Synergies and inconsistencies between two modelling approaches to predict the vegetation dynamic distribution in riparian semi-arid environments

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INTRODUCTION

Deterministic **models** → valuable tools to predict the **vegetation distribution** in riparian **semi-arid** environments

Riparian plants behaviour → directly linked to the **river hydrology**

Riparian Vegetation Dynamics

MODELLING APPROACHES

MAIN HYDROLOGICAL PROCESSES → **Transpiration** and **Flood impacts**

MAIN ECOLOGICAL PROCESSES → **Competition**

COMPARISON OF TWO MODELLING APPROACHES :

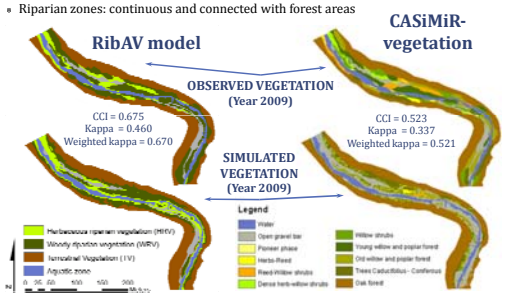
RibAV model (García-Arias *et al.*, 2013b) and **CASiMiR – Vegetation** (García-Arias *et al.*, 2013a)

Filling the gaps: The **RVDM** model

CASE STUDY

TERDE (Mijares River, Spain)

- Natural reach (no regulation, no channelization and no restoration)
- Permanent flow (daily average 0.86 m³/s)
- Reach length: 539 meters
- Typical Mediterranean semi-arid: 11 ºC, 500 mm
- Altitude: 850 m.a.s.l.
- Riparian zones: continuous and connected with forest areas



COMPARISON ANALYSIS

RibAV model

- The **daily time step** approach allows scenarios analysis → Useful to predict the impact of water demand and river flow regulation (García-Arias *et al.*, 2013c) or climate change effects on the riparian vegetation
- It is a **static model** → allows the analysis of the vegetation distribution after a simulation period. The plant clasification through PFTs does not allow the analysis of the vegetation dynamics
- The **vegetation death is not considered** → bare soil areas cannot be simulated; recruitment is not modelled
- The model includes affections by **water scarcity/excess** (↓ET) but plant remotion by floods is not considered
- Interactions between the riparian vegetation and the **river morphodynamics** cannot be analyzed

CASiMiR – Vegetation

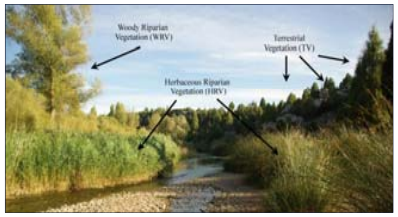
- It is a **dynamic model** → allows the analysis of the vegetation distribution evolution during a simulation period
- The **succession phases** approach overcome the vegetation species divergences between sites → Applicable to riparian ecosystems from diferent ecoregions (different climates and hyological conditions)
- The **colonization stage** must be common for every succession lines → competition analysis is not allowed
- **Flood impacts are absolute** → partial remotion of the vegetation is not considered
- The model does not include the relations between the **soil moisture** and the vegetation behaviour
- Important **limiting parameters for the recruitment** are not considered → only driven through the annual water level elevation related to the base flow

RibAV model

- Is a static tank flow model based on the actual riparian plants transpiration (ET)
- Simulates a certain number of riparian plant functional types (PFTs) and decides which is simulated by the comparison of the evapotranspiration index, E_{idx}

E_{idx} → relation between the actual ET calculated by RibAV and the potential ET corrected by a coverage factor

- Spatial scale: REACH SCALE
- Time step: DAILY
- Spatial resolution: 0.2 - 1 m² (1 m² in Terde)
- State variable: PFTs

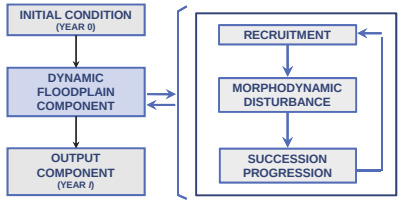


Inputs:
- Model parameters (vegetation and soils)
- Hydrological, topographical and soil maps
- Hydrometeorological daily data series

Results:
- Vegetation map
- ET_{idx} map (simulated vegetation)
- ET_{idx} maps (each PFT)

CASiMiR - Vegetation

- Takes into account the vegetation succession and retrogression in response of:
  - Recruitment (Height over base flow level)
  - Shear stress affections (plant critical thresholds)
  - Succession/retrogression (plant age/impacts)
- Spatial scale: REACH SCALE
- Time step: ANNUAL
- Spatial resolution: 0.2 - 5 m² (1 m² in Terde)
- State variable: riparian vegetation succession phases (Woodland and Reed succession lines in Terde)



- Flood duration effects inclusion allowed (Benjankar *et al.*, 2011) → number of days flooded per year (plant critical thresholds)

Inputs:
- Initial condition
- Yearly inputs definition (database)
- Sub-models parameters
- Hydrological and topographical maps

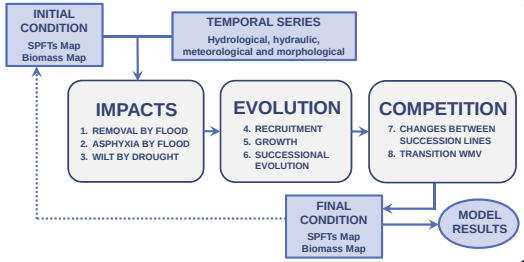
Results:
- Succession phases yearly maps (plant ages)

CONCLUSIONS - Strengths and weaknesses

- RibAV and CASiMiR-Vegetation are **valuable tools** for the riparian vegetation distribution analysis once the limitations are understood. Both models validate satisfactorily in different river reaches form Mediterranean semi-arid environments (spatial validation is required for new case studies). The outputs are in numerical and map formats (both models are spatially distributed). This and their easy implementation for systematic analyses allow both scientific and technical interpretations. In consequence, the results are suitable for non-scientific personnel (policymakers and environmental managers).
- Main weaknesses → lack in impacts processes parameterization, excessively simplistic recruitment and evolution of the vegetation submodels (growth/succession progression), absence of competition simulation, omission of river morphological changes, need for a state variable to determine differences within patches of same type of vegetation (ET_{idx} is a first approach)

An improved approach: RVDM

- **Flood and drought impacts** → biomass loss or plant death, depending on the magnitude of the impact.
- **Evolution** and **competition** → compromise between complex processes that determine plant behaviour (seed presence, germination, competition and establishment, plant growth and succession progression, etc.) and parameterization through environmental variables (light, soil moisture, temperature, oxygen, etc.) that increase the model robustness.



ACKNOWLEDGEMENTS

***SCARCE* project**: Assessing and Predicting Effects on Water Quantity and Quality in Iberian Rivers caused by Global Change. *CONSOLIDER* Plan, Ministerio de Ciencia e Innovación (ref.: CSD2009-00065). http://www.idaea.csic.es/scarceconsolider

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