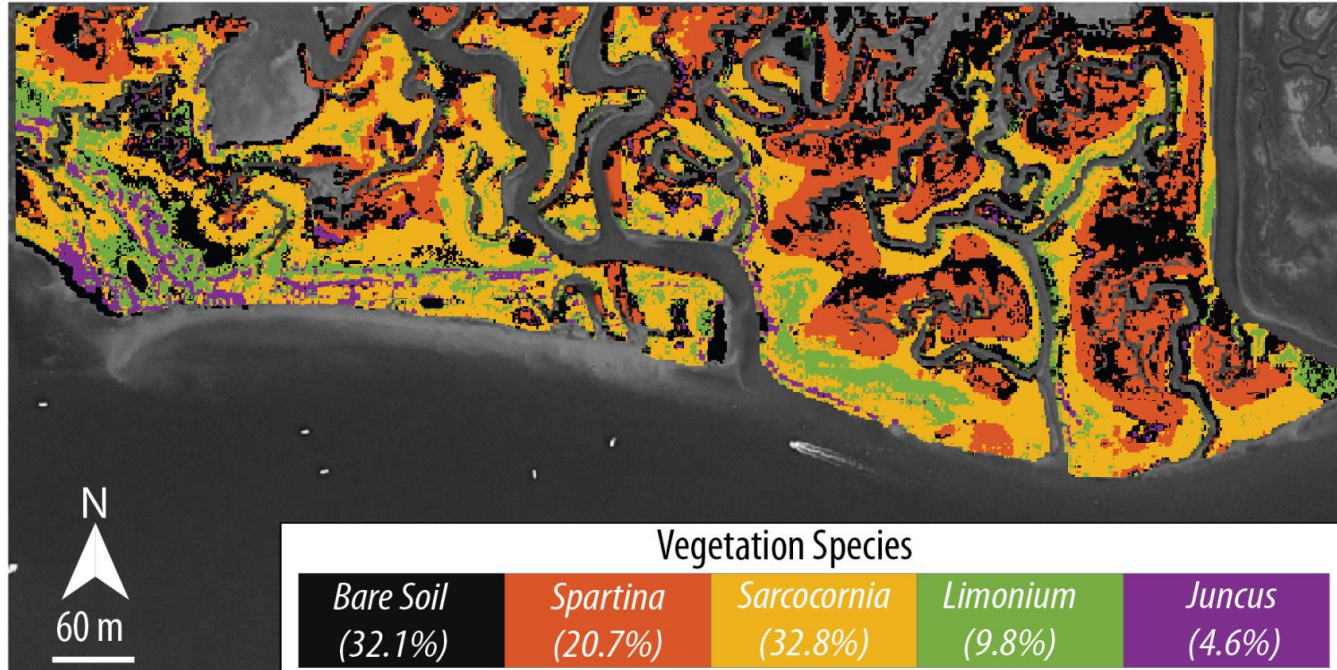
Salt marshes and vegetation

Image © NOAA

(Marani et al., 2007)

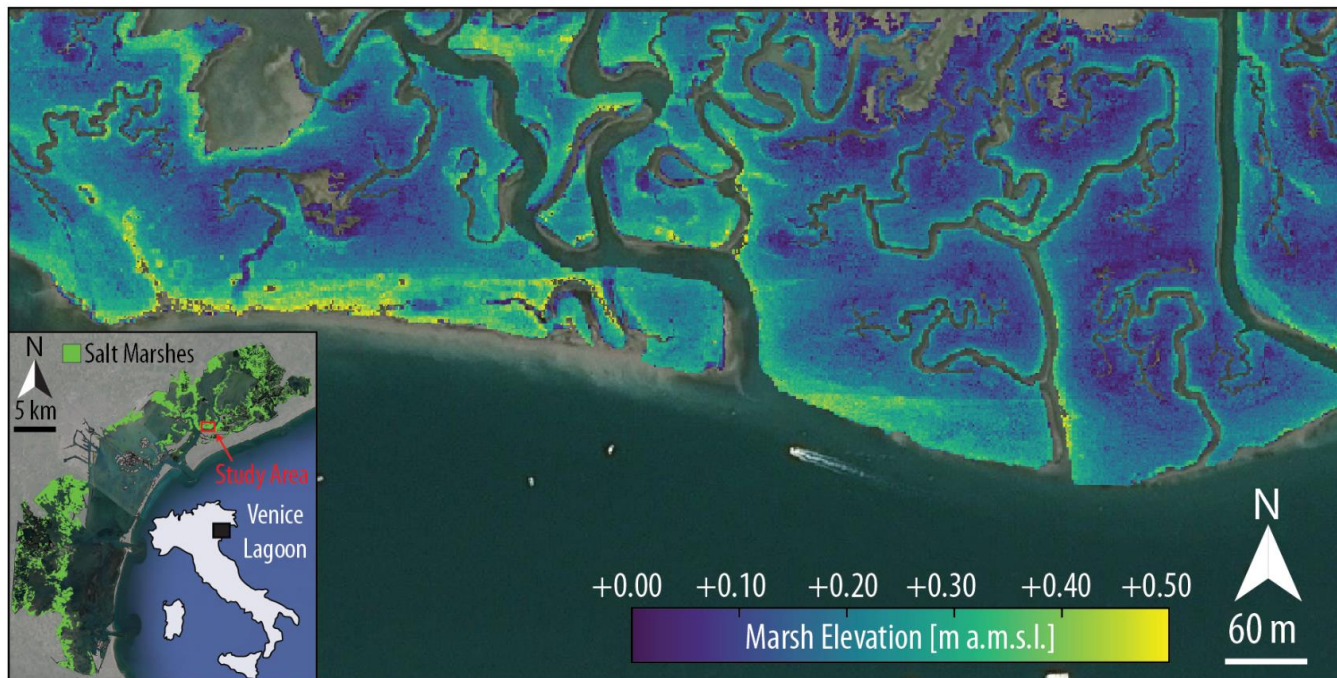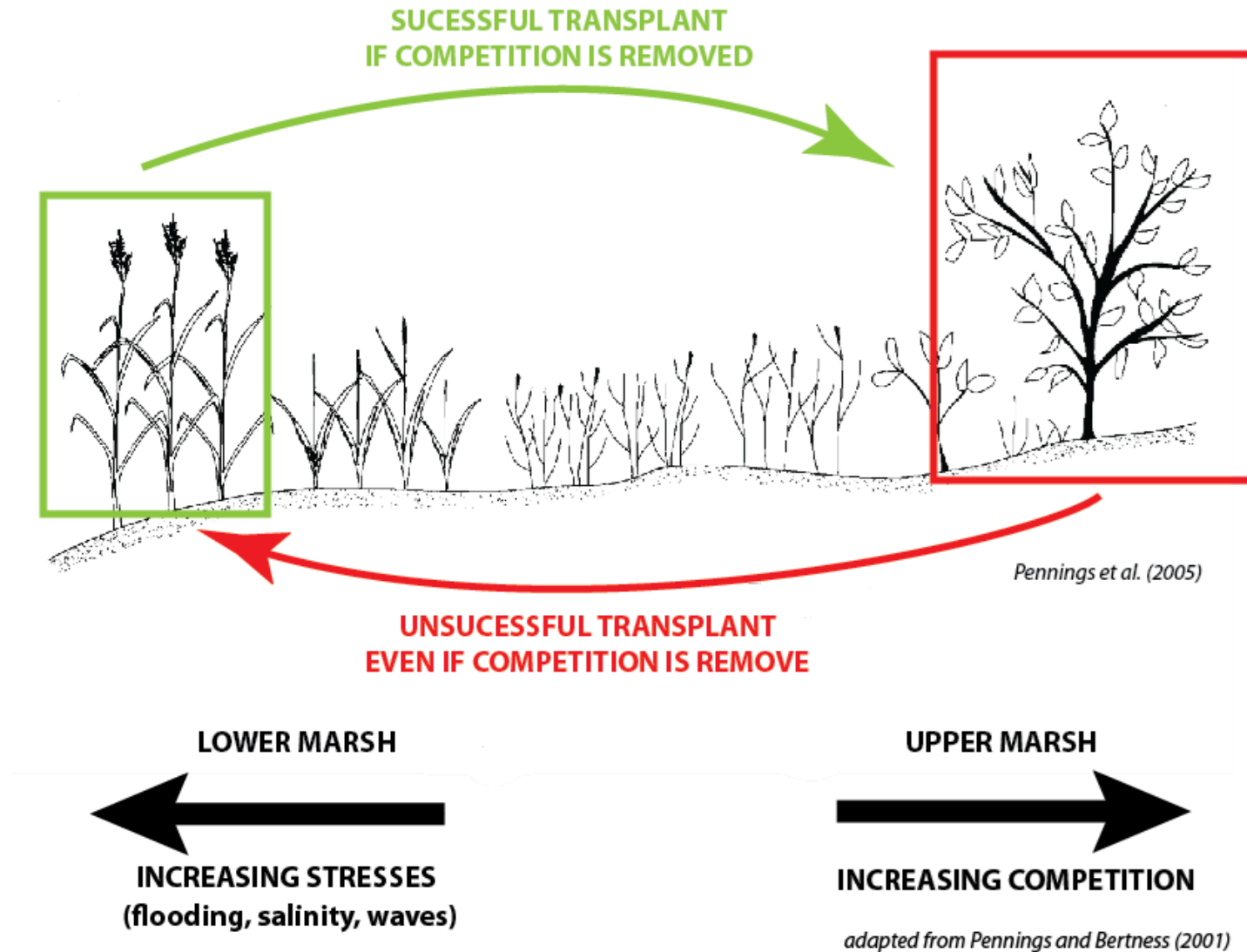**Improving our current understandings of salt-marsh vegetation dynamics is of critical importance to enhance projections of salt-marsh response to changes in climate and relative sea level.**

Salt marshes and vegetation

Limits of previous modelling: Transplant experiments

SUCESSFUL TRANSPLANT
IF COMPETITION IS REMOVED

Pennings et al. (2005)

UNSUCESSFUL TRANSPLANT
EVEN IF COMPETITION IS REMOVE

LOWER MARSH

INCREASING STRESSES
(flooding, salinity, waves)

UPPER MARSH

INCREASING COMPETITION

adapted from Pennings and Bertness (2001)

Limits of previous modelling: Theoretical vs Realized Niche
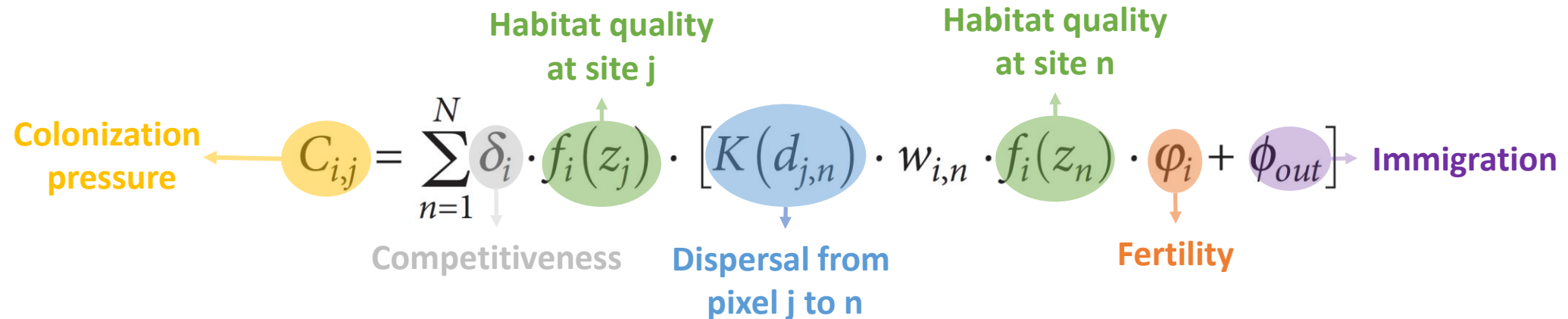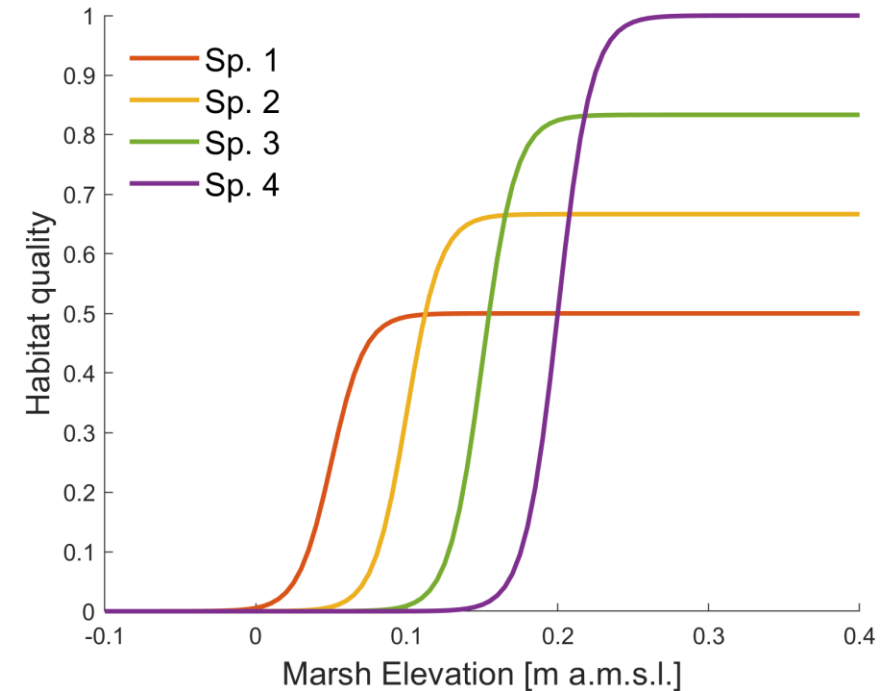

Theoretical Niche
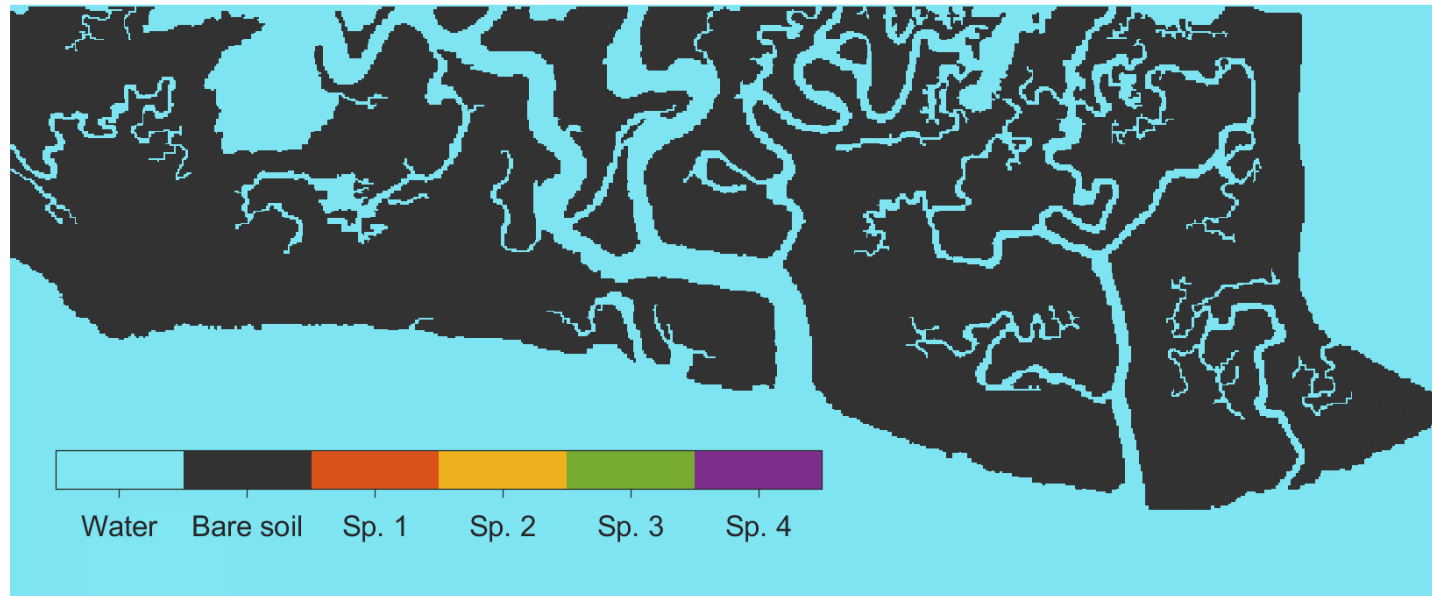Without competition
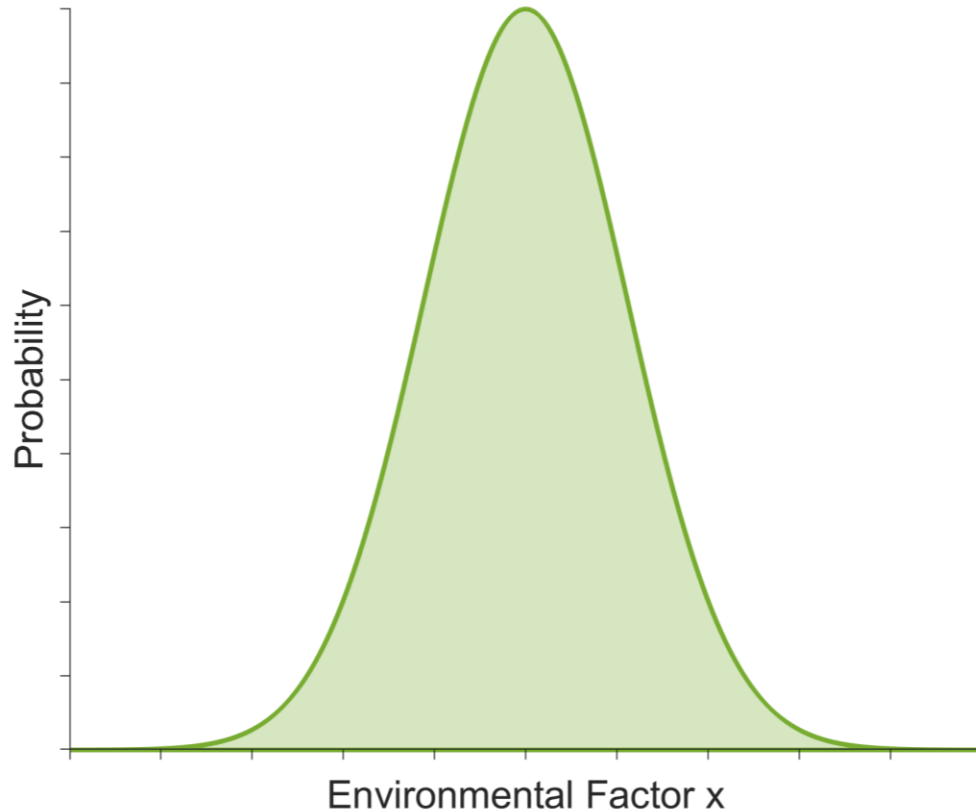
Realized Niche
With competition
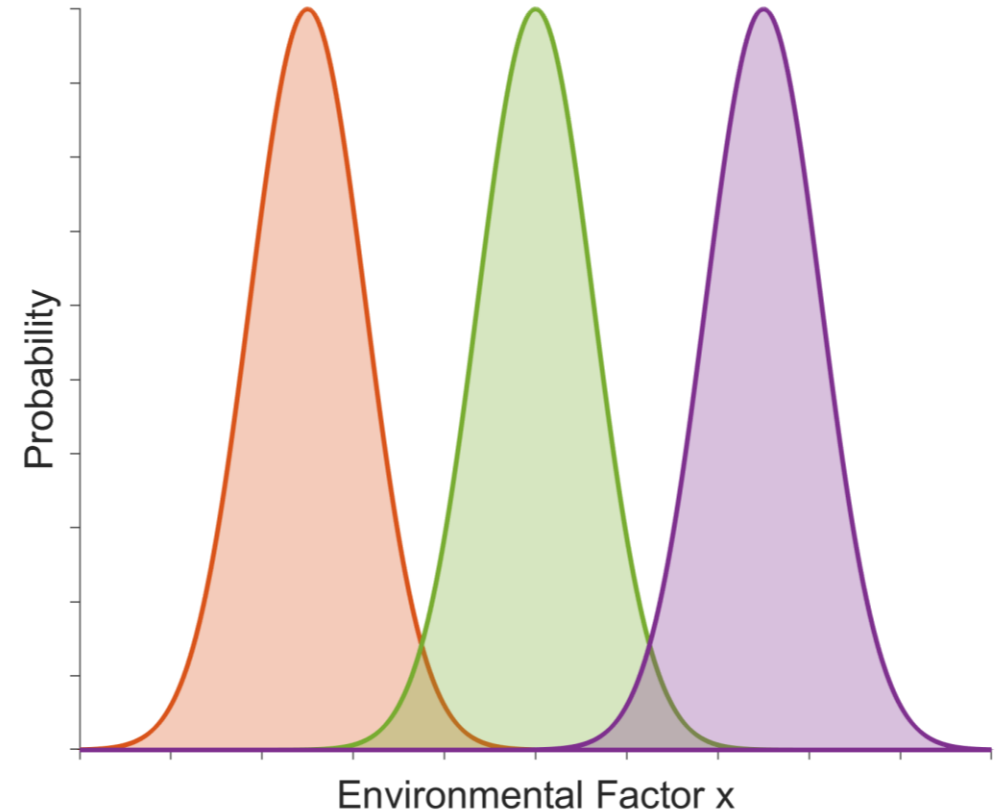
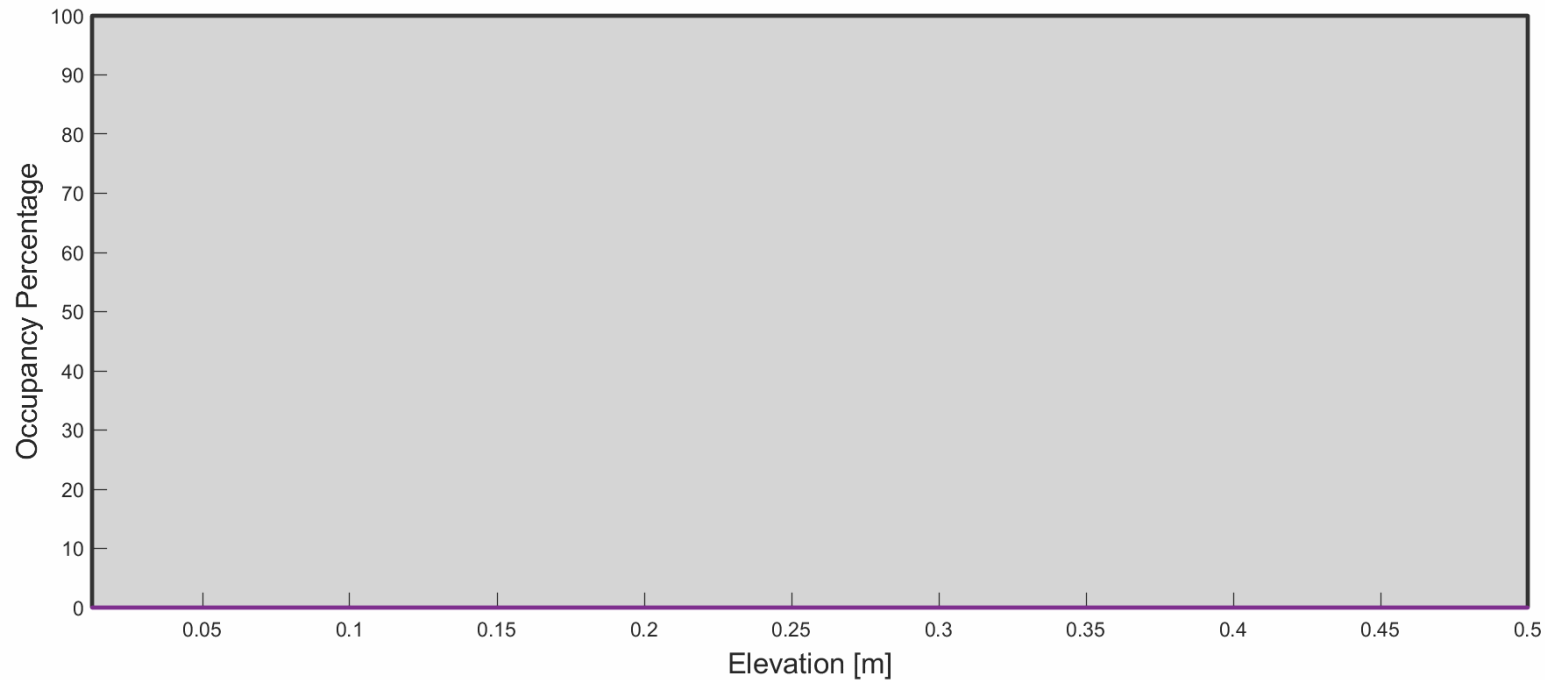# Spatially-Explicit Species Interaction Model

- **Theoretical Niche** (habitat quality) saturating function

- **Habitat quality** affects both mortality and fertility

- Pixel-based, stochastic dynamical model. When an individual dies, the empty space is colonized according to the **colonization pressure** exerted by the other individuals
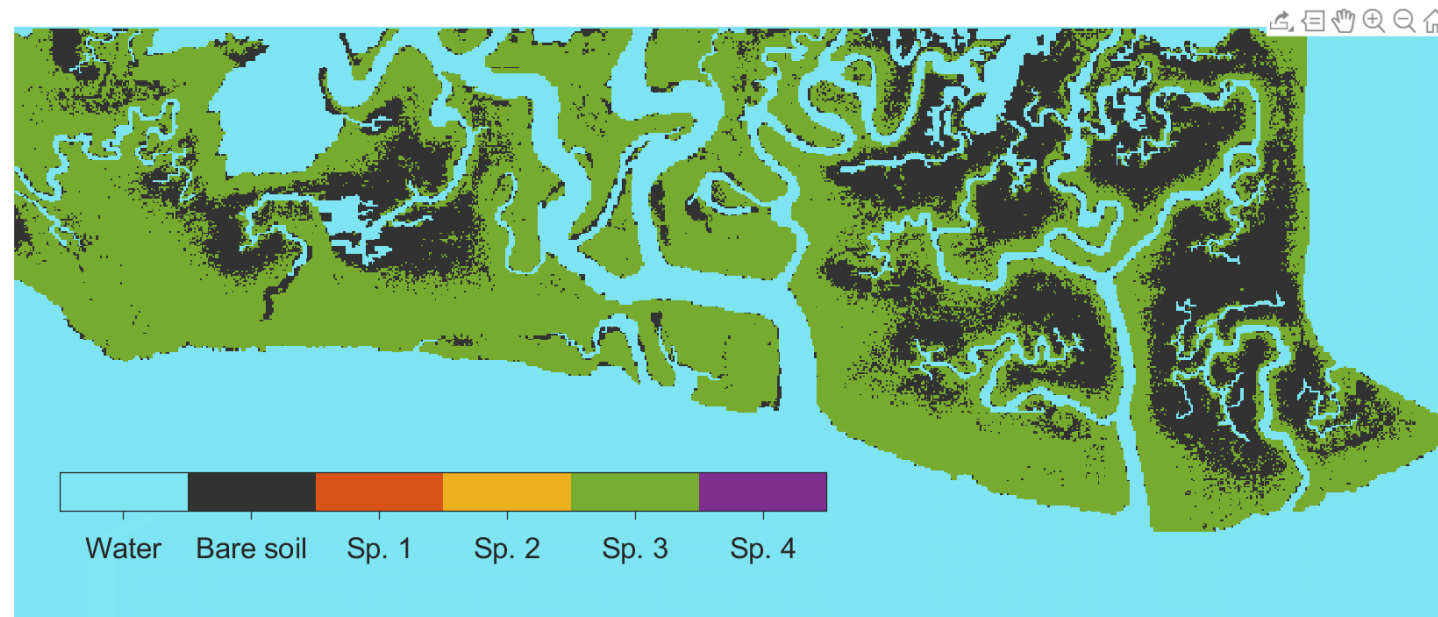

Colonization pressure

Habitat quality at site j

Habitat quality at site n

$$C_{i,j} = \sum_{n=1}^{N} \delta_i \cdot f_i(z_j) \cdot \left[K(d_{j,n}) \cdot w_{i,n} \cdot f_i(z_n) \cdot \varphi_i + \phi_{out} \right]$$

Immigration

Competitiveness

Dispersal from pixel j to n

Fertility

Model Simulation

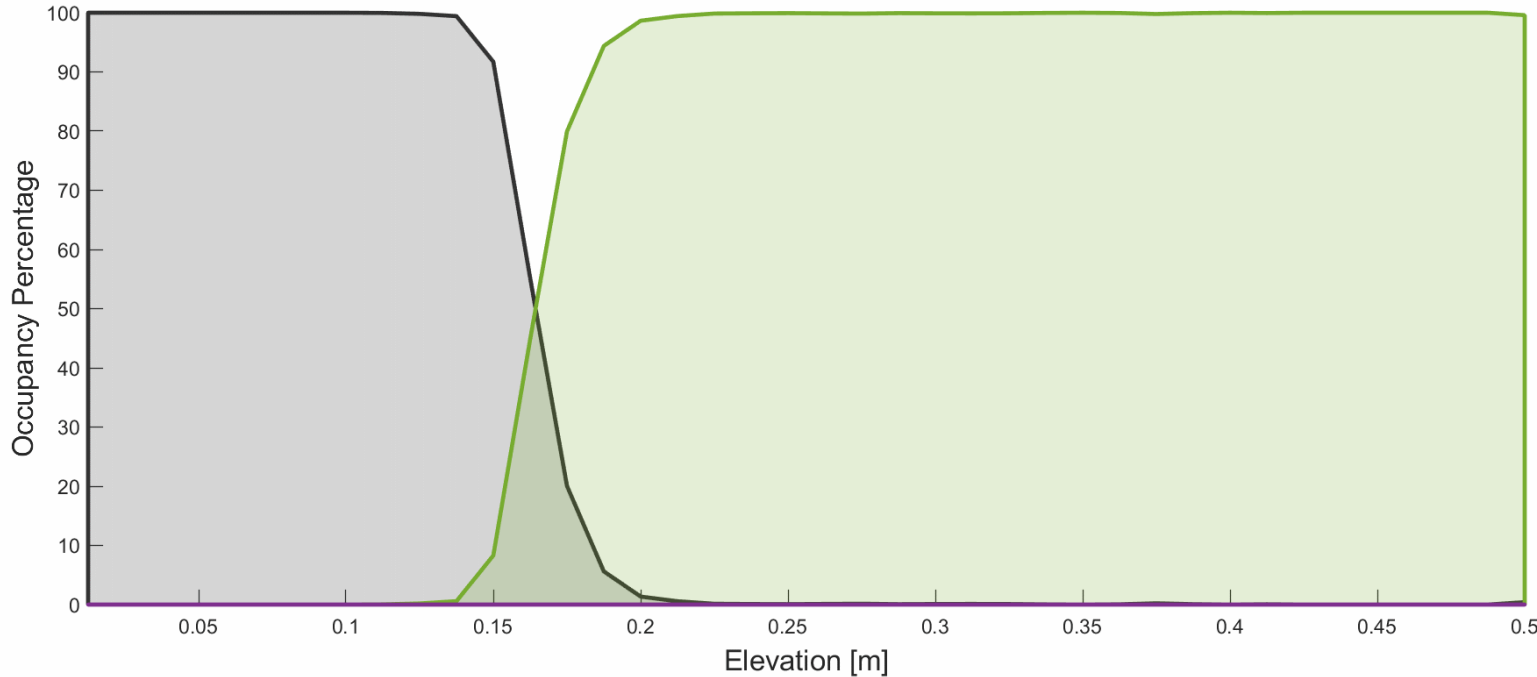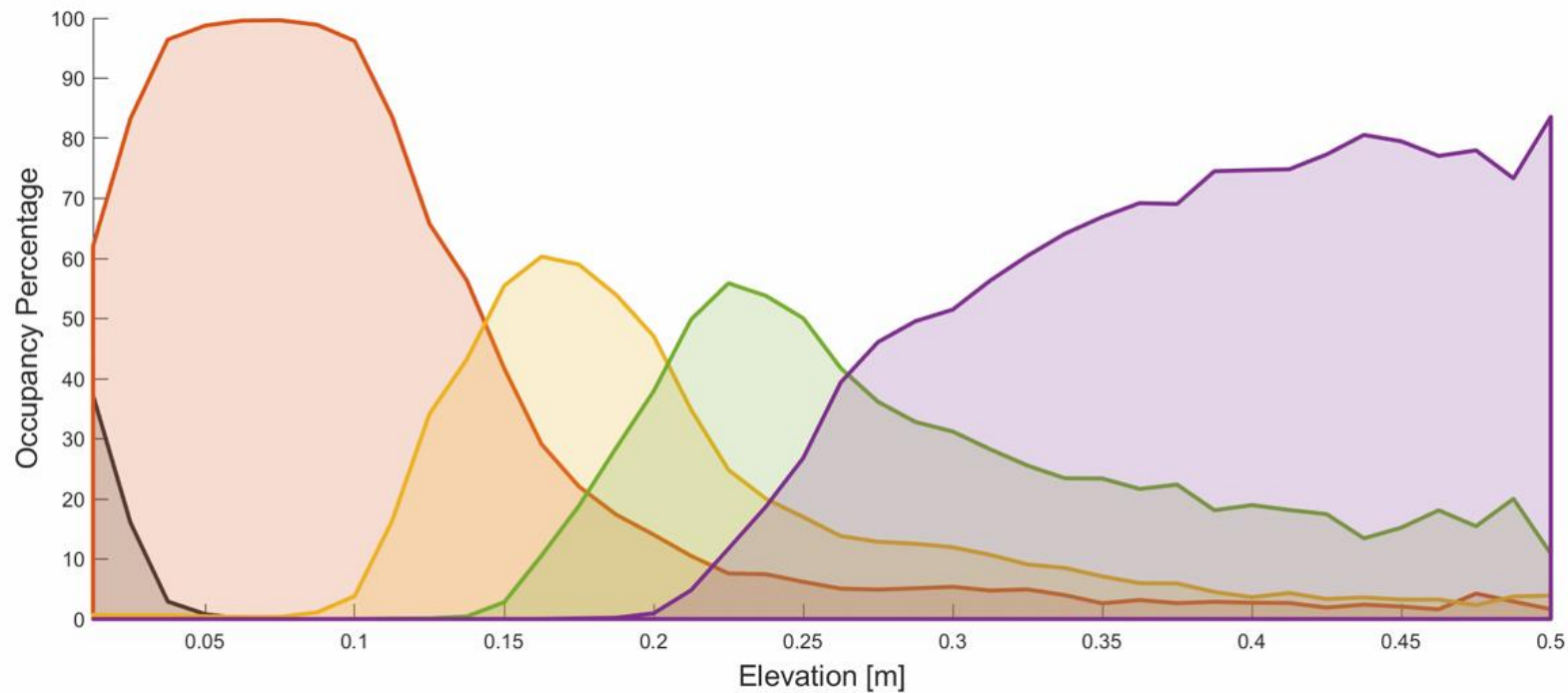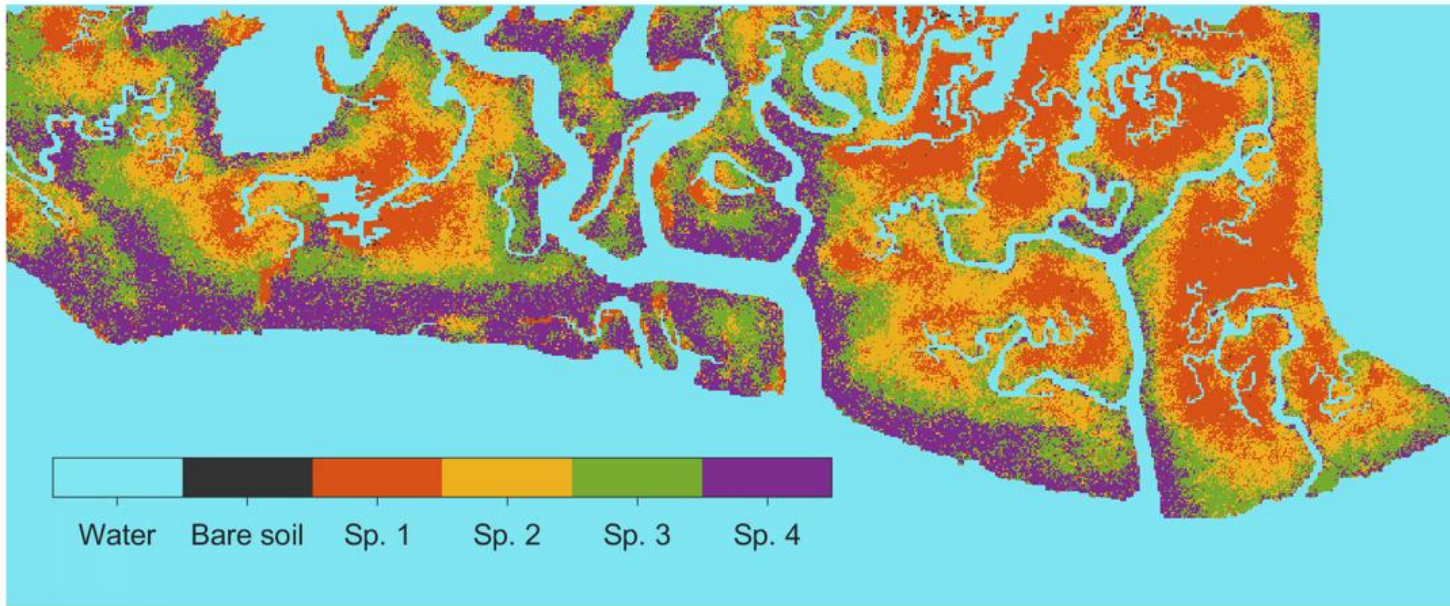- **Initial condition**: bare soil, observed elevation

- **Single species**

Model Simulation

- **Initial condition**: bare soil, observed elevation

- **Single species**

- **Realized niche** similar to the **theoretical niche**
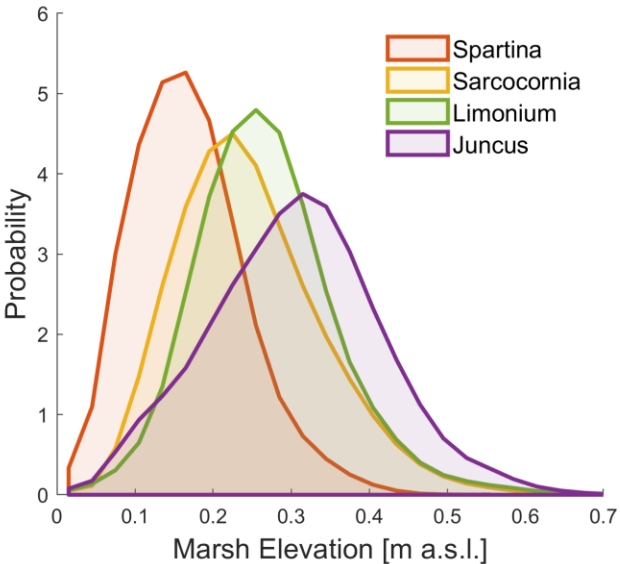
- **3 more species** allowed
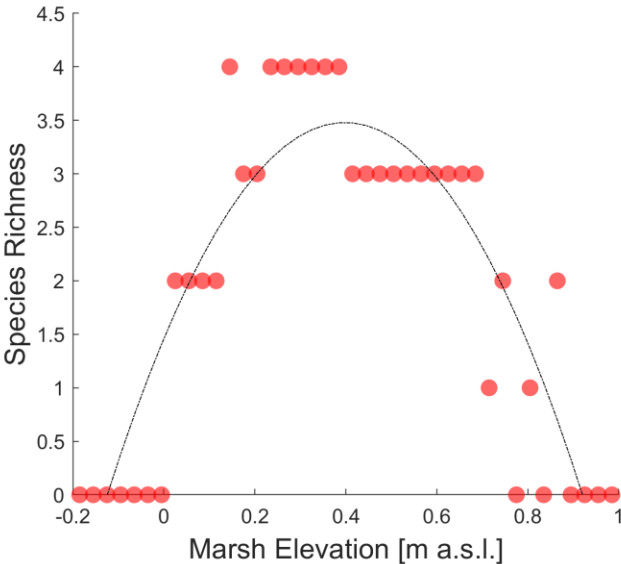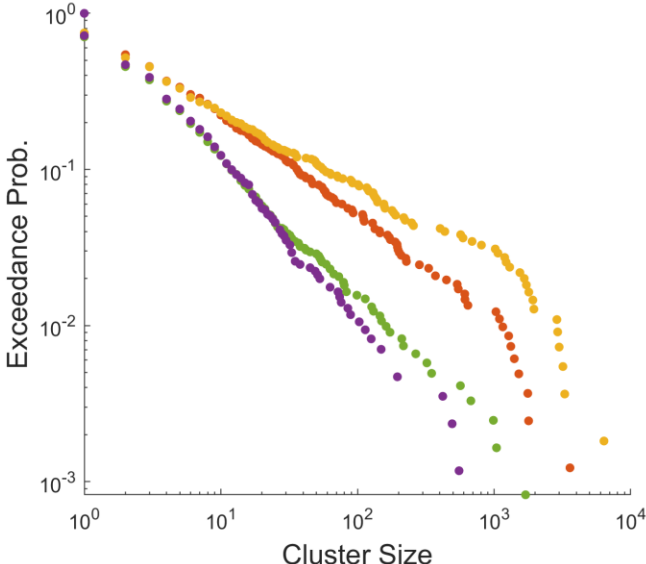
- **Dynamical Equilibrium**

Model Simulation

- **Initial condition**: bare soil , observed elevation

- **Single species**

- **Realized niche** similar to the **theoretical niche**

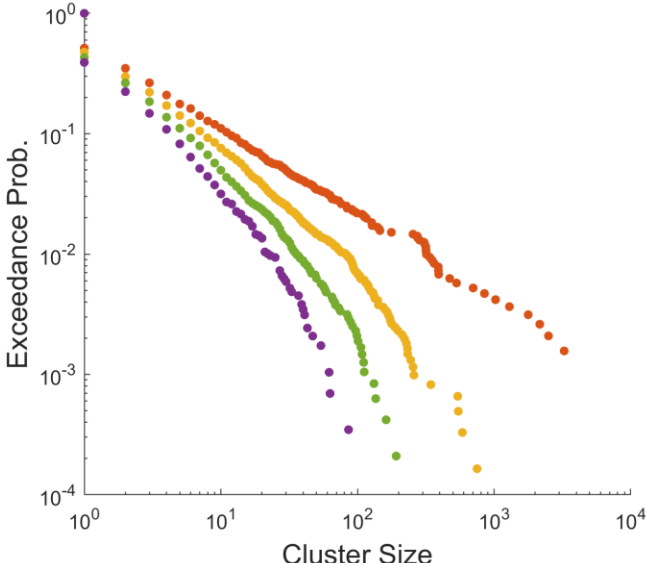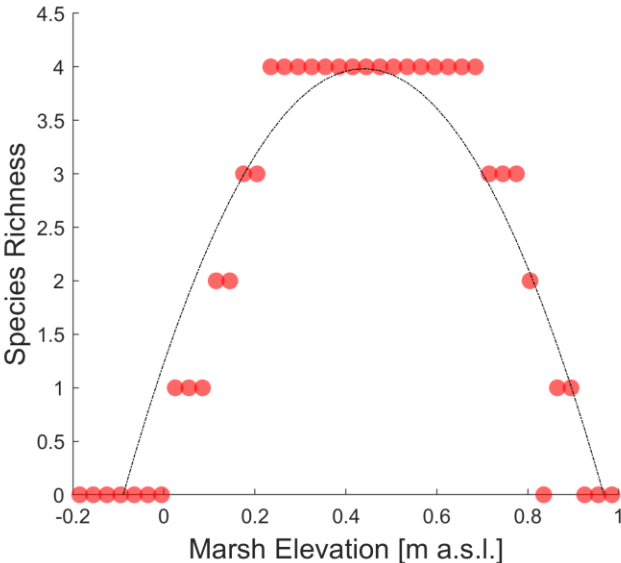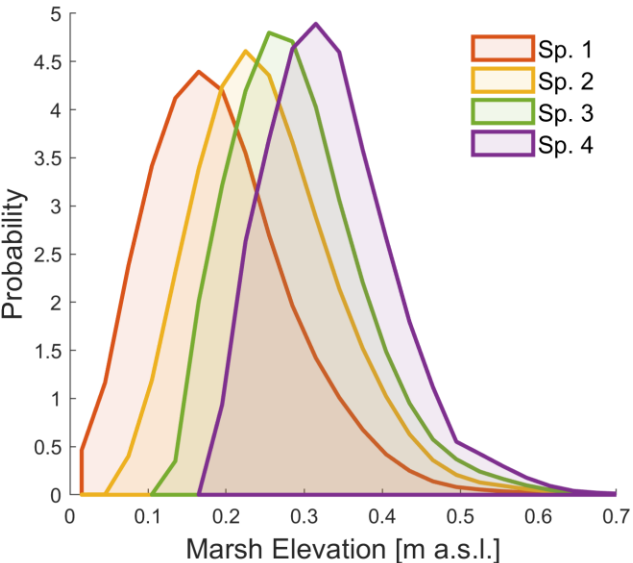- **3 more species** allowed

- **Dynamical Equilibrium**

Results

Realized Niche **Species Richness** **Cluster Size**
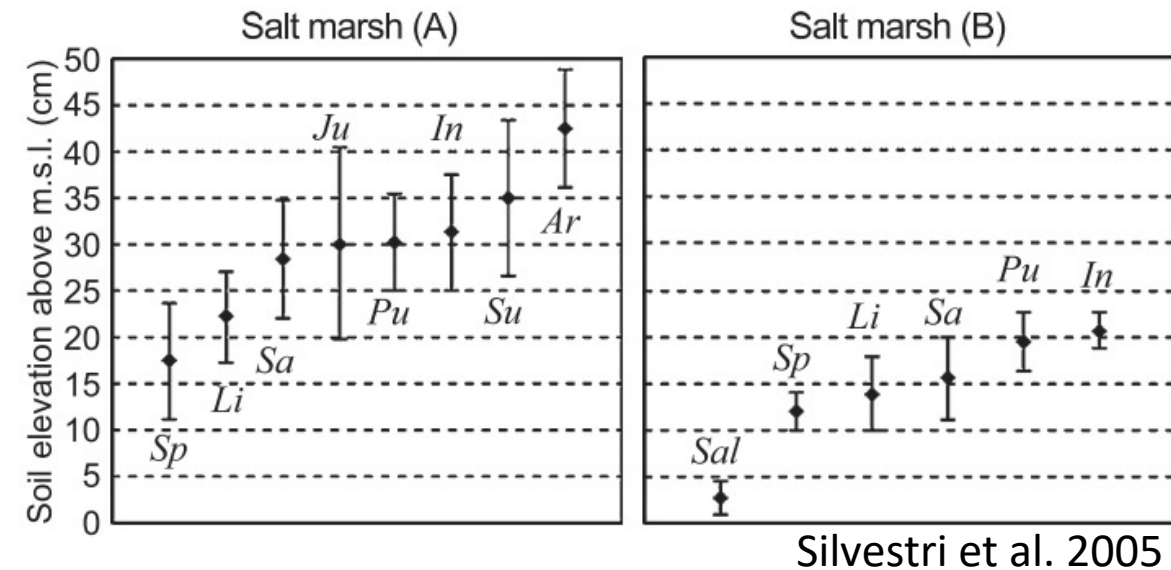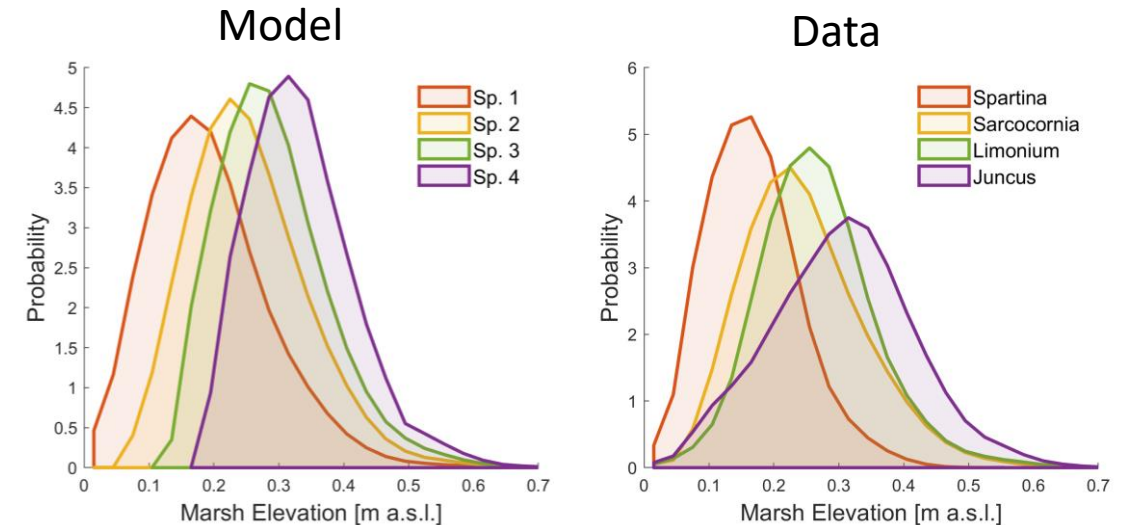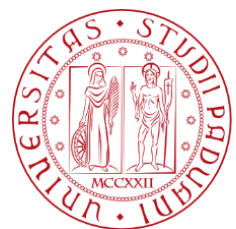
Data

Model

Next Steps

- **Parametrize the theoretical niches** so that the simulated realized niches match those empirically observed

- **Explain why** in neighbouring marshes the **same species is found at different elevation**

- Implement the vegetation model in a **complete ecomorphodynamic model**

Silvestri et al. 2005

Thanks

enrico.bertuzzo@unive.it

@enricobertuzzo