ANALYSES OF SUCCESSION-RETROGRESSION FOR DYNAMIC MODELLING OF RIPARIAN VEGETATION IN THE RIPFLOW PROJECT

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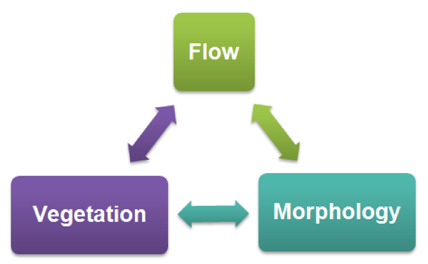
INTRODUCTION

Patterns of vegetation dynamics

- **Succession** (gradual process of ecosystem development that proceeds toward relatively stable condition following some kinds of disturbances)
- **Mosaic and cyclic processes** (smaller scale dynamics by which the character of stable vegetation is maintained)

Processes

- **Autogenic** (internal mechanistic) → Plant themselves modify their environment and induce successional changes with processes such as competition.
- **Allogenic** (external) → External processes (such as hydrological events) can regenerate the forest in the active floodplain.



RIPFLOW MODEL COMPONENTS

Static Component (*Starting Condition*)
It provides an initial landscape, predicting the different habitats based on height over water level, topographic elevation as well as three different zones and assigns specific vegetation type for each habitat. Main purpose of this component is to predict potential natural vegetation community and to use it as starting condition for the dynamic floodplain component.

Dynamic Component
It simulates the vegetation succession or retrogression in space and time

STUDY SITES

The study sites were nearly-natural reaches of the rivers Drau in Austria, Odelouca in Portugal and Mijares in Spain.

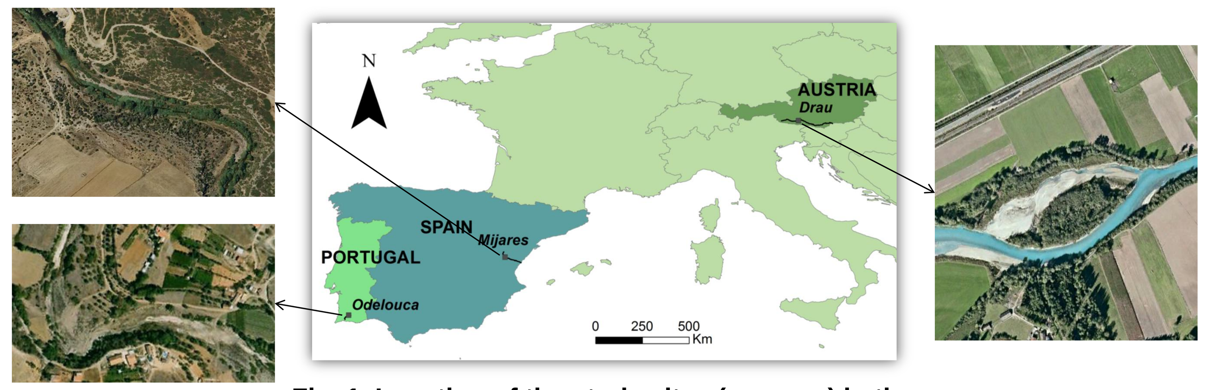


Fig. 1. Location of the study sites (squares) in the selected rivers of Austria, Portugal and Spain.

They had long time series of flow records and meteorological data, good ecological status, natural dynamism and natural variety of vegetation types, succession phases and stand ages.

Table 1. Characteristic of the study sites

Country	Altitude (m)	Site length (m)	River length from birth (km)	Soil character	Average annual Temperature (ºC)	Average annual precipitation (mm)	Mean annual discharge (m³/s)	Bankfull discharge (m³/s)
Austria	580	700	103	Mixed	7	1200	74	320
Portugal	134	398	35	Acid	15.5	750	2	80
Spain	850	539	43	Basic	11	500	0.894	5

FIELD SURVEY AND PROCESSING

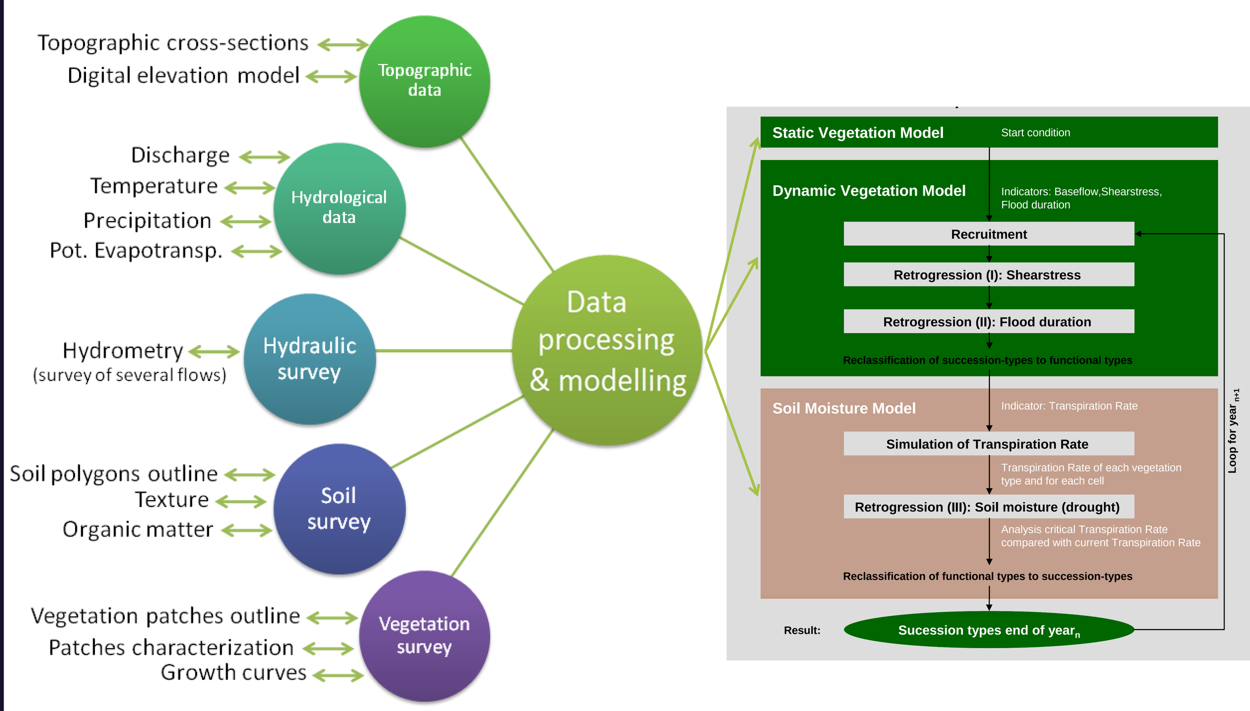


Fig. 2. Field surveys carried out in the Ripflow project, processing and modelling of the data to obtain the necessary inputs for the model.

Topographic survey

Fig. 3. Equipment used in the georreferenciation of the sites and cross sections in the Spanish study case to complete the digital elevation model (right).

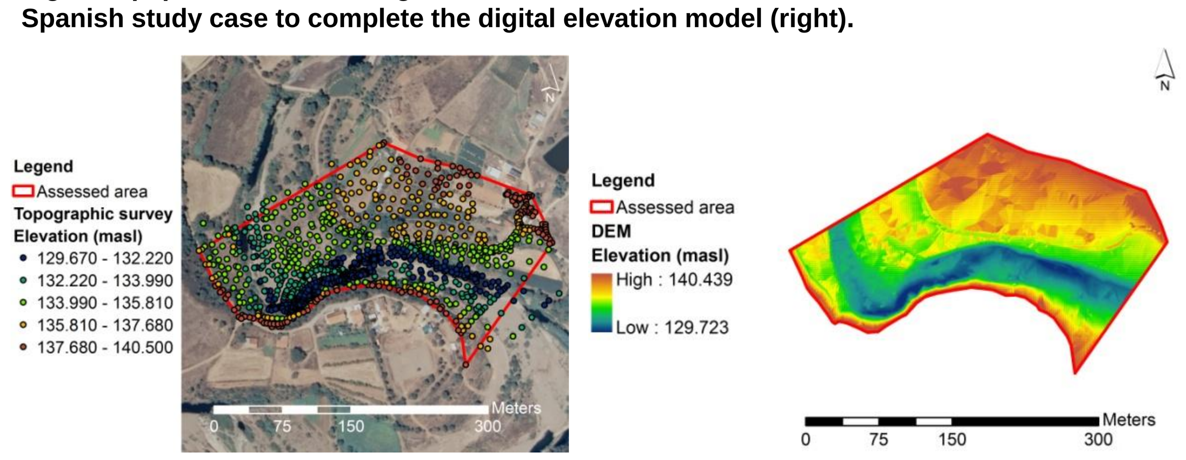
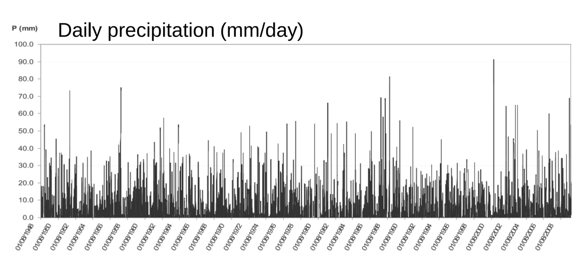


Fig. 4. Points of the topographic survey in the Portuguese site (left) and Digital Elevation Model obtained with the ESRI® ArcGIS™ 9.2 software (right).

Hydrological data



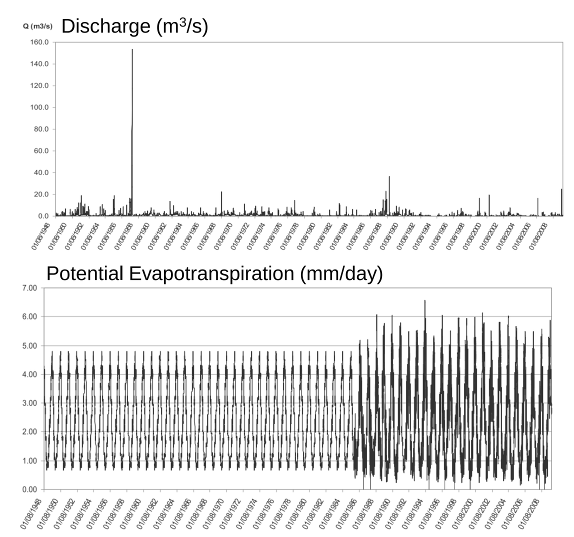


Fig. 5. Hydrological data for the period 1948-2009, obtained from different data networks (Spanish site).

Hydrometry and hydraulic modelling

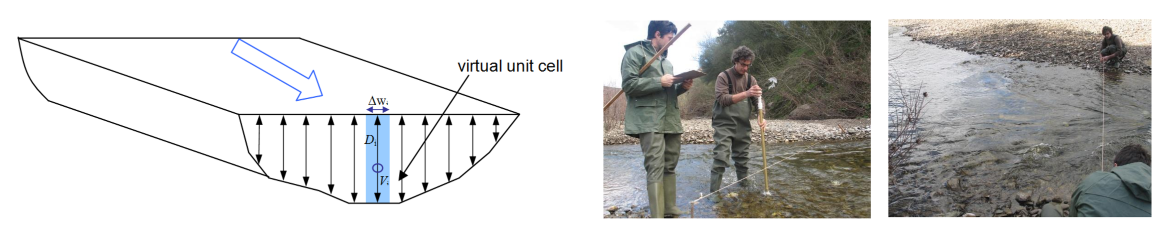


Fig. 6. Hydrometry survey in a river cross-section (right) using the area-velocity method to estimate the flow (left).

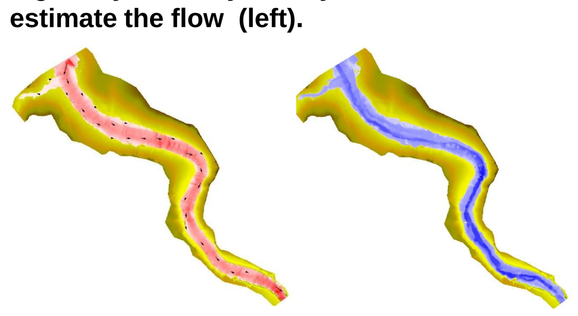


Fig. 7. 2D Hydraulic model outputs: water depths and velocities (Spanish site).

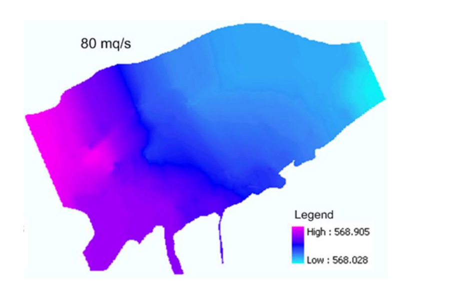


Fig. 8. Groundwater table elevation for the 80 m³/s mean spring flow (Austrian site).

Vegetation survey

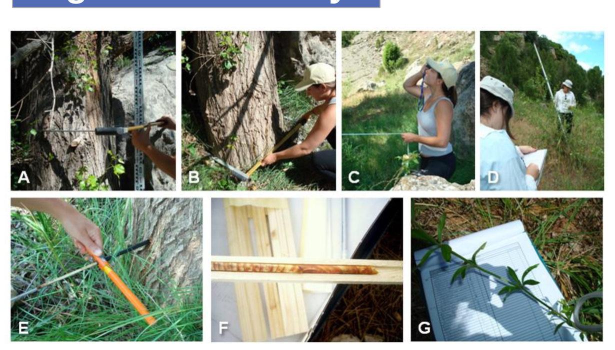


Fig. 9. Different procedures during vegetation survey in the Spanish site: DBH, DGL and height measurements (A-B-C), core samples extraction and conservation (E- F) and vegetation characterization (D-G).

Soil survey

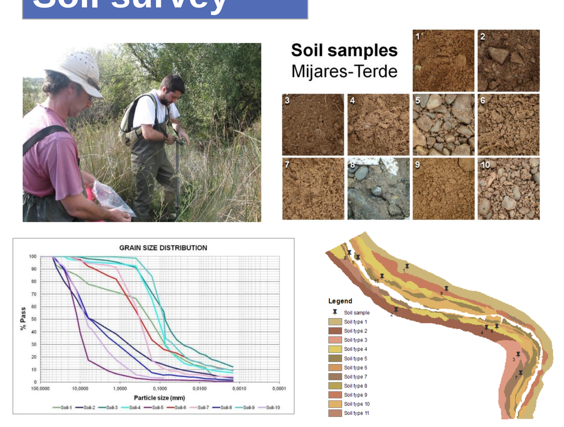
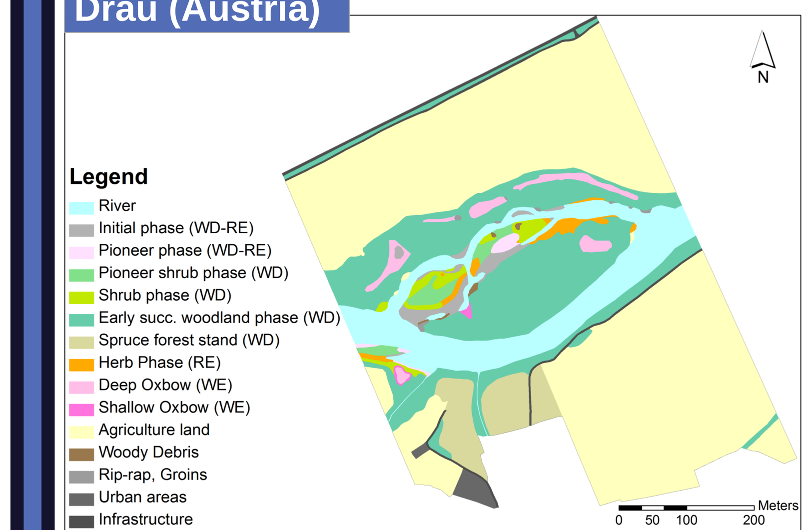


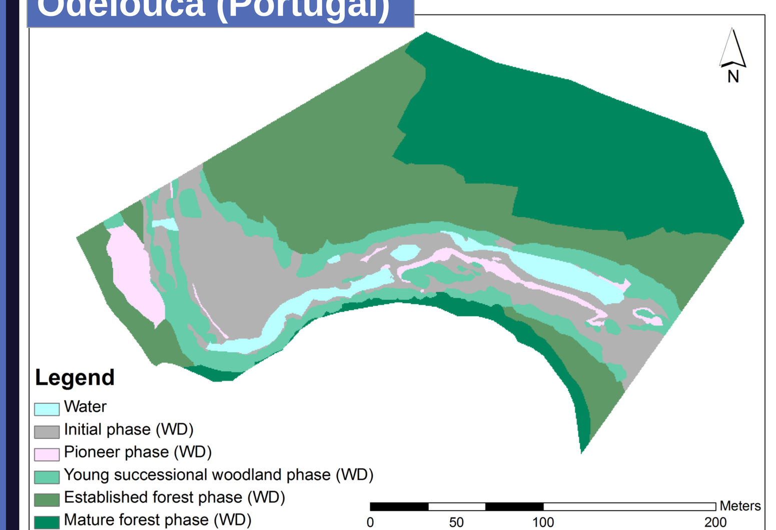
Fig. 10. In order, soil survey campaign in the Portuguese site and soil samples, grain size distribution and soils map of the Spanish site.

RESULTS

Drau (Austria)



Odelouca (Portugal)



Mijares (Spain)

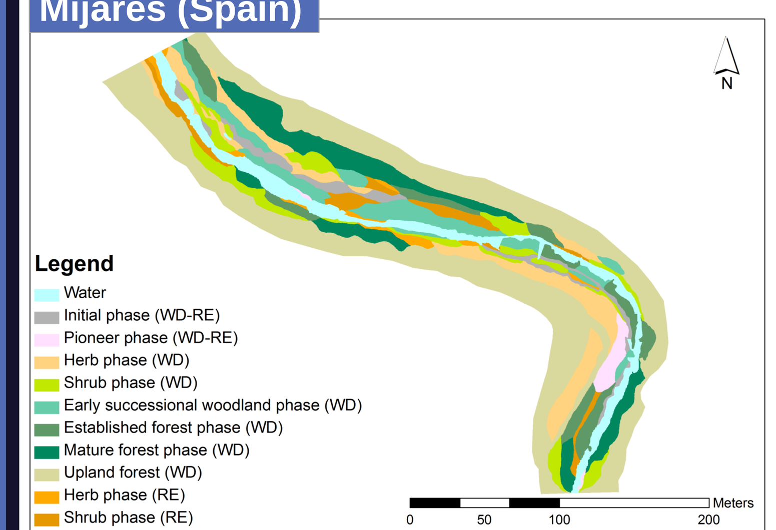


Fig. 11. Maps of succession phases. The legend indicates the phases identified in each country (codes of succession series in brackets)

To compare results across countries, the vegetation types were re-classified, based on the concept of **succession phases**. The phases were defined according to the plant species and development stage.

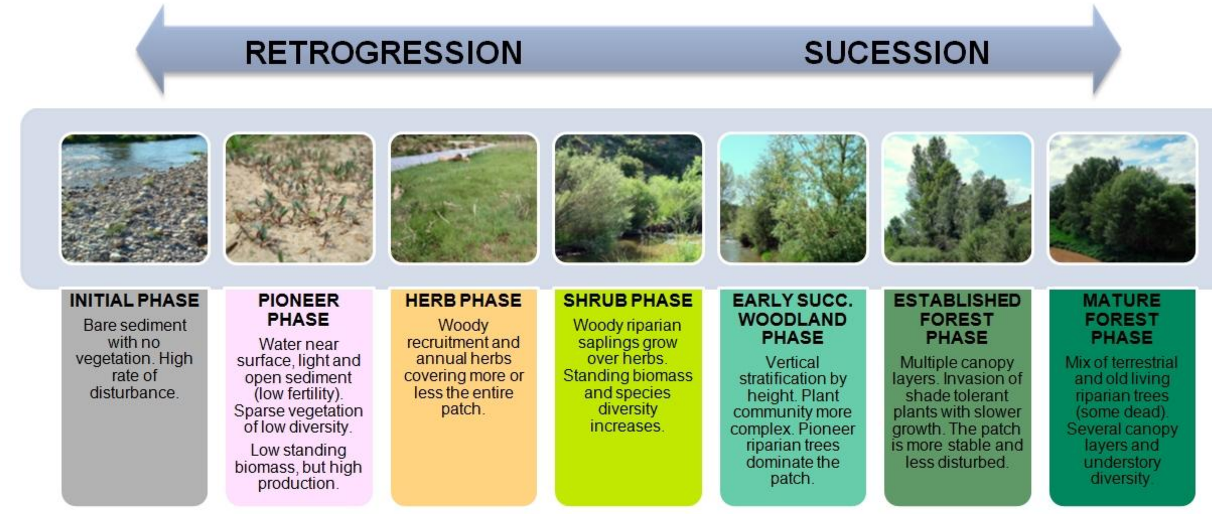


Fig. 12. Pathway of succession-retrogression in the Spanish study site.

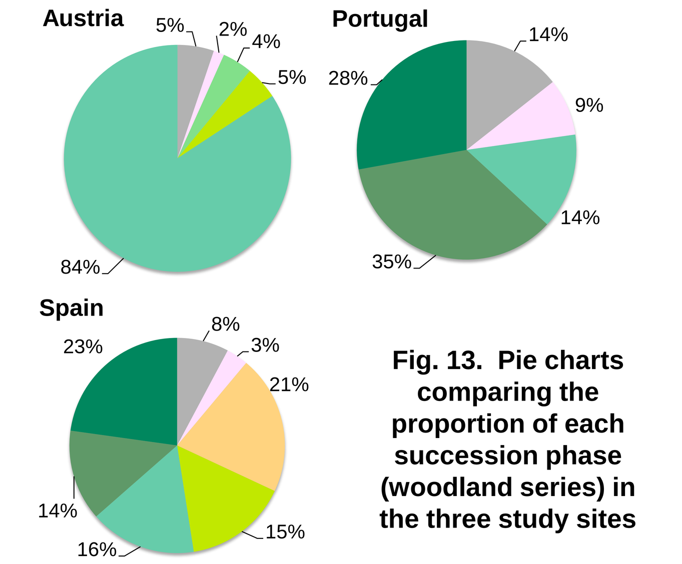


Fig. 13. Pie charts comparing the proportion of each succession phase (woodland series) in the three study sites

Table 2. Series and succession phases in each study site.

Colour	Code	Series	Austria	Portugal	Spain
	River	-	X	X	X
	WD-IP	Woodland (& Reed)	X	X	X
	WD-PP	Woodland (& Reed)	X	X	X
	WD-HP	Woodland	-	-	X
	WD-PSP	Woodland	X	-	-
	WD-SP	Woodland	X	-	X
	WD-ES	Woodland	X	X	X
	WD-EF	Woodland	-	X	X
	WD-MS	Woodland	-	X	X
	WD-UF	Woodland	X	-	X
	RE-HP	Reed	X	-	X
	RE-SP	Reed	-	-	X
	WE-DO	Wetland	X	-	-
	WE-SO	Wetland	X	-	-
	WE-BF	Wetland	-	-	-

Table 3. Age ranges definition for the considered succession phases in each study site.

Succession stages	Succession phases (woodland series)	Austria Age range	Portugal Age range	Spain Age range
	Bank zone			
Colonization-establishment stage	Initial phase (IP)	0-1	0-2	0-1
	Pioneer phase (PP)	2-2	2-5	2-3
Transition stage	Herb phase (HP) or Pioneer shrub phase (PSP)	3-3	-	4-6
	Shrub phase (SP)	4-10	-	7-10
	Floodplain zone			
	Early succ. woodland phase (ES)	10-60	5-16	11-15
	Established forest phase (EF)	60-150	16-49	16-20
Mature stage	Mature forest phase (MF)	> 150	> 49	21-44
	Upland forest phase (UF)	-	-	45-250

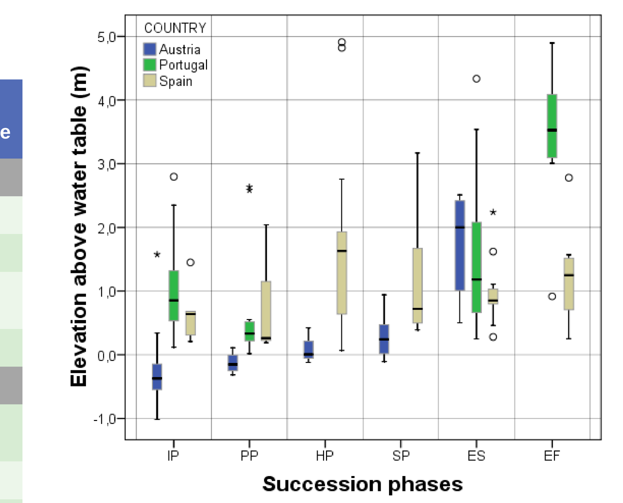


Fig. 14. Elevation above water table for each succession phase (Austria: average flow, Spain and Portugal: base flow)

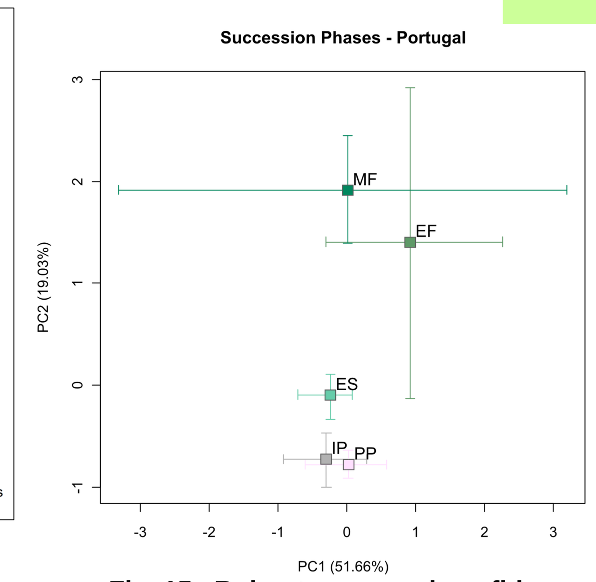


Fig. 15. Robust mean and confidence intervals of succession phases (Portugal)

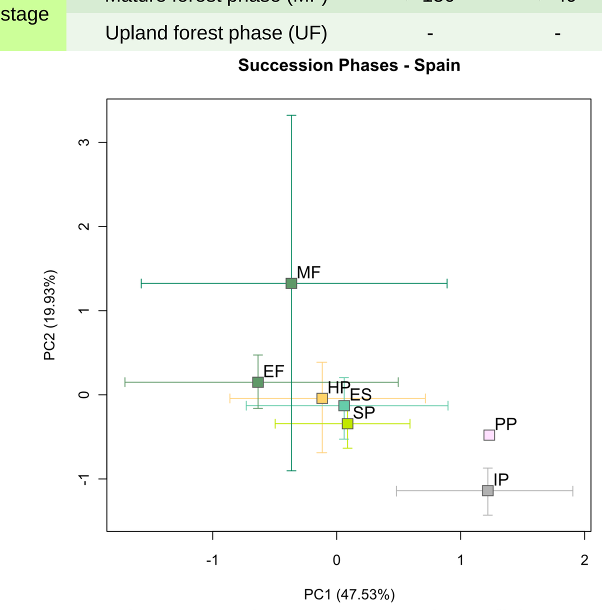


Fig. 16. Robust mean and confidence intervals of succession phases (Spain)

- Plots of succession phases in the PCA (variables: minimum and maximum age, substrate types' percentages, substrate index, height over base flow).
- Principal components, in both countries: PC1 correlated with substrate composition; PC2 correlated with minimum and maximum age of the patches, and height over base flow (HBF).
- Data variability within succession phases: largest variability in substrate for most of succession phases; large variability in age and HBF observed in Established and Mature Forest.
- PC2 is the principal for phases' ordination.

CONCLUSIONS

- Using succession phases instead of dominant vegetation types was essential in this international context, where a species-to-species comparison can be hardly performed, especially for comparing Alpine and Mediterranean vegetation.
- Height over base flow (HBF) and age determination are critical to characterize succession phases (necessary to consider vegetative reproduction), while superficial substrate was usually overlapped across habitat types.
- Field sampling and data processing allowed us to obtain "expert rules" for the starting condition submodel (using the most explicative variables of the succession phases, based on the ranges of height over water table and min. and max. age where each succession phase was found).
- In the Portuguese and Spanish sites, the base flow was considered as limiting factor for the vegetation development and maintenance. In the Austrian site, the elevation above the average flow was considered instead.
- The data quality of the field data survey and DEM and its processing is particularly important, because they determine the results' quality. From the hydraulic modelling point of view is important to record the flow at different stages in the site (base flow, average, over bankfull, etc.). Those flow levels over the riparian mosaic of patches are especially valuable.
- Small modifications are possible in data acquisition, depending on the in-house resources, availability of historic information (e.g. river morphology), etc.
- When the study site is a regulated river, the natural reference site (where model is calibrated) should be comparable in terms of hydrology, morphology and plants community; this allow us the comparison of results after a given time period.
- The selection of a good natural reference site (as much natural as possible) is important from the data collection point of view. It is required to infer the parameters values for the model, and the dynamic processes of succession-retrogression can be studied in natural conditions.

ACKNOWLEDGEMENTS

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- ***RIPFLOW* project**. Riparian vegetation modelling for the assessment of environmental flow regimes and climate change impacts within the WFD. Era-net IWRM Funding Initiative, Acciones Complementarias del MEC (ref.: CGL2008-03076-E/BTE).

- ***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).

FINAL REPORT: Francés F., Egger G., Ferreira T. *et al* (2011). Ripflow Project. Final Report. Riparian vegetation modelling for the assessment of environmental flow regimes and climate change impacts within the WFD. Regional and national research programmes network on Integrated Water Resource Management (IWRM-Net). http://www.iiama.upv.es/RipFlow/index.htm