ASSESSING THE RELATIVE EFFECT OF VEGETATION AND SOILS ON STREAM FLOW RESPONSE IN RELATION TO VEGETATION RECOVERY

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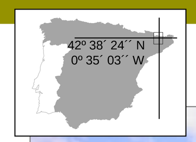
1. THE PROBLEM

Mediterranean mountains are largely affected by land abandonment and subsequent vegetation recovery, with significant implications on their hydrological response (García-Ruiz & Lana-Renault, 2011). The reduction in flows usually observed following reforestation has been mostly explained by changes in vegetation cover but fewer studies have considered the effect of changes in soil properties. This is a key issue, particularly for studying the long-term hydrological effects of vegetation recovery.

Our aim was to **investigated the relative effect of soils and vegetation on stream flow response related to forest establishment in previously cultivated areas**. For this we used an advanced modelling approach and hydrological data collected in two neighbouring small catchments (Spanish Pyrenees) with similar lithology and topography but different land cover.

2. THE CATCHMENTS

	Past agricultural catchment (Arnás)	Forested catchment (San Salvador)
Area (km^2)	2.84	0.92
Bedrock	flysch	flysch
Mean slope (mm^{-1})	0.38	0.52
Mean topographic index ln (a/tan b) (-)	6.3	5.6
Drainage density (km km^{-2})	0.12	0.11
Bare ground (%)	2	<1
Herbaceous (%)	7	<1
Shrubs (%) *G. scorpius, B. sempervirens*	71	1
Forest (%) *P. sylvestris*	20	98
Rainfall (mm)	926±182	935±171



DIFFERENCES IN STREAM FLOW

In the past agricultural catchment **peak flows were always greater, the response was faster, and the recession limbs were shorter**.

Differences in storm flow were characterized by marked seasonality: under dry conditions storm flows tended to be greater in the past agricultural catchment, whereas under wet conditions they tended to be similar or sometimes greater in the forested catchment (Lana-Renault *et al.*, 2011).

3. THE MODELLING APPROACH

THE MODEL (PyCatch)- The model was built using PCRaster Python scripting language. It includes a series of stores that are interconnected by water fluxes, representing the main hydrological processes (Lana-Renault & Karssenberg, 2013). These are described by standard modules:

- Evapotranspiration → Penman-Monteith
- Infiltration → Green-Ampt
- Soil storage → one layer; subsurface flow → Darcy's law
- The overland flow is routed through the local drain network
- The model also includes a maximum surface storage
- The shading effect of topography on incoming radiation is included

Time step: 1 hour, Grid cell: 10 x10 m

Vegetation	Soils
LAI [-]	Porosity [-]
Albedo [-]	Wilting Point [-]
Vegetation Height [m]	Field Capacity [-]
Interception storage per LAI [m] PRic	Limiting Point to transpiration [-]
Max.stomatal conductance [m s^{-1}] PRmm	Saturated conductivity [m d^{-1}] PRsc
	Saturated conductivity of the upper soil [m d^{-1}] PRks
	Regolith Thickness [m] PRrt

Table 1. Vegetation and soil parameters used in the model. In blue are the calibrated parameters.

THE STOCHASTIC CALIBRATION, PARTICLE FILTER

For a detailed explanation on stochastic calibration using the PCRaster Python framework see Karssenberg *et al*. (2010).

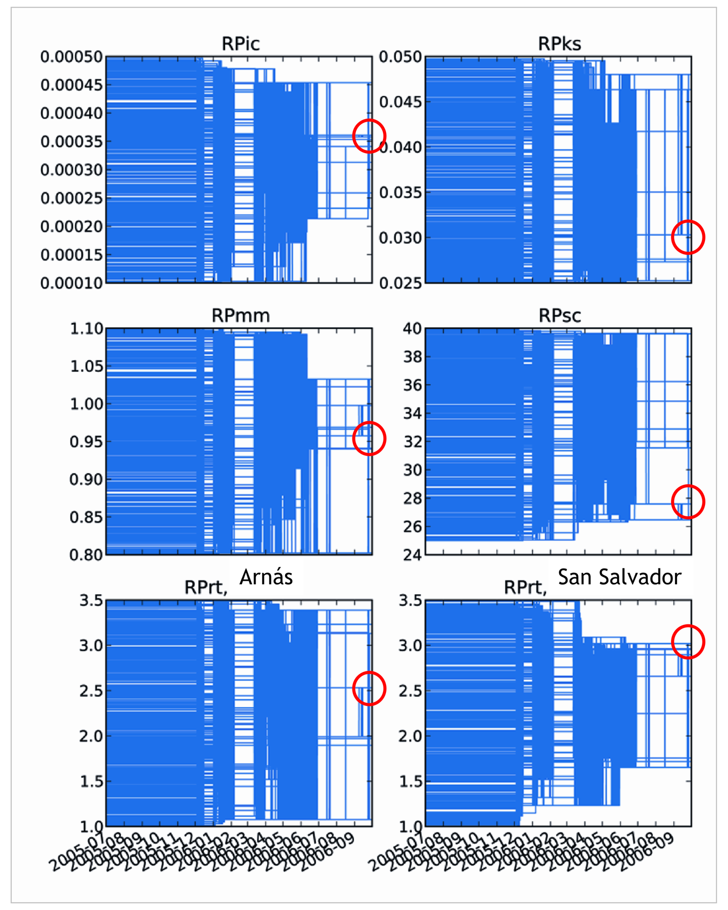


Fig 1. Results of the PF calibration. For each calibrated parameter, the value with more realizations is indicated in red.

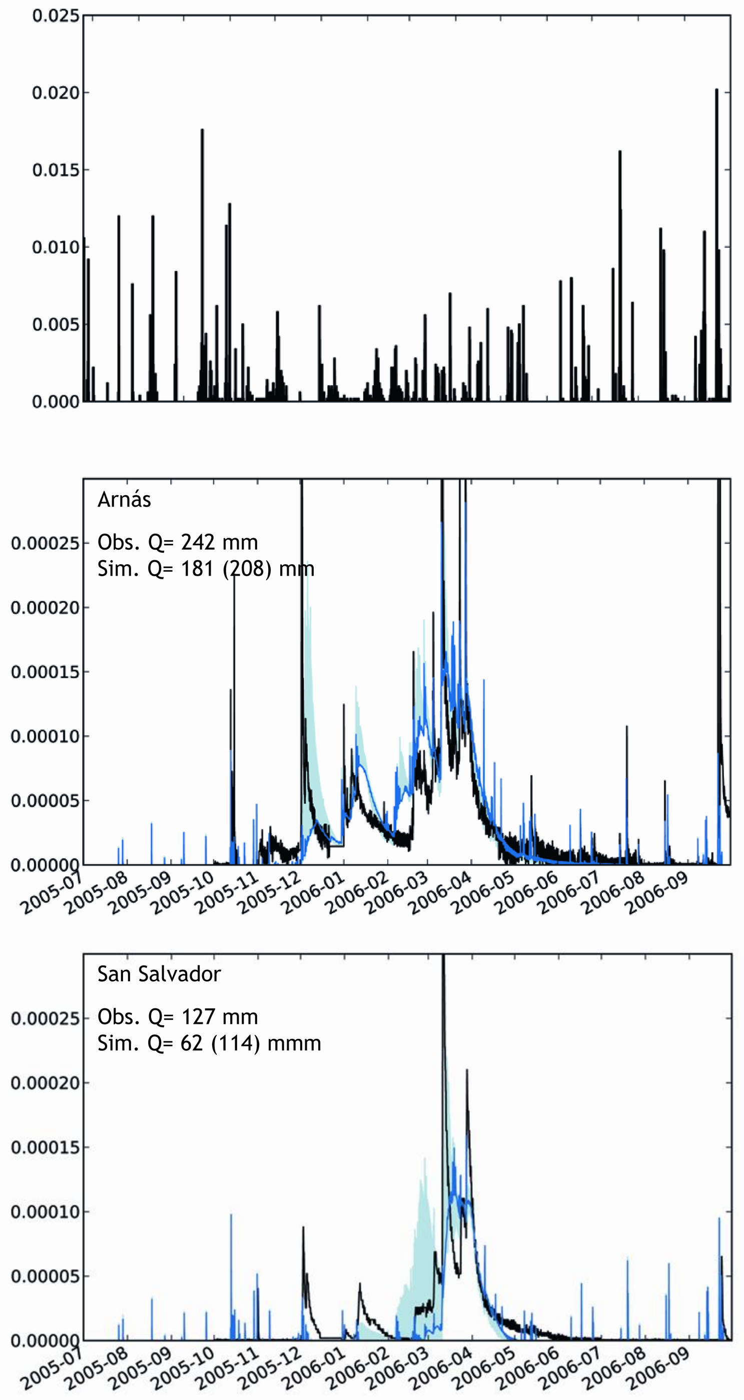


Fig 2. Hourly rainfall, and observed (black) and calibrated (blue) discharge Q (in m).

THE APPROACH- First, we calibrated the model parameters using discharge data from the two catchments. With these calibrated parameters and observed meteorological drivers, runoff at the outlet of each catchment was simulated. **Land cover was swapped** between catchments and new runoff simulations were performed, using the same meteorological drivers. The separate effect of vegetation and soils was determined by analyzing the differences between the first simulation (standard) and the "swapped" scenarios.

Two scenarios were investigated: i) only vegetation cover was swapped, and ii) both vegetation and soils were swapped.

4. RESULTS

Arnas catchment

San Salvador catchment

SCENARIO 1
Only vegetation cover was swapped

SCENARIO 2
Both vegetation and soils were swapped

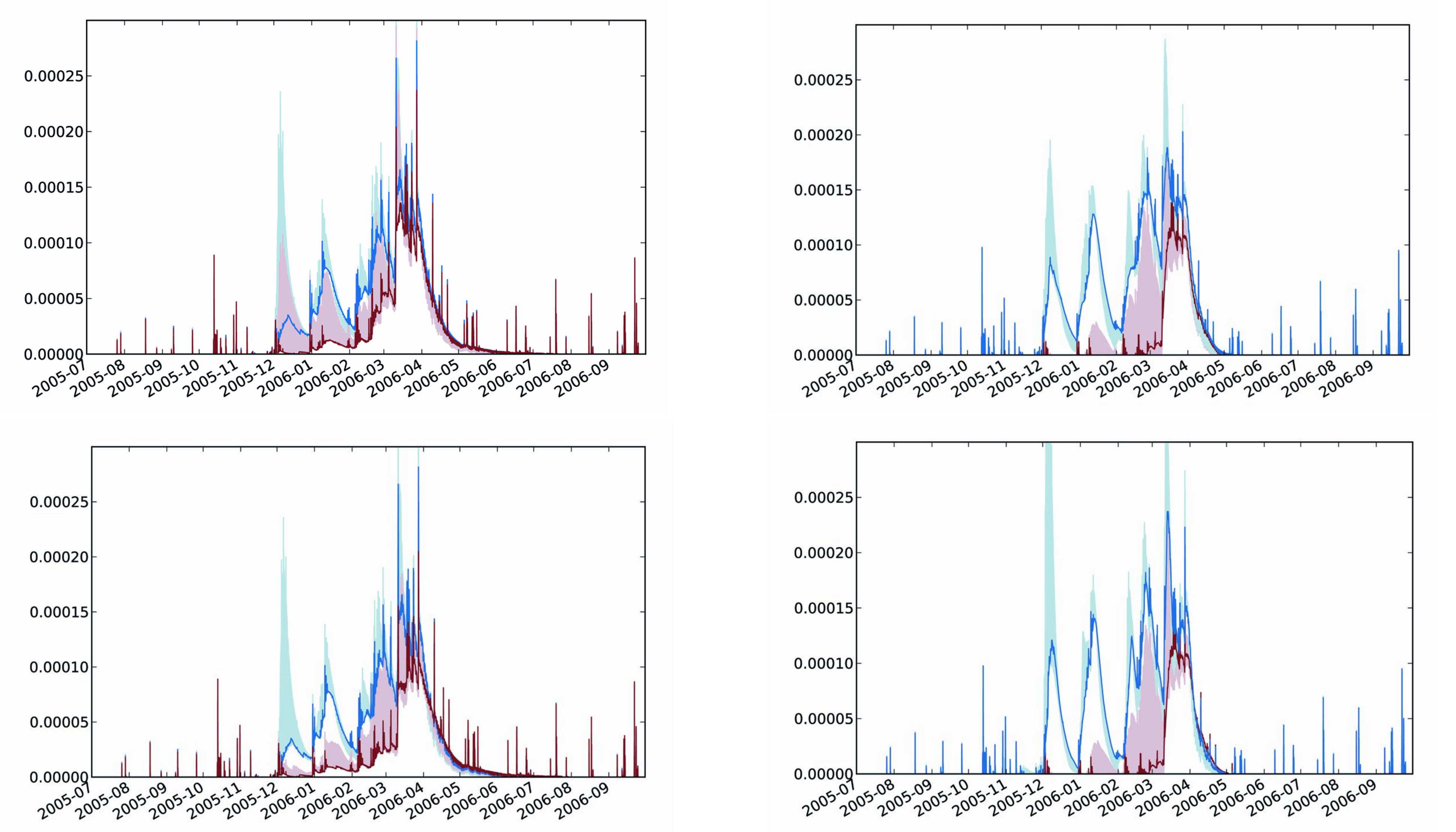


Fig 3. Hydrographs for the different scenarios. Blue: schrubs; Red: forest. Discharge is in m.

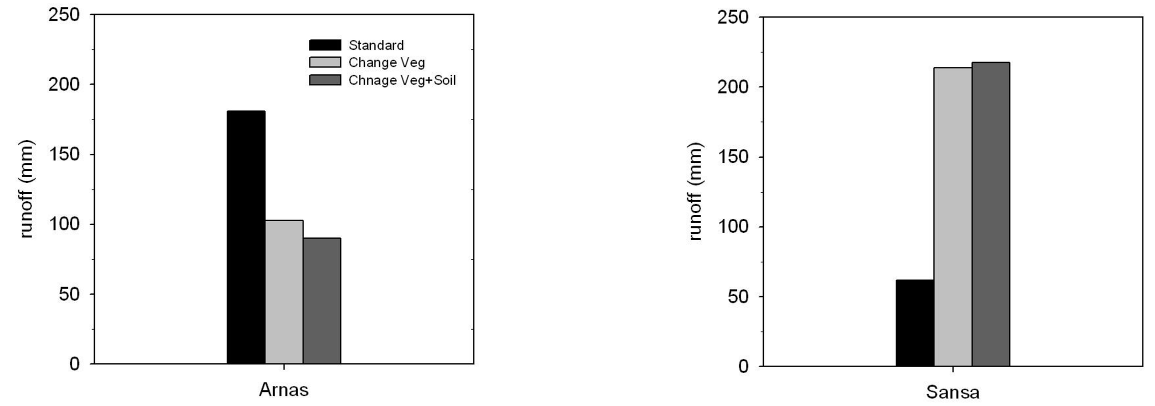


Fig 4. Annual water yield for the different scenarios.

5. CONCLUSIONS

1. Largest differences in discharge between forest and shrubs occurred during the wetting-up period (dec to feb); during the wet period (mar to apr) they were less.
2. These differences were mainly due to changes in vegetation (interception and evapotranspiration). Adding changes in soils mostly affected peak flows and recessions (runoff generation processes) but little the discharge (soil water storage).
3. It seems the effect is larger in the small catchment.

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