

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

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# Study area

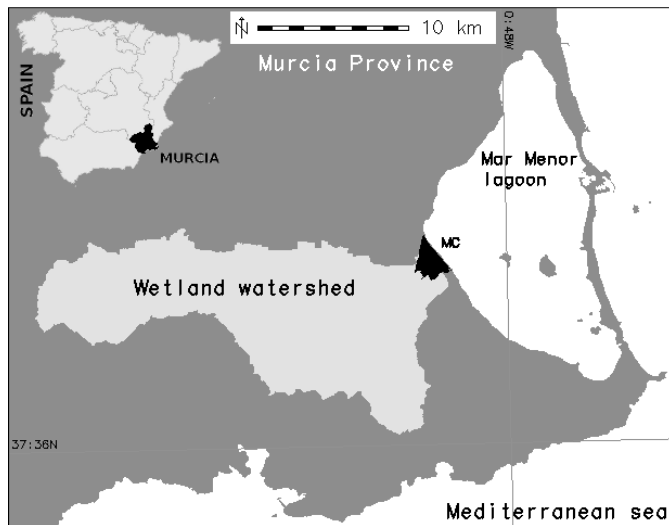
Wetland model

ISEM 2013

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# Marina del Carmoli wetland (300 ha)

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# Wetland plant communities

Wetland model

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Semiarid Mediterranean saline wetlands are semi-terrestrial ecosystems

HUMIDITY

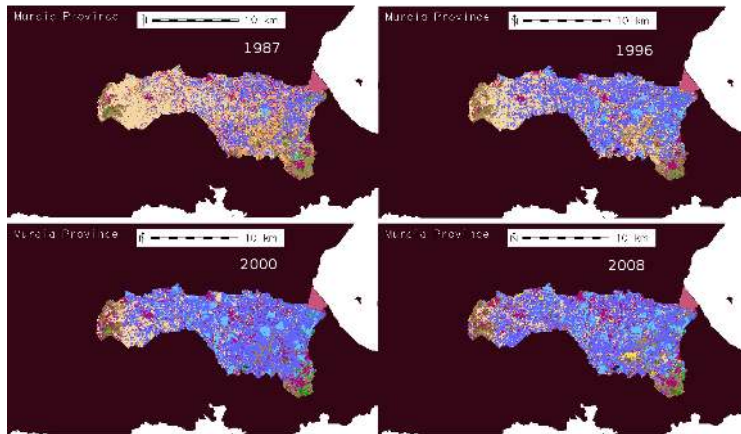


SALINITY

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

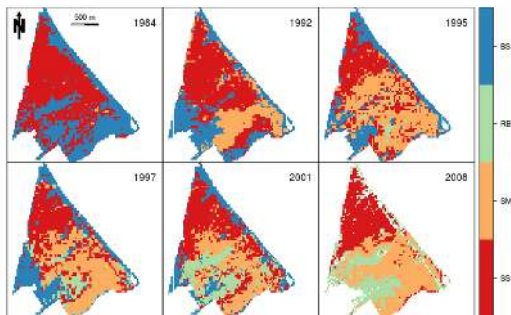
# External water inputs

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

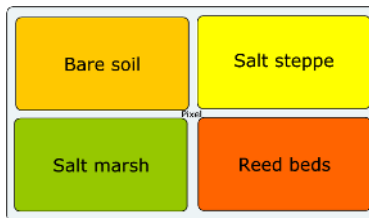
- ▶ Spatially explicit wetland model of how irrigated agriculture is affecting plant community composition in this semiarid Mediterranean wetland

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



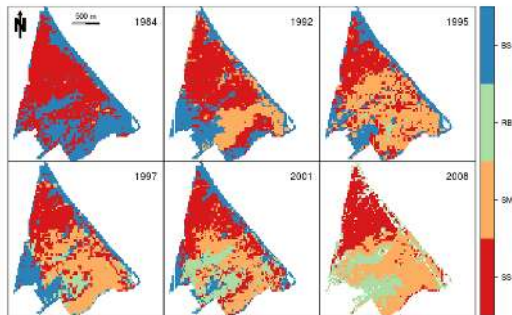


- ▶ Wetland is divided into pixels (25 m)
- ▶ Plant communities are modelled separately pixel by pixel (4 maps)
- ▶ The total abundance of plant communities within a pixel is limited so:
  - ▶ competition among plant communities mediated by
    - ▶ total drainage water input to the wetland
    - ▶ spatial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



# Initial and validation maps of plant communities

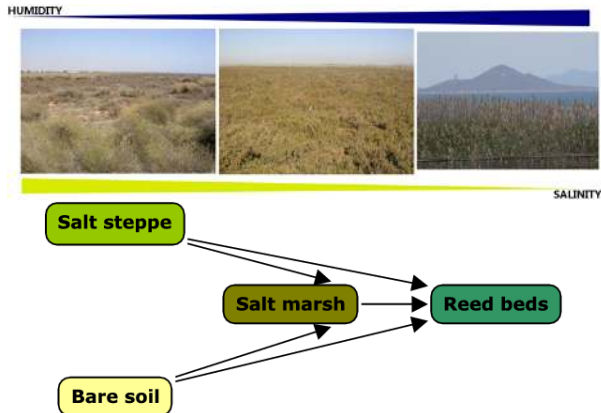
Model was tested by means of remote sensing data for the period 1992-2008



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

# Model assumptions I

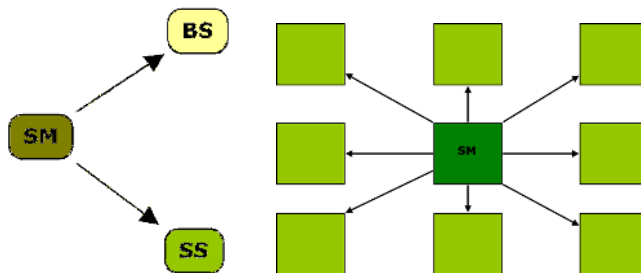
- ▶ Increasing water input
- ▶ Only conversion to more humid / less saline plant communities



# 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

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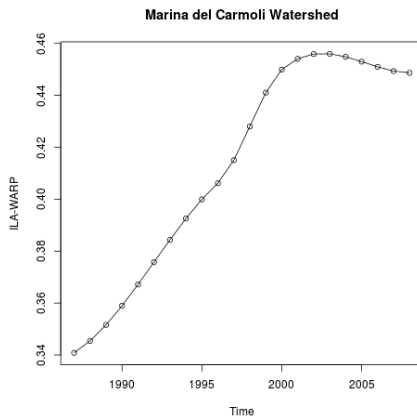
## Drainage water input

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

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# Wetland environmental spatial parameters

Wetland model

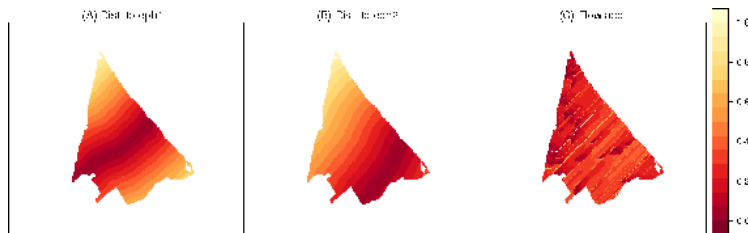
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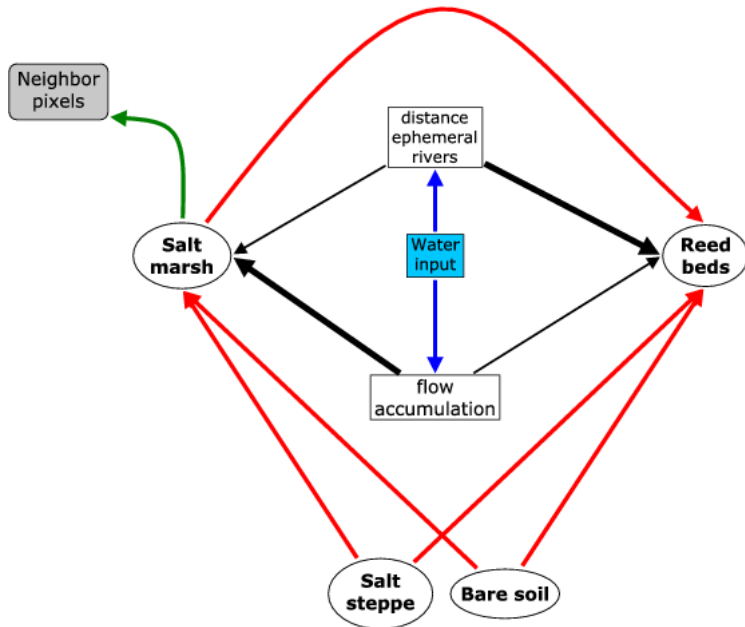
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- ▶ (A) distance map to ephemeral river 1 (**reed beds**)
- ▶ (B) distance map to ephemeral river 2 (**reed beds**)
- ▶ (C) Flow accumulation map (**salt marsh**)



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

# Model diagram



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")



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