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RIVER CONSERVATION UNDER WATER SCARCITY

Integration of water quantity and quality in Iberian Rivers under global change

20-21 October 2014
Tarragona, Spain

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RIVER CONSERVATION UNDER WATER SCARCITY: INTEGRATION OF WATER QUANTITY AND QUALITY IN IBERIAN RIVERS UNDER GLOBAL CHANGE

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Modelling hydroecological processes in semi-arid riparian areas

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Introduction

In Mediterranean semi-arid areas the river hydrodynamics determines the riparian vegetation distribution. Although different modelling approaches are currently available (e.g. Hooke *et al*., 2005; Camporeale and Ridolfi, 2006; Perona *et al*., 2009; Benjankar *et al*., 2011; Maddock III *et al*., 2012; García-Arias *et al*., 2013; Ye *et al*., 2013; García-Arias *et al*., 2014), there is still a necessity of quantitative modelling approaches that represent better the coupling between the riparian vegetation dynamics with the river hydrological and morphological changes (Merrit *et al*., 2010; Camporeale *et al*., 2013). The aim of the present study was to develop a new model that integrates the knowledge provided by previous tools and that represents an upgrade in the way of understanding the riparian hydrobiodynamics.

Modelling approach

The RVDM (Riparian Vegetation Dynamic Model) is the result of integrating the analysis of the impacts over the riparian vegetation, its evolution and its competition with the terrestrial vegetation. Through a daily time step and an spatial resolution between 0.5 and 2 metres, this model allows to analyze in detail not only the distribution of the vegetation dynamics in the riverine areas during a simulated period, but also the biomass of each unit area.

The river dynamics direct effects over the riparian vegetation wellbeing and distribution are considered as well as the impacts caused by changes in the river morphology. RVDM considers the effect of the hydrological extremes over the vegetation. It is capable to translate the stress caused by flood or droughts events into changes on the plant biomass and the vegetation distribution. The main impacts have been established as removal and asphyxia by floods and wilt by drought. RVDM estimates the effects of the removal through the water shear stress related to a flood event. On the other hand, the effects of asphyxia and wilt are estimated through the soil moisture.

The natural evolution of the vegetation is in addition considered by RVDM. This model analyses not only the potential recruitment in clear areas but also the vegetation growth and the succession or retrogression between different successional plant functional types (SPFTs). The recruitment occurrence depends on the plant reproductive period, the soil moisture and the temperature. The recruitment succeeds if the adequate environmental conditions are maintained during the time lapse required for germination. The vegetation growth in terms of biomass production and the successional evolution are estimated through the light use efficiency (LUE) and the soil moisture.

Finally, the competition between the riparian and the terrestrial vegetation is analyzed considering changes between successional patterns and transitional areas taking into account the SPFT most benefited through transpiration capabilities calculations.

The SPFT is the main state variable of RVDM. The proposed SPFTs are related to the wetland and woodland riparian succession lines, and to a terrestrial succession line considered the zonal vegetation that would occupy the riparian areas if the river disturbances disappear. The RVDM model requires as inputs the initial SPFTs map, soil and vegetation parameters, and other meteorological, morphological, hydrological and hydraulic maps and datasets. The model results consist of the simulated vegetation maps (SPFTs and biomass) that are considered as new inputs in the next model iteration.

This model integrates the knowledge provided by previous models as CASiMiR-vegetation (Benjankar *et al*., 2011; García-Arias *et al*., 2013), RibAV (García-Arias *et al*., 2014) and RIPFLOW (Francés *et al*., 2011), representing an upgrade in the way of understanding the riparian hydrobiodynamics.

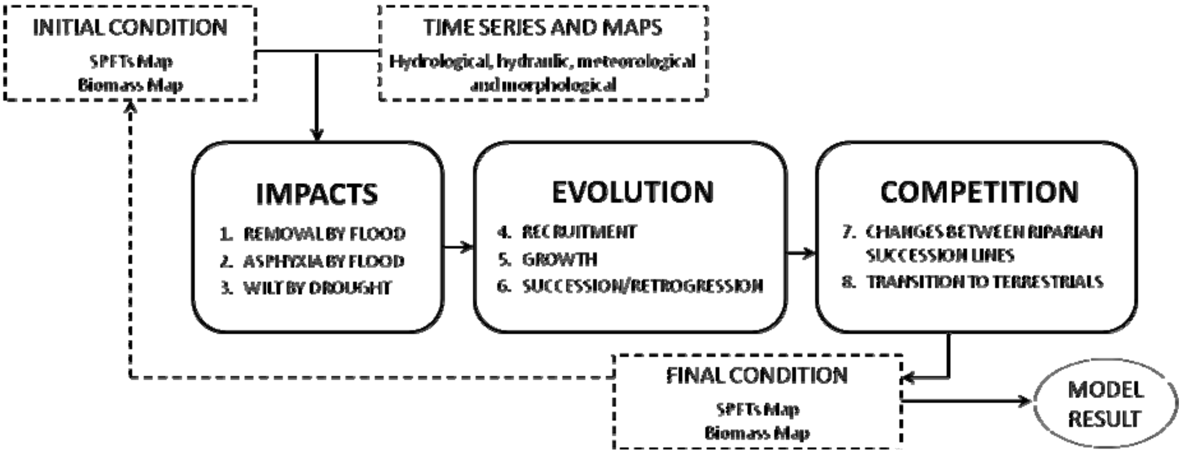

Figure 1: RVDM general schema

Implementation methodology

The model has been implemented in the Terde reach (Mijares River, Spain). This study site was selected because of its location on a Mediterranean semi-arid environment. Most of the inputs required for RVDM implementation were available from previous modelling approaches (García-Arias *et al*., 2013; García-Arias *et al*., 2014). Four SPFT maps (corresponding to July 1985, July 2000, August 2006 and December 2009) were created from aerial photographs and information obtained on past field surveys. Three succession lines were considered (reed, cotonwood and terrestrial) with different successive SPFTs: bare soil (BS, shared by the three succession lines), potential settlement conditions ($PS_{re}C$, $PS_{cw}C$, $PS_{tv}C$ respectively), pioneers (P_{re}, P_{cw}, P_{tv} respectively) and herbs (H_{re}, H_{cw}, H_{tv} respectively). The following woody SPFTs only occur for the cotonwood and terrestrial succession lines (W_{cw} and W_{tv} respectively). A transitional SPFT between these last two lines has been defined as the woody mixed vegetation SPFT (W_{mv}).

The model calibration considered the time period between 2000 and 2006. A temporal validation was analyzed for four periods between 1985 and 2000, between 1985 and 2006, between 1985 and 2009, and between 2000 and 2009. The 2009 distribution represents the riparian conditions after an important flood (300 m^3/s).

Hundred thousand Monte Carlo simulations (uniform distribution) were performed. Among them, the best set of parameters was selected to consider the model calibrated. The objective functions used as model performance criteria were the correctly classified instances (*CCI*) and the kappa coefficient of agreement (*k*), both recommended for species distribution modelling evaluation (Mouton *et al*., 2010). The simulation results were used additionally to analyze the model sensitivity to the different parameters.

Results

The model resulted to be sensitive to several parameters, especially those related to transpiration processes, resistance to floods scour and timing for succession or transition. The calibration of RVDM for the case study was considered very satisfactory (Figure 2). The results for the calibration objective functions (period 2000-2006: $CCI = 0.679$; $k = 0.601$) were comparable to the validation results (period 1985-2000: $CCI = 0.407$, $k = 0.313$; period 1985-2006: $CCI = 0.473$, $k = 0.349$; period 1985-2009: $CCI = 0.380$, $k = 0.237$; period 2000-2009: $CCI = 0.497$, $k = 0.382$). Even in those periods when objective function did not obtained remarkable results, the confussion matrices showed that mistakes were mainly of one SPFT distance. The vegetation dynamics was correctly represented, with vegetation destruction under stress conditions and vegetation growth during optimal periods.

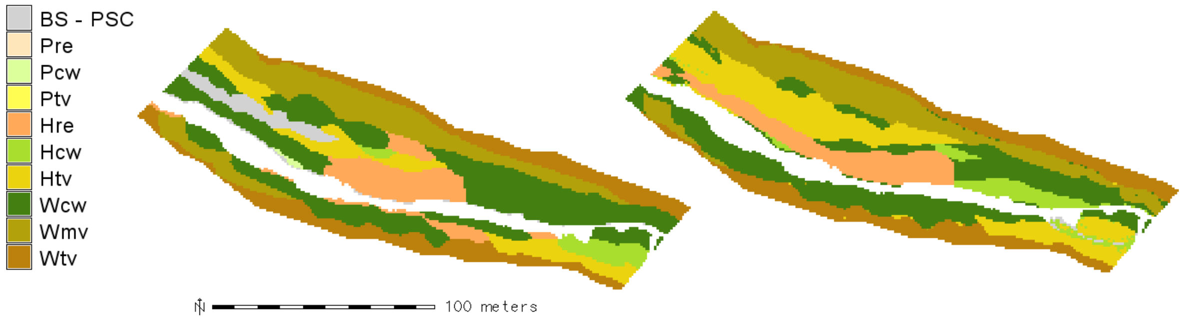

Figure 2. Observed SPFTs map on August 2006 (left) and predicted SPFTs map on August 2006 by RVDM (right) with the observed SPFTs map on July 2000 as initial condition.

Discussion

RVDM represents a major improvement on the vegetation dynamics modelling in riparian areas of semi-arid environments. This new tool is capable to provide daily vegetation maps that represent the dynamics of plant communities in the riverine zone. The calibration and validation of the model have obtained results comparable, or even better, to the most recent preexistent models (e.g. Benjankar *et al*., 2011; Francés *et al*., 2011; García-Arias *et al*., 2013; Ye *et al*., 2013; García-Arias *et al*., 2014). The SPFTs approach represents an innovation that combines the advantages of two classification approaches: functional types and phases of succession. The implementation of RVDM is easy and intuitive. The model allows a large amount of possible type of results, making possible to focus the attention to specific areas or to specific hydroecological variables. Finally, the river morphodynamics can be included in the model implementation (daily time step), which has been pointed out as a main lack of previous models (Camporeale *et al*., 2013). All these characteristics combined make RVDM a useful tool to provide a better understanding of the plant communities dynamics under the hydroecological processes that take place in riparian areas.

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