Spatio-temporal dynamic modeling of plant communities responses to hydrological pressures in a semiarid Mediterranean wetland

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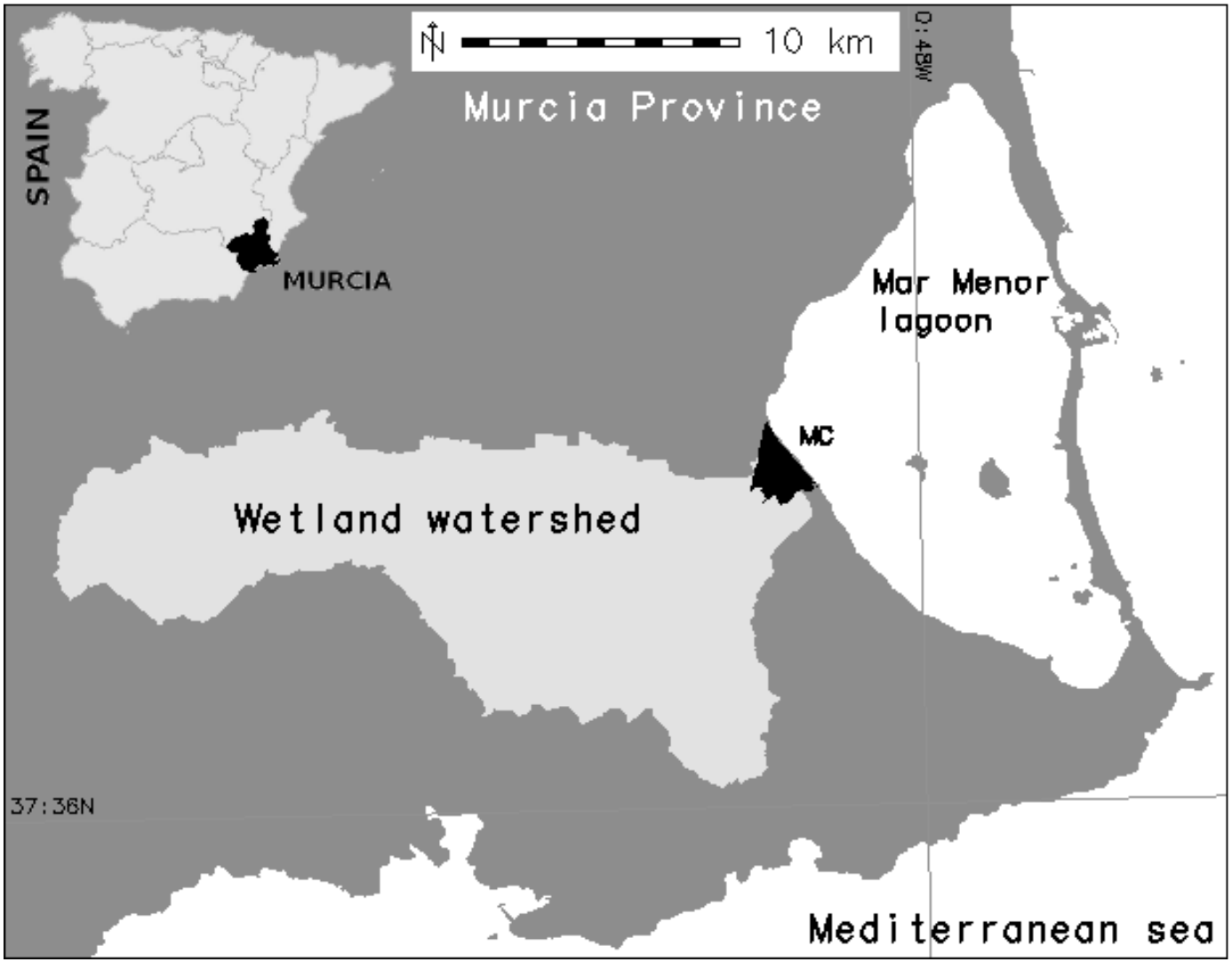
Study area


10 km
Murcia Province
SPAIN
MURCIA
Mar Menor
lagoon
MC
Wetland watershed
37:36N
Mediterranean sea

Marina del Carmoli wetland (300 ha)

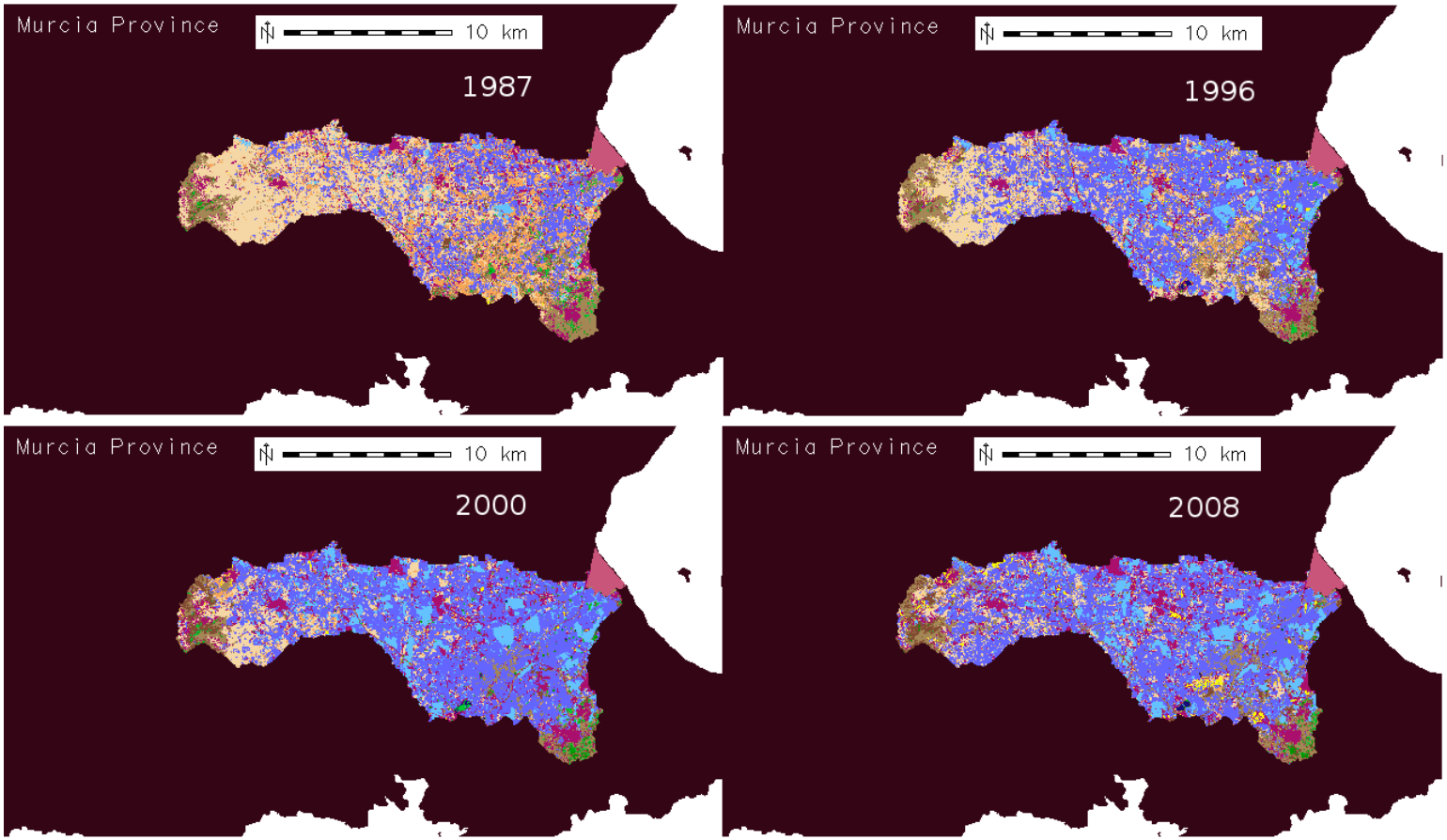
Wetland plant communities

Semiarid Mediterranean saline wetlands are semi-terrestrial ecosystems

- Salt steppe (left) - priority habitat by the Habitats Directive
- Salt marsh (center) - habitat of interest by the HD
- Reed beds (right) (*Phragmites australis*) - invasive

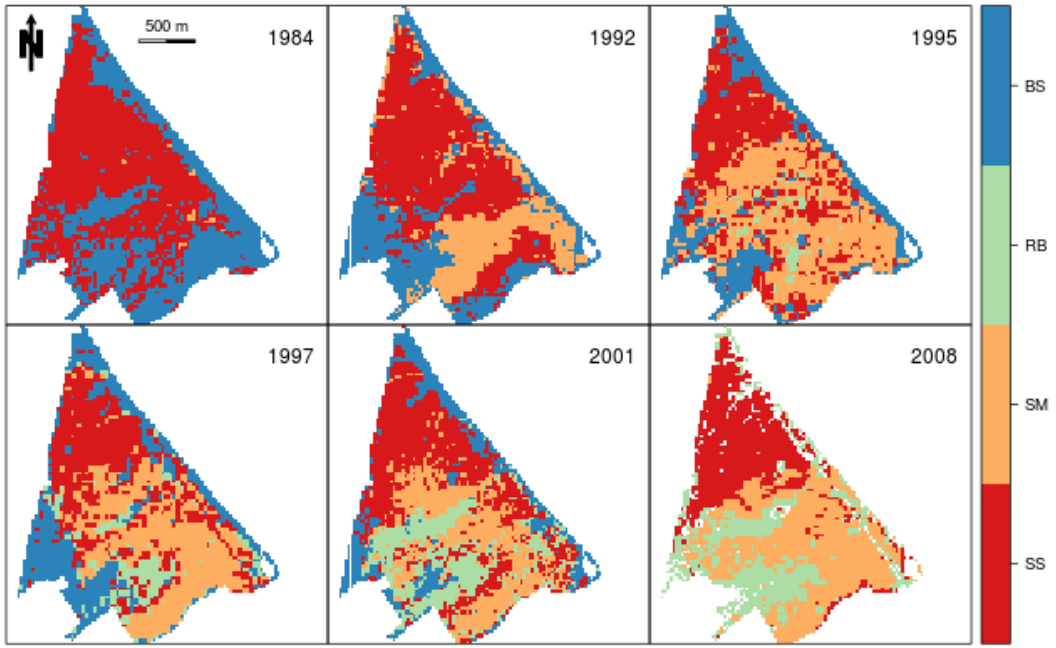
External water inputs

Percentage of irrigated areas has increased in the last decades due to the opening of a water transfer (Martínez-López et al., 2013)



Plant communities change

Important plant communities are being lost!



Carreño et al., 2008; Martínez-López et al., 2012

Objective

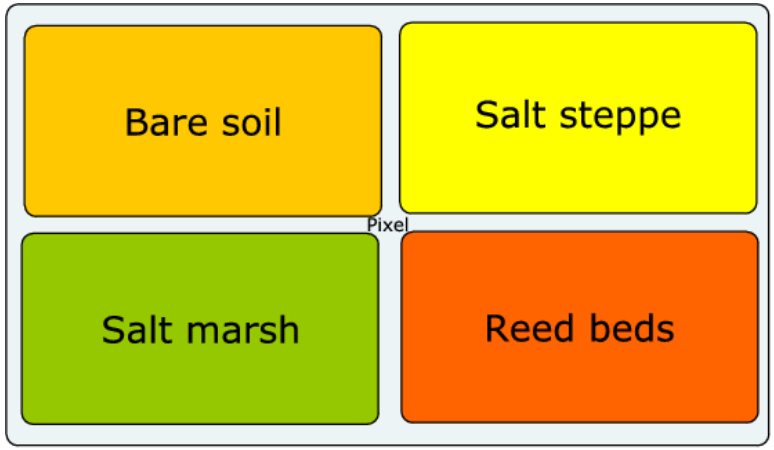
- Spatially explicit wetland model of how irrigated agriculture is affecting plant community composition in this semiarid Mediterranean wetland

Modelling environment

- R as a modelling environment:
  - GIS capabilities
  - source code is flexible
  - free availabity and growing user community

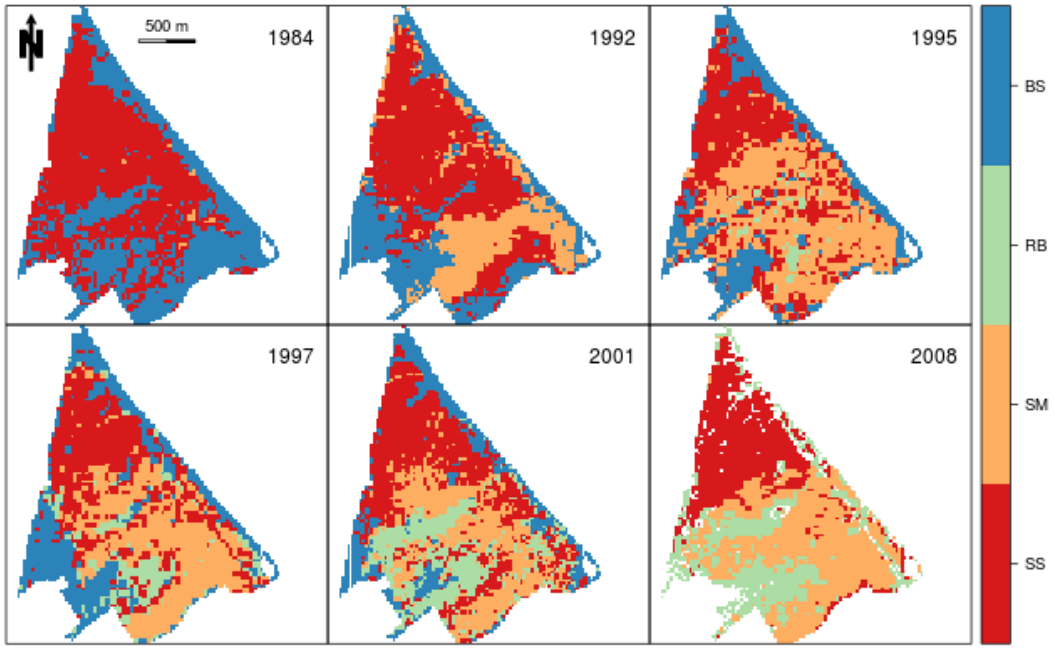
State variables

- Wetland is divided into pixels (25 m)
- Plant communities are modelled separately pixel by pixel (4 maps)
- The total abundance of plant communities within a pixel is limited so:
  - competition among plant communities mediated by
    - total drainge water input to the wetland
    - spatial environmental variables influencing water availability and growth
  - the dispersion of other PC from the surrounding pixels



Initial and validation maps of plant communities

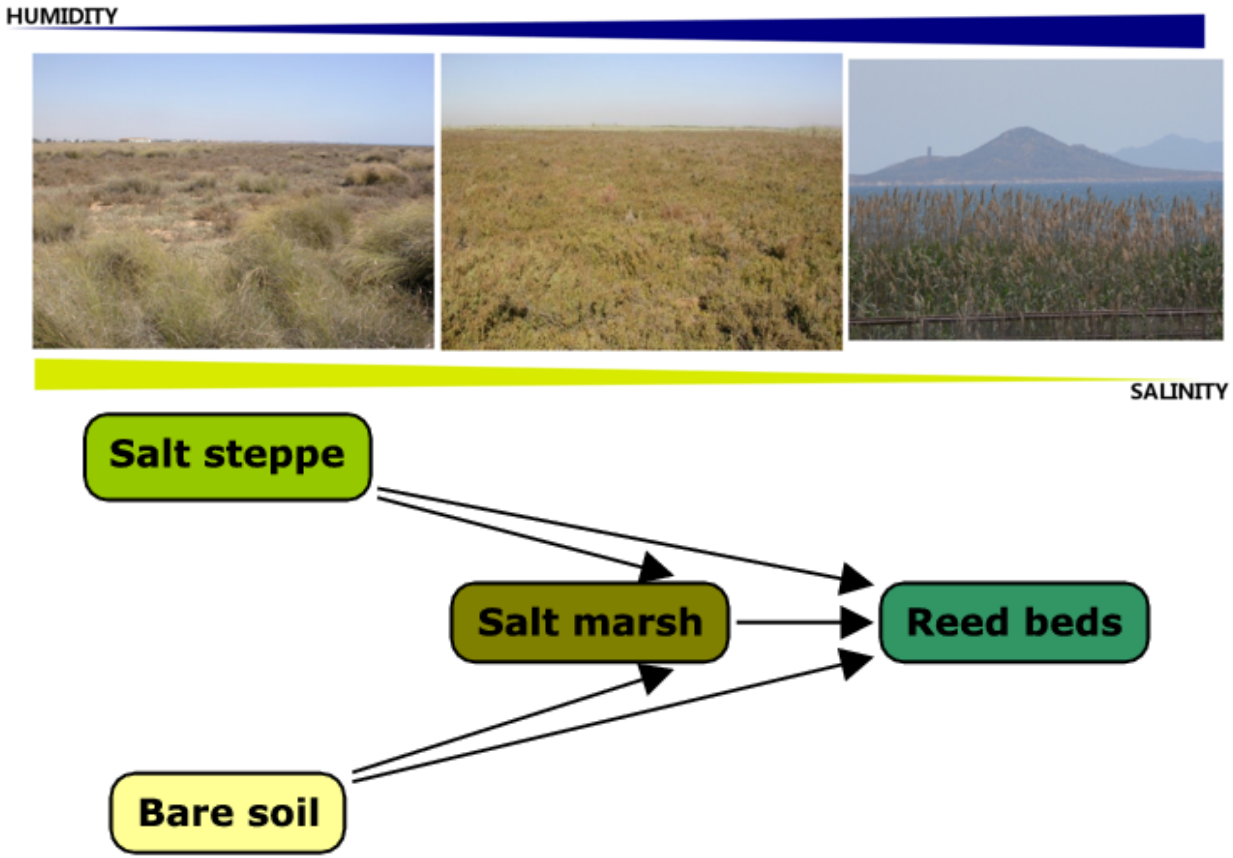
Model was tested by means of remote sensing data for the period 1992-2008



Carreño et al., 2008; Martínez-López et al., 2012

Model assumptions I

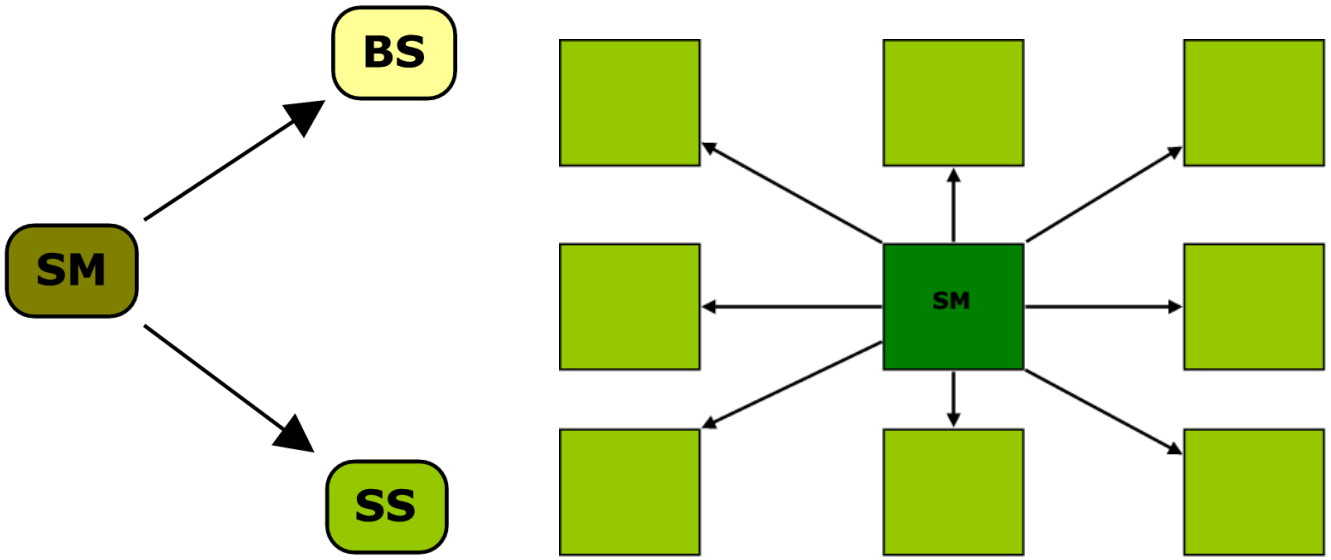
- Increasing water input
- Only conversion to more humid / less saline plant communities



Model assumptions II

native vs. invasive taxa

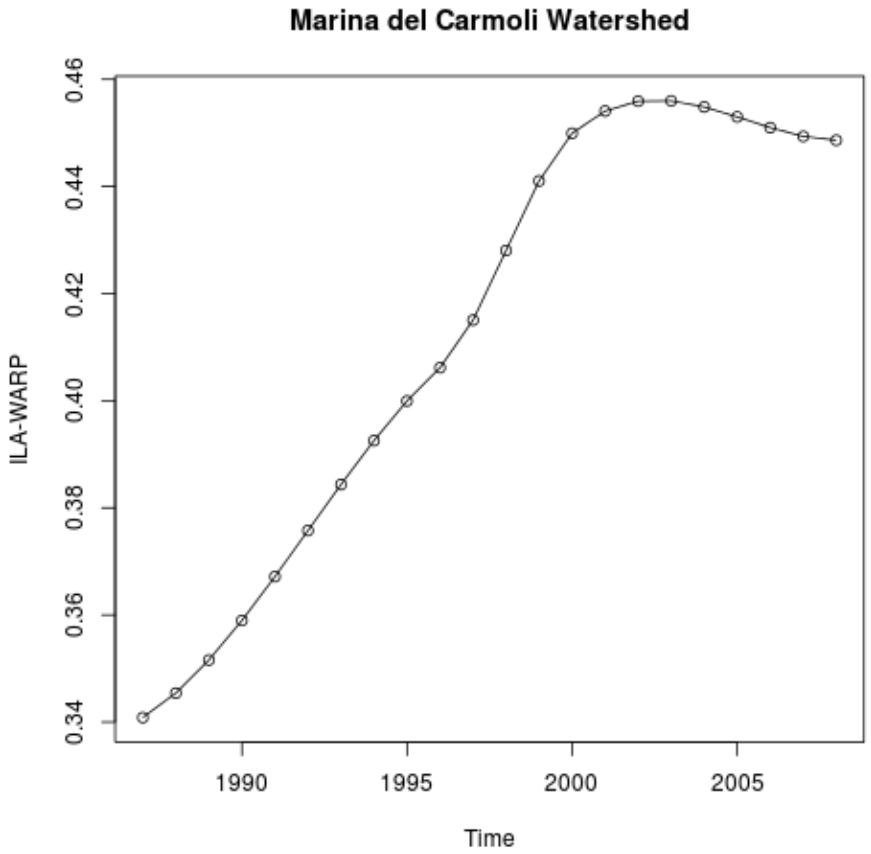
- invasive reed beds are potentially present in all pixels
- salt marsh is able to disperse into neighbour pixels



Non spatial forcing input

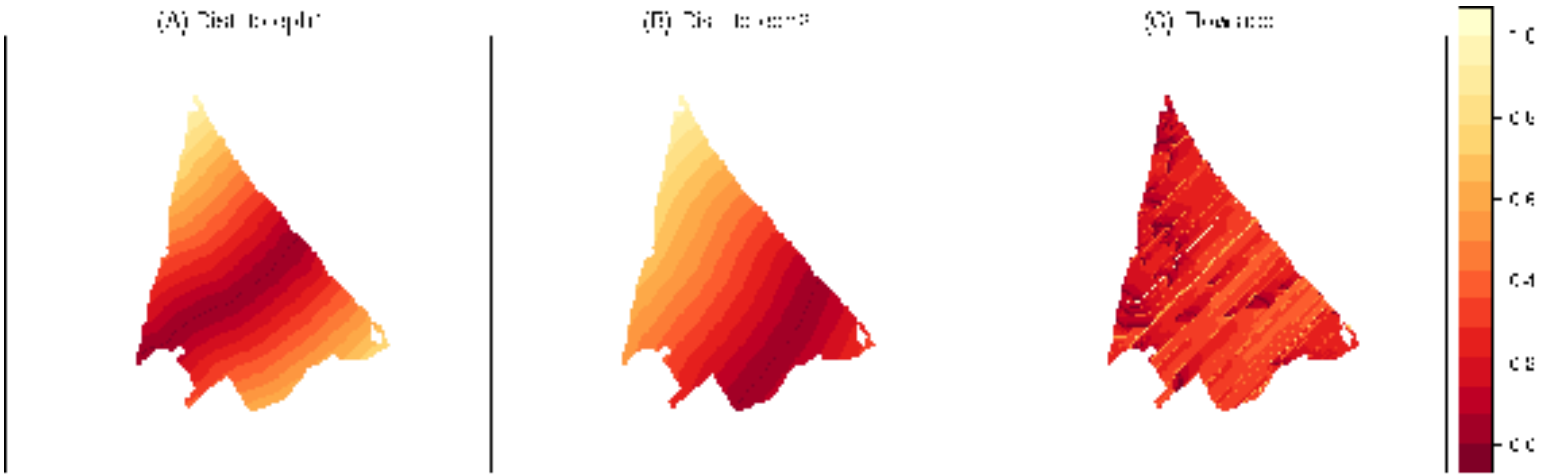
Drainage water input

WARP index (Martínez-López et al., 2014a,b)



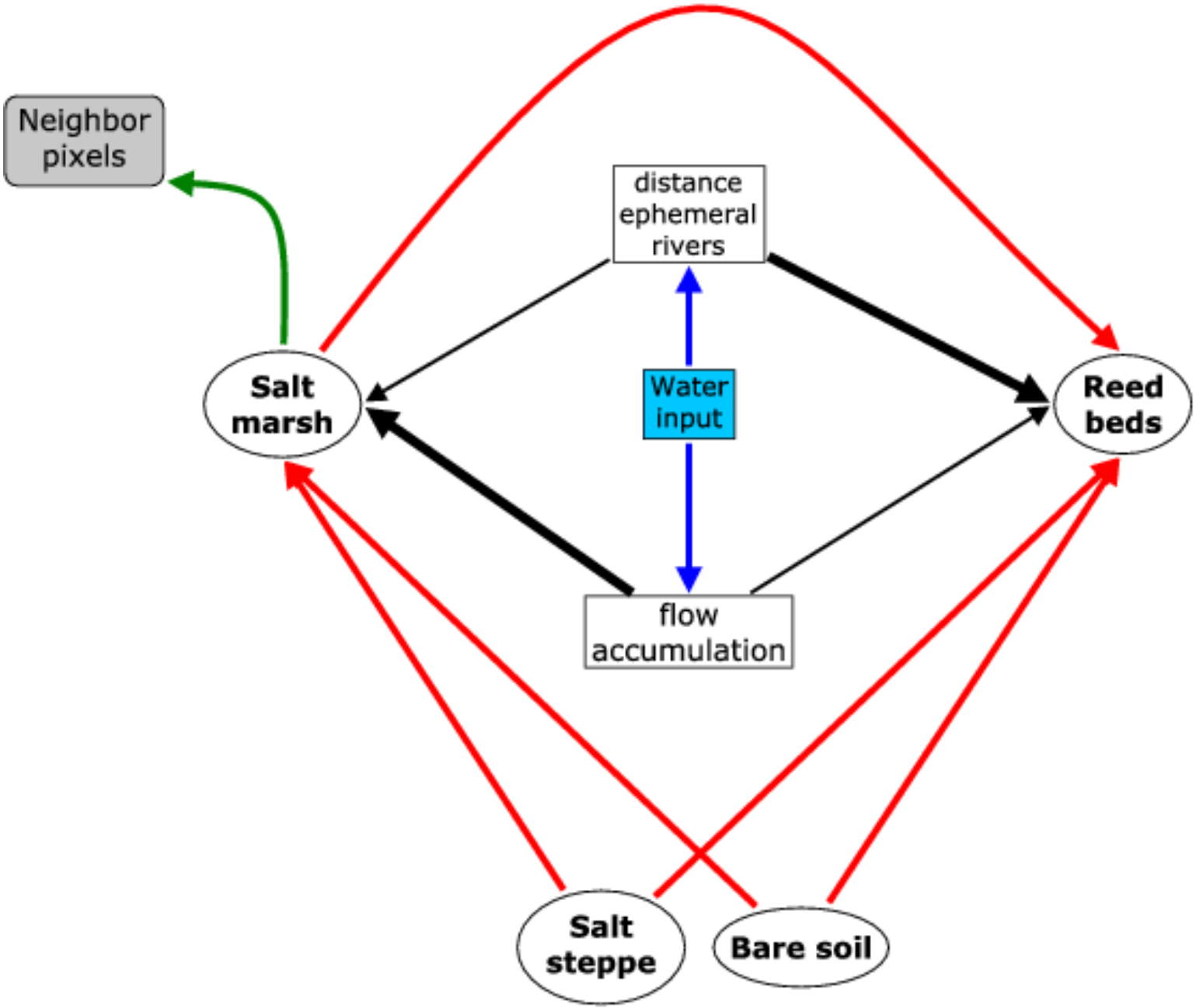
Wetland environmental spatial parameters

- (A) distance map to ephemeral river 1 (**reed beds**)
- (B) distance map to ephemeral river 2 (**reed beds**)
- (C) Flow accumulation map (**salt marsh**)



- All parameters are on a relative 0–1 scale.

Model diagram



Model development/execution

1. Initial dynamic model was developed using Stella (1 pixel)
2. Conversion to R using 'StellaR' script (Naimi and Voinov, 2012)
3. State variables and spatial environmental variables as matrices
4. Model wrapped as a R function
5. ode.2D("euler" method, time = 24 year, TS = 0.25) (library "deSolve")

Conclusions

1. The model serves as a tool for
   - wetland conservation and management studies (habitat loss)
   - testing plant community interactions
   - testing relationships between plant communities and environmental variables in space and time
2. The library undergoes further developments in order to become a flexible tool for the development of new spatio-dynamic models