Riparian vegetation modelling for the assessment of environmental flow regimes and climate change impacts within the WFD

www.iiama.upv.es/RipFlow/index.htm

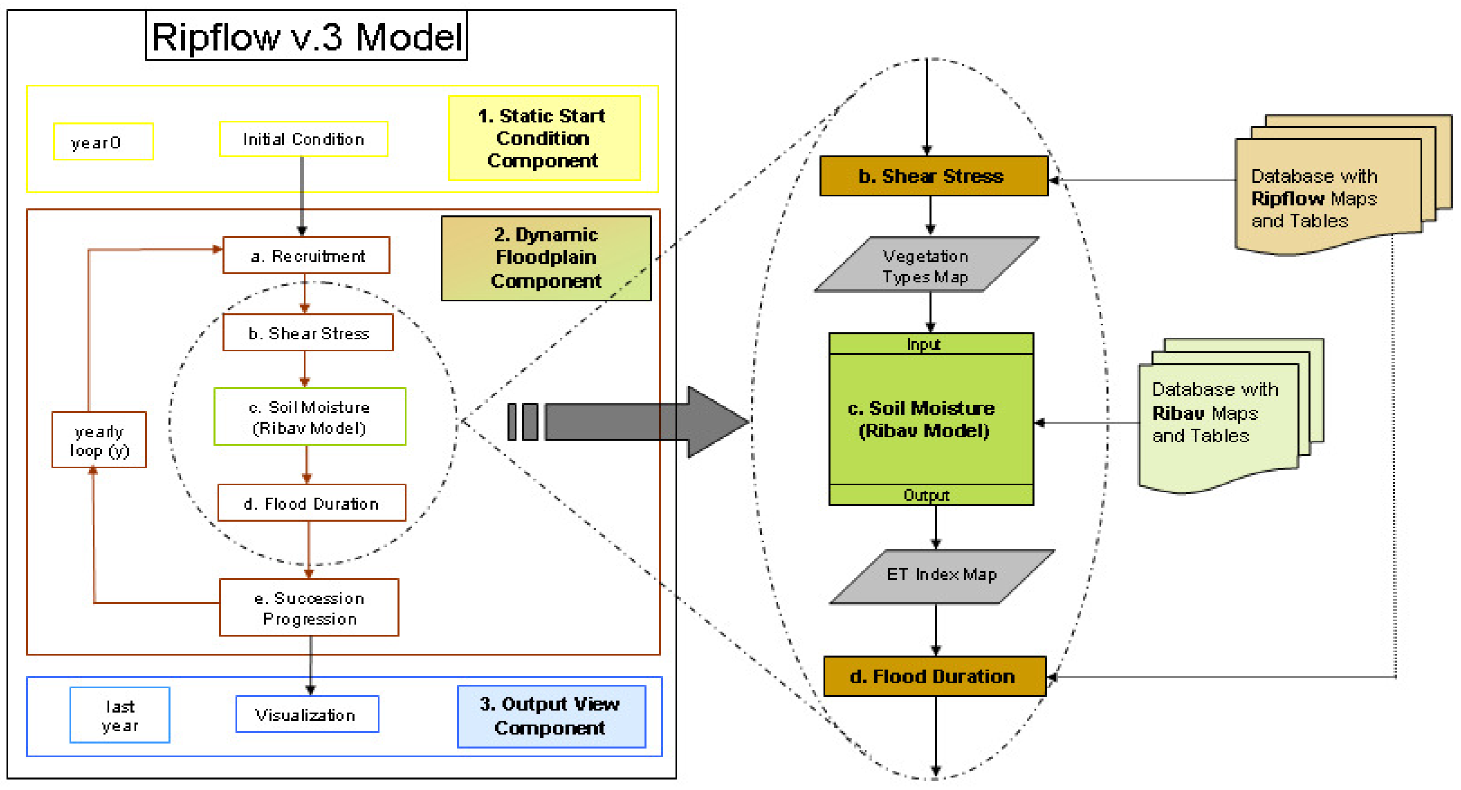
1. Objectives

Riparian ecosystems are important by their self and for their ecological services, therefore it is necessary to have a tool capable to predict the riparian vegetation response to its driving forces. The main goals of this project are:

I. To develop a flexible dynamic model of riparian vegetation that could be easily applied in a wide range of conditions across Europe:
→ from humid regions to Mediterranean conditions
→ with permanent and non-permanent flow regimes.

II. To apply the model to case studies of the countries involved in the project (Austria, Portugal and Spain) by:
→ calibrating and validating the model
→ delivering tools that support water management decisions

2. Ripflow Model



Main Ripflow v.3 Model

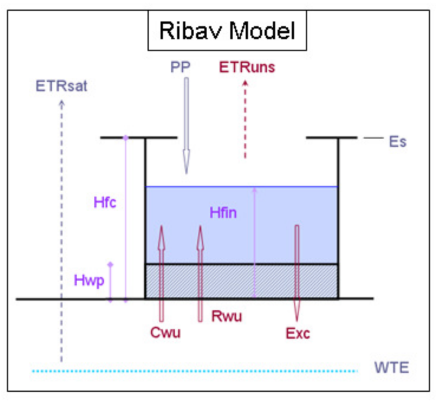
The Ripflow model is a type of vegetation model with dynamical rules that are based in:

- simulated physical parameters
- observed data
- expert rules

The model's components are represented by raster meshes that simulate the succession/retrogression processes in a yearly time interval.

The model has 3 main components:

1. **Start Condition**: It estimates the vegetation of the study site before the first year of simulation, given ordinary conditions.
2. **Dynamic Floodplain**: This component evaluates the growth (succession) and spatial distribution of the study site's vegetation. It has five modules which are executed in each iteration of the yearly loop:
   a. **Recruitment**: this module establishes a strip over the river level where seeds can develop, starting the riparian vegetation series.
   b. **Shear Stress**: it determines if the vegetation is destroyed when the shear stress from the river is higher than the plant's critical value.
   c. **Soil Moisture**: this module uses the **Ribav model** to determine how the plants are affected by water shortage.
   d. **Flood Duration**: it determines how the flooding time periods affect the plants due to the anaerobiosis effect.
   e. **Succession Progression**: it represents the flow from a pioneer to a climax stage within a vegetation succession series.
3. **Output View**: Although this last component does not carry out any computational task, it is used to organize the output data after the simulation ends.

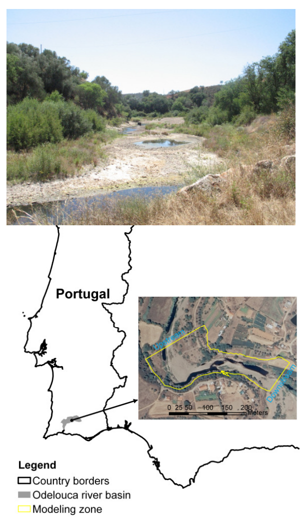


Ribav v.2.c Model

In this model the studied soil section is represented as a water tank filled with porous material. The vertical water of the tank has a daily variation depending on the soil moisture fluxes. The inputs of this model are the hydro-meteorological inputs and the morphology from the study site, but also taking into account the soil and the vegetation parameters. The main output is an **Evapotranspiration index**, which determines how the plant is affected by the water variation.

3. Case Studies

3.1 Portugal



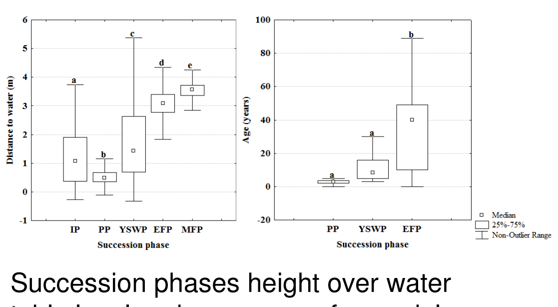
STUDY SITE

Odelouca river:
+ typical Mediterranean river
+ **non-permanent** flow regime.

→**No flow regulation** upstream
→Near natural conditions (human pressure and riparian vegetation).

MODEL CALIBRATION

Expected vs observed: Good strength of agreement (quadratic weighted Kappa=0,61)



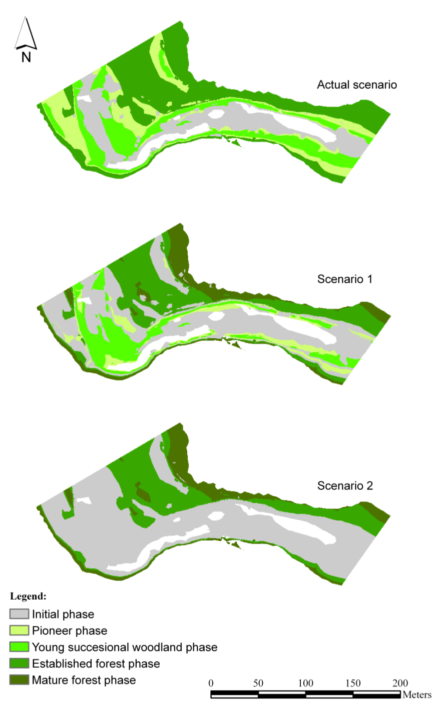
Succession phases height over water table level and age ranges for model calibration

CLIMATE CHANGE SCENARIOS

__Scenario 1__: 50% increase in winter floods intensity with a reduction of 1m in the water table)
__Scenario 2__: 130% winter flood intensity increase with the lowering of about 4 meter of the water table

RESULTS

- The riparian vegetation zonation found could be related to the biological traits of each species
- Succession phases distinguished from each other by habitat features, driven by the hydrologic regime.
- The results of the riparian vegetation model appeared to be correct for this case study, taking into account the expected changes in riparian vegetation caused by stream flow patterns modification



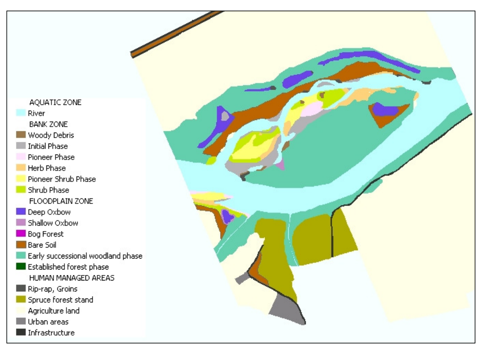
3.2 Austria

STUDY SITE

Drau river:
-typical alpine river
-permanent flow regime.

→ No flow regulation upstream
→ Channelized in the1970s
→ Restored in 2002:
700m-section has been widened
a side channel has been restored

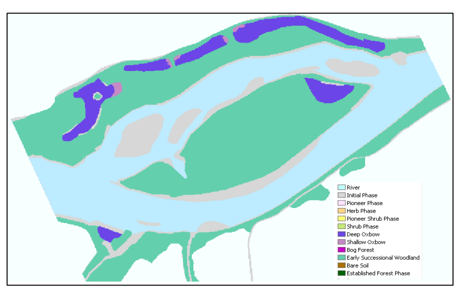
CURRENT VEGETATION



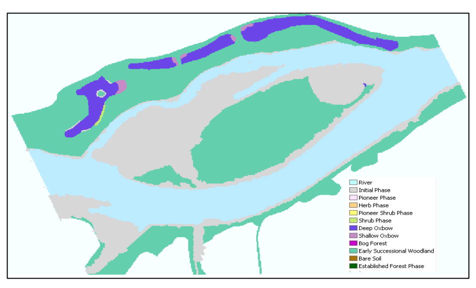
SCENARIOS SUPPORTING WATER MANAGEMENT DECISIONS

Two scenarios have been performed to find out the effect of channel geometry on habitats for riparian vegetation. The development of vegetation was simulated considering the hydrograph of the last 60 years assuming there are not climate change

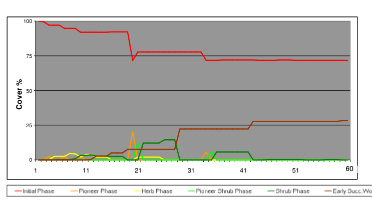
RESULTS



__Scenario 1__:Narrow and deep side channel and small in-stream bars

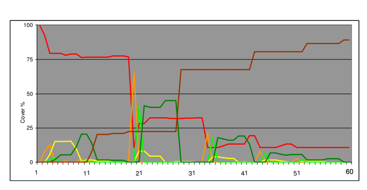


__Scenario 2__: : Wide and less deep side channel and large in-stream bars.



__Scenario 1__: **"Small In-Stream Bars":**

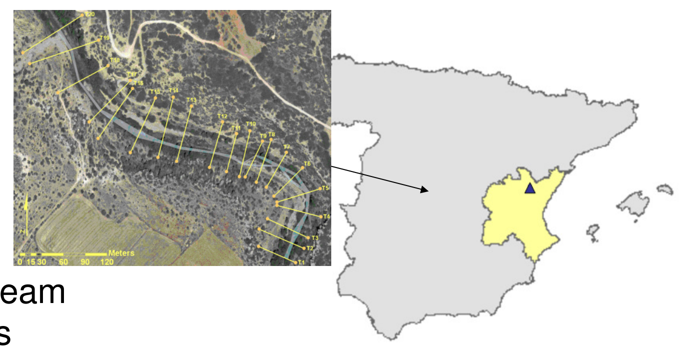
- Little succession phases turnover
- Prevailing of recycling processes



__Scenario 2__: **"Large In-Stream Bars"**

- Succession phases turnover limited in time
- Prevailing of succession processes

3.3 Spain

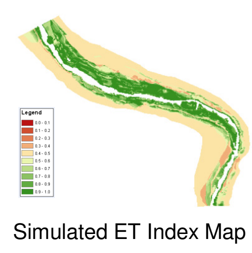


STUDY SITE

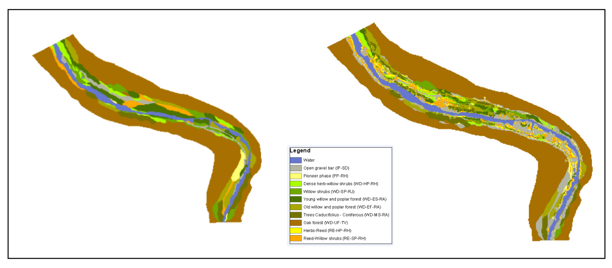
Mijares river:
- **permanent** flow regime.
- **no flow regulation** upstream and near natural conditions

MODEL CALIBRATION

- a **confusion matrix** with the simulated vs the observed vegetation types was used to make easier the calibration process.
- the main parameters to calibrate where the **ET index thresholds** and the **critical shear stresses** from the vegetation types.



Simulated ET Index Map



Observed and simulated vegetation types distributions maps

Comparison between the percentages of observed and simulated vegetation functional types

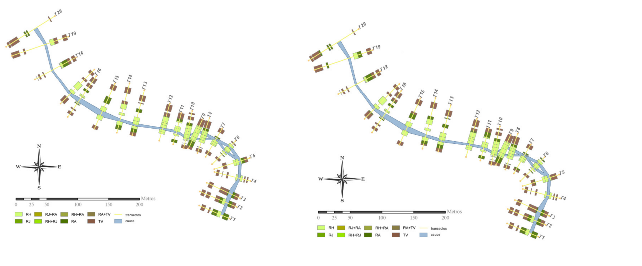
NAME	PHASE CODE	OBSERVED VEGETATION (2009)	SIMULATED VEGETATION (2009)
Water	0	8.43%	10.43%
Open gravel bar **(IP)**	111	3.59%	12.70%
Pioneer phase **(PP)**	122	1.52%	1.16%
Dense herb - willow shrubs **(HP)**	132	3.77%	2.17%
Willow shrubs **(SP)**	143	5.46%	2.47%
Young willow and poplar forest **(ES)**	154	7.90%	3.02%
Old willow and poplar forest **(EF)**	164	5.79%	5.69%
Trees Caducifolius - Coniferous **(MS)**	174	4.12%	5.02%
Oak forest **(UF)**	185	55.74%	51.16%
Herbs-Reed **(HP)**	232	0.00%	1.83%
Reed-Willow shrubs **(SP)**	242	3.67%	4.36%
	TOTAL	100.00%	100.00%

Observed Vegetation Types	Simulated Vegetation Types: IP	PP	HP	SP	ES	EF	MS	UF	HP	SP
IP	2952	230	190	104	98	62	0	0	338	958
PP	426	93	0	0	0	0	0	0	151	56
HP	107	25	520	57	18	47	6	0	50	79
SP	241	1	0	631	33	65	66	0	15	59
ES	80	1	5	1	752	568	336	0	31	67
EF	23	10	0	0	0	1240	226	0	14	11
MS	14	2	0	0	0	0	1119	0	2	0
UF	187	0	0	0	0	0	0	17882	0	0
HP	2	0	0	0	0	0	0	0	12	8
SP	279	44	43	69	153	6	0	0	23	286

Confusion matrix used in the calibration

CLIMATE CHANGE SCENARIOS

Simulations with hidro-meteorological inputs from the **HadCM3 global** circulation model and the **PROMES regional** model using __**A2 (pessimistic)**__ and __**B2 (optimistic)**__ scenarios.



Vegetation distribution from the reference period (1960-1990)

Vegetation distribution using the HadCM3--Promes model with a B2 scenario for the years (2070-2100)

RESULTS

- After the calibration a Kappa coefficient of k=0,71 was obtained.
- The simulations from the HadCM3 climate change inputs showed that the climate change scenarios would not influence significantly the riparian vegetation distribution

1-3 Dec 2010, IWRM-Net Final Conference ***RIPFLOW*** **Project**