Analysis of the riparian vegetation dynamics through the RIPFLOW model. Disturbed flow scenarios in Mediterranean rivers

Instituto de Ingeniería del Agua y Medio Ambiente

Alicia García-Arias (algarar2@posgrado.upv.es), Félix Francés (ffrances@hma.upv.es), Francisco Martínez-Capel, Rui Rivaes, Patricia Rodríguez-González, Antonio Albuquerque and Teresa Ferreira

Instituto Superior de Agronomia
Universidade Técnica de Lisboa

INTRODUCTION

The riparian ecosystems in Mediterranean environments are:

- three main elements interacting: vegetation, water and soil
- essential to sustain life of fluvial ecosystems
- under threat of degradation (human activities)

The riparian vegetation:

- is structurally complex
- has high biomass density and biodiversity
- Provides channel stability (sediment retention)
- balances nutrients availability (retention/contribution)
- controls water temperature and so its quality (shadow effect)
- favours diversity of habitats (for terrestrial and aquatic fauna)

Distribution and diversity of the riparian vegetation in semiarid areas are determined by the hydrological regime .

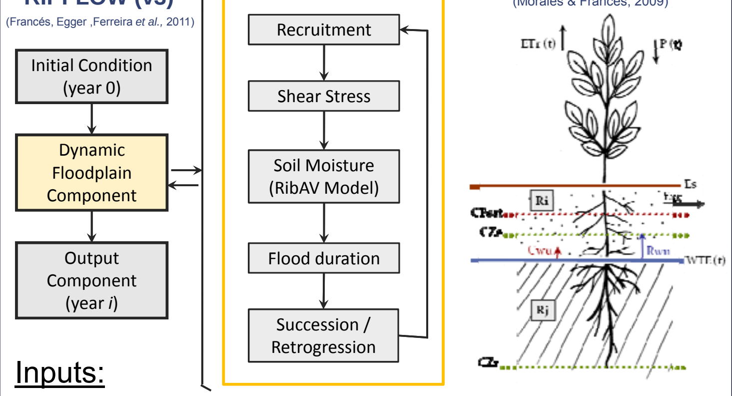
Main factors for the riparian vegetation succession → **Water Table Elevation**; **Shear stress**

RIPFLOW v3 MODEL

- Simulates riparian vegetation distribution in a time period, it is spatially explicit (Arc GIS)
- Takes into account the vegetation succession and retrogression in response of:
  - Recruitment
  - Shear stress affections
  - Evapotranspiration capabilities
  - Flood duration stress

  } **related physical parameters**
- Practical tool to tackle water management issues and predictions about restoration projects

RIPFLOW (v3) (Francés, Egger ,Ferreira et al., 2011) — **RibAV Model** (Morales & Francés, 2009)



Inputs:

- Database (yearly inputs definition)
- Sub-models parameters
- Hydrological and topographical maps
- Hydrometeorological daily data series

Outputs:

- Vegetation maps (years= {1, 2, …, n})
- ETidx maps (years= {1, 2, …, n})

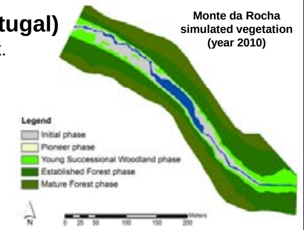
The RIPFLOW Project

The model has been already calibrated for Terde, Spain (kappa coefficient of agreement k=0.71), and Odelouca, Portugal (k=0.61) both in natural flow regime. It has been validated as well in Monte da Rocha (k=0.65) with regulated flow regime.

CASE STUDIES

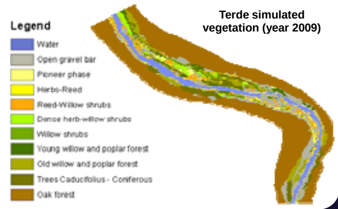
1. MONTE DA ROCHA (Sado River, Portugal)

- Regulated reach (Monte da Rocha dam, approx. 1 km upstream. No ecological flow release)
- Reach length: 480 meters
- Dominant species: *Fraxinus angustifolia, Salix atrocinerea* and *Tamarix africana*
- Riparian zones: continuous along river stretch



2. TERDE (Mijares River, Spain)

- Natural reach (no regulation, no channelization and no restoration)
- Permanent flow (daily average 0.86 m^3/s)
- Reach length: 539 meters
- Dominant species: *Salix eleagnos, Salix purpurea* and *Populus nigra.*
- Riparian zones: continuous and connected with forest areas



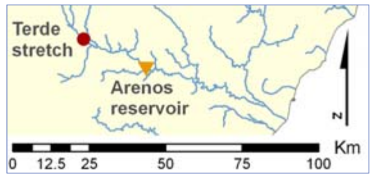
DATA AND SCENARIOS

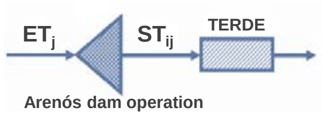
Regulated flow scenario

- Study site: Terde (Spain)
- Took as reference the Arenós dam operation (1988-2006)

$$ST_{ij} = SA_{ij} \cdot \frac{ET_j}{EA_j}$$

STij, is the regulated flow in Terde (day *i*, year *j*)
SAij, is the regulated flow in Arenós (day *i*, year *j*)
ETj, is the global contribution in Terde (year *j*)
EAj, is the global contribution in Arenós (year *j*)





Minimum environmental flow scenario

- Study site: Terde (Spain)
- Flows range between the 50 and 80% of the maximum Weighted Usable Area (WUA) for native fish species
- Assessments followed Physical Habitat Simulation adapted to regional budget
- Minimum ecological flow in Terde (Q_{min}) estimated: 0.203 m^3/s (September)
- Ecological flow regime by month should follow a pattern of variability similar to natural flow regime. This pattern was introduced with a variability factor (Vf_i)

$$Q_{eco} = Q_{min} \cdot VF_i \qquad VF_i = \sqrt{\frac{Q_i}{Q_{min}}}$$

Q_{eco}, is the minimum environmental flow (m^3/s)
Q_i is the average natural monthly flow (m^3/s)

Regulated flow with ecological flow release scenario

- Study site: Monte da Rocha (Portugal)
- Took as reference the Monte da Rocha dam operation (2000-2010):
  - Existent downstream flow caused by dam drainage losses and irrigation operations, estimated at 0.03 m^3/s.
  - Hydrologic regime imposed by dam: 9 years without discharges and one 5 m^3/s spillway discharge due to a heavy precipitation event.
- Ecological flow: calculated using the Portuguese Water Institute (INAG) methodology (Alves *et al.*, 2003).

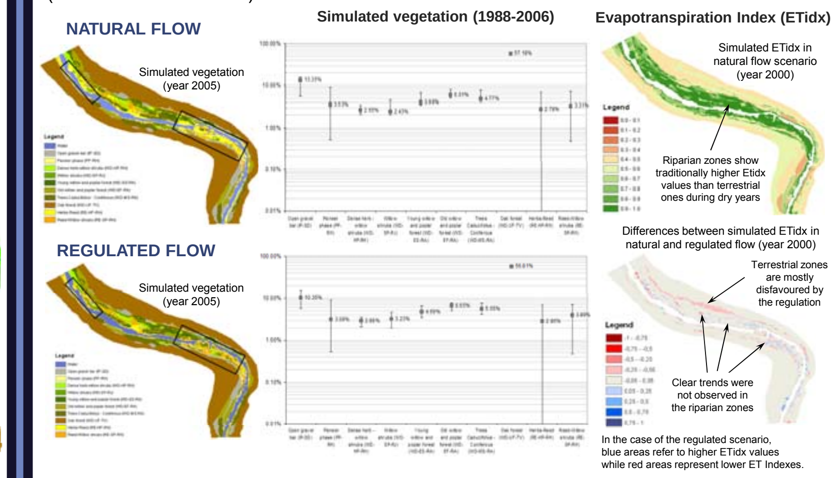
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Set
qmed	q25	(q50+q25)/2	q50	q50	q50	q50	q50	q50	qmed	qmed	qmed
Every two years, a discharge with a magnitude corresponding to a two years return period											

Calculation of the Minimum ecological flow following the INAG methodology, where q is the discharge flow (m^3/s) and 25,50 and med, respectively, the 1st and 2nd quartile, and mean flow of the respective month.

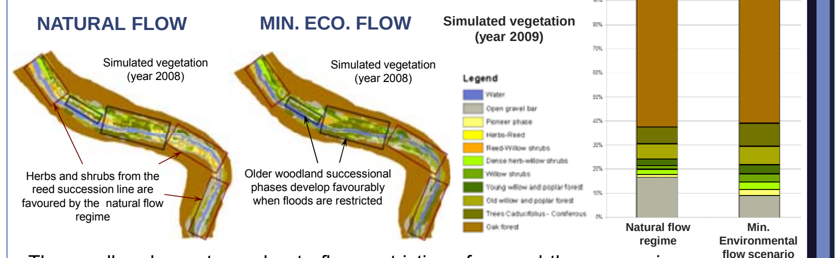
RESULTS

Regulated flow scenario

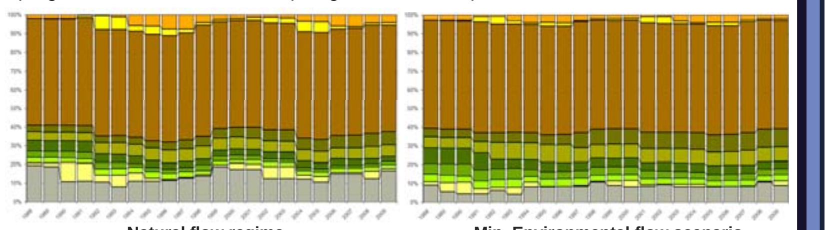
Changes in riparian vegetation distribution were consequence of frequent low flows during wet season (upstream storage) and frequent high flows during dry season (downstream demands)



Minimum environmental flow scenario

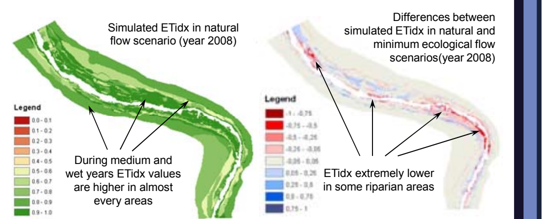


The smaller shear stress due to flow restrictions favoured the succession progress → reduced areas of open gravel bars and pioneer zones



Evapotranspiration Index (ETidx):

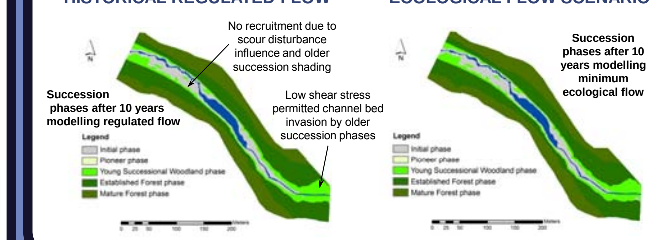
The establishment of a limited flow regime produced in the minimum ecological flow scenario reductions of the ETidx values in most of the reach analyzed areas.

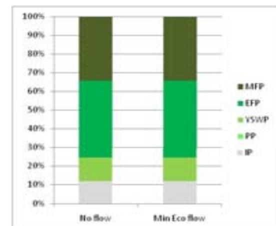


Regulated flow with ecological flow release scenario

Inputted ecological flow

- was not able to promote the channel fluvial disturbance necessary to enhance the consequent vegetation recycling to initial stages
- had no significant effect on riparian vegetation succession phases





Minimum environmental flow differed only 0.1% more recycling than no flow scenario.

Flushing flows for channel maintenance need to be higher than a 2 year return period discharge.

The ecological flow modelled disregards the fluvial dynamics determinant to the succession/retrogression patch formation process.

Shear stress caused by discharges was lower than riparian vegetation shear stress resistance thresholds.

CONCLUSIONS

Regulated flow scenario

- The regulation scenario showed a trend towards higher presence of riparian vegetation, with substantial decrease of the pioneer phase and open gravel bars, caused by the reduction of the shear stress (flood reservoir routing).
- Flow regulation seem to produce higher evapotranspiration rates during dry years on the stream surrounding areas compared to the natural flow regime, but lower in further zones. This causes the terrestrial vegetation death in some points and consequently a minor reduction on the terrestrial vegetation presence.
- During most of the years the regulation does not introduce clear trends in the riparian zones evapotranspiration rates.

Minimum environmental flow scenario

- Retrogressions produced by shear stress are substituted by retrogressions caused by ETidx reduction (being extremely low in some riparian areas).
- The water managers should take into account that, although the riparian ecosystem evolution seems to be favoured with minimum environmental flow establishment, no retrogressions finally cause a replacement of riparian vegetation with terrestrial.

Regulated flow with ecological flow release scenario

- The riparian vegetation changes are not very influenced by the establishment of ecological flows in dam operations.
- The flow regime is the driving force to the riparian vegetation succession or retrogression in regulated reaches, instead of the establishment of ecological flows.

ACKNOWLEDGEMENTS

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***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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