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

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Study area

In the image, there is a map showing the study area in Murcia Province, Spain, with specific regions labeled as Murcia, Wetland watershed, Mar Menor lagoon, and Mediterranean sea. The map includes a scale indicating 10 km and geographic coordinates.
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 availability 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 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

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