The relevance of natural engineering and riparian afforestation within a context of water scarcity and drought risk: an Iberian perspective

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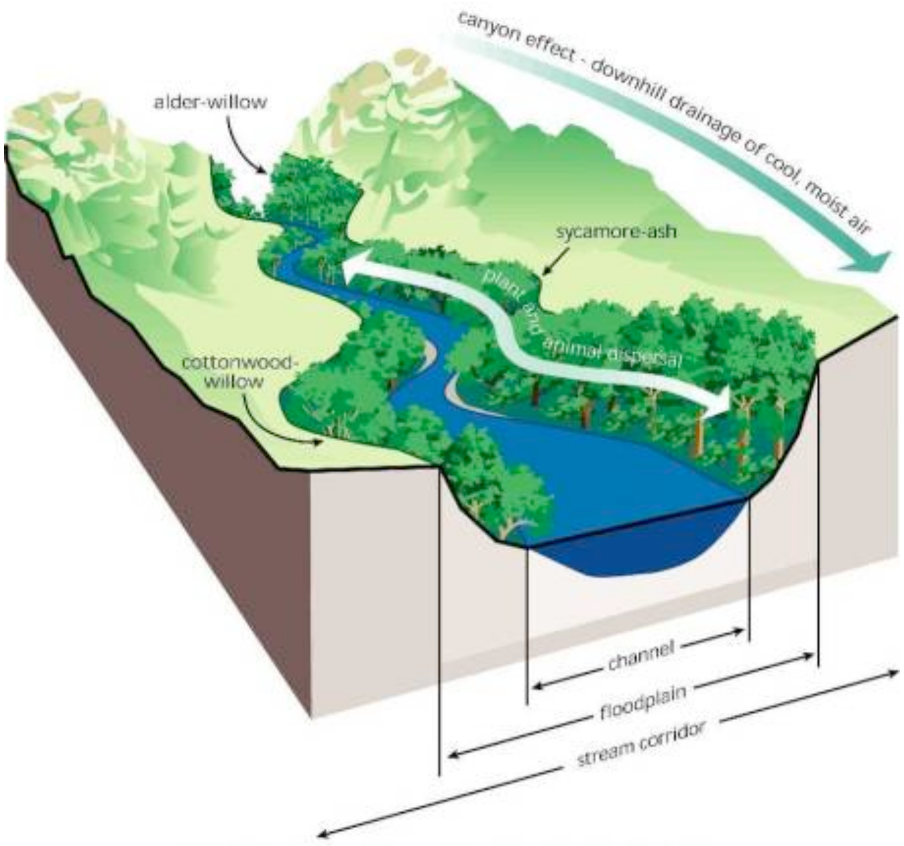
Natural Water Retention Measures (NWRM)

"measures that aim to safeguard and enhance the water storage potential of landscape, soil, and aquifers, by restoring ecosystems, natural features and characteristics of water courses and using natural processes. They support Green Infrastructure by contributing to integrated goals dealing with nature and biodiversity conservation and restoration, landscaping, etc"

River systems

- Fundamental and dynamic
  - Catchment land use
    - Influences river systems across many scales
  - Water
    - transport, storage and quality
  - Transport
    - Sediment, nutrient and energy
  - Ecosystem & Biodiversity

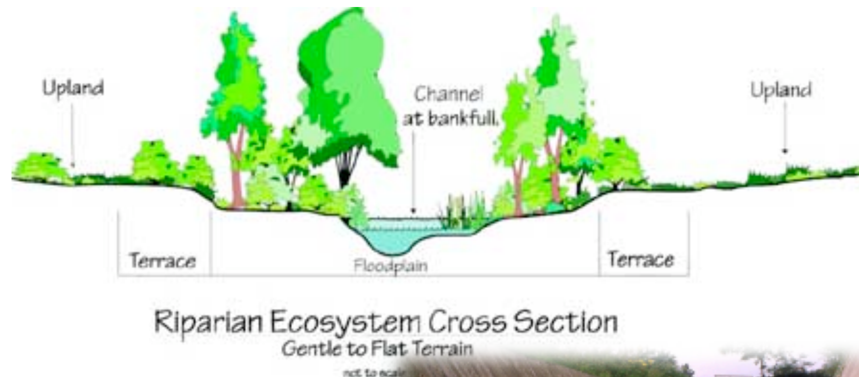
- 4 dynamic dimensions
  - Longitudinal
    - zonation
  - Lateral
    - Floodplain interactions
  - Vertical
    - Groundwater recharge
  - Time
    - Flow patterns – influences many processes



NWRM studies on this scale need a transdiciplinary, integrated approach to restore system function. Many complex interrelated processes to consider and quantify:

The Riparian zone – an Ecotone

- Often degraded and highly restricted in area by human activity
- Moist to saturated soils, water-loving and woody plant species and associated ecosystems
    - Ecosystem complexity & resilience
- Highly productive, dynamic , transitional system
- Seasonal flooding
    - Contain flood resistant plant and tree species
- Fundamental biological, physical and chemical processes linked to natural flood patterns
    - Buffering systems: temperature, flow, pollutants and sediment, nutrient availability
- Provide or contribute to provision of fundamental ecosystems services
    - Groundwater recharge
    - Water quality

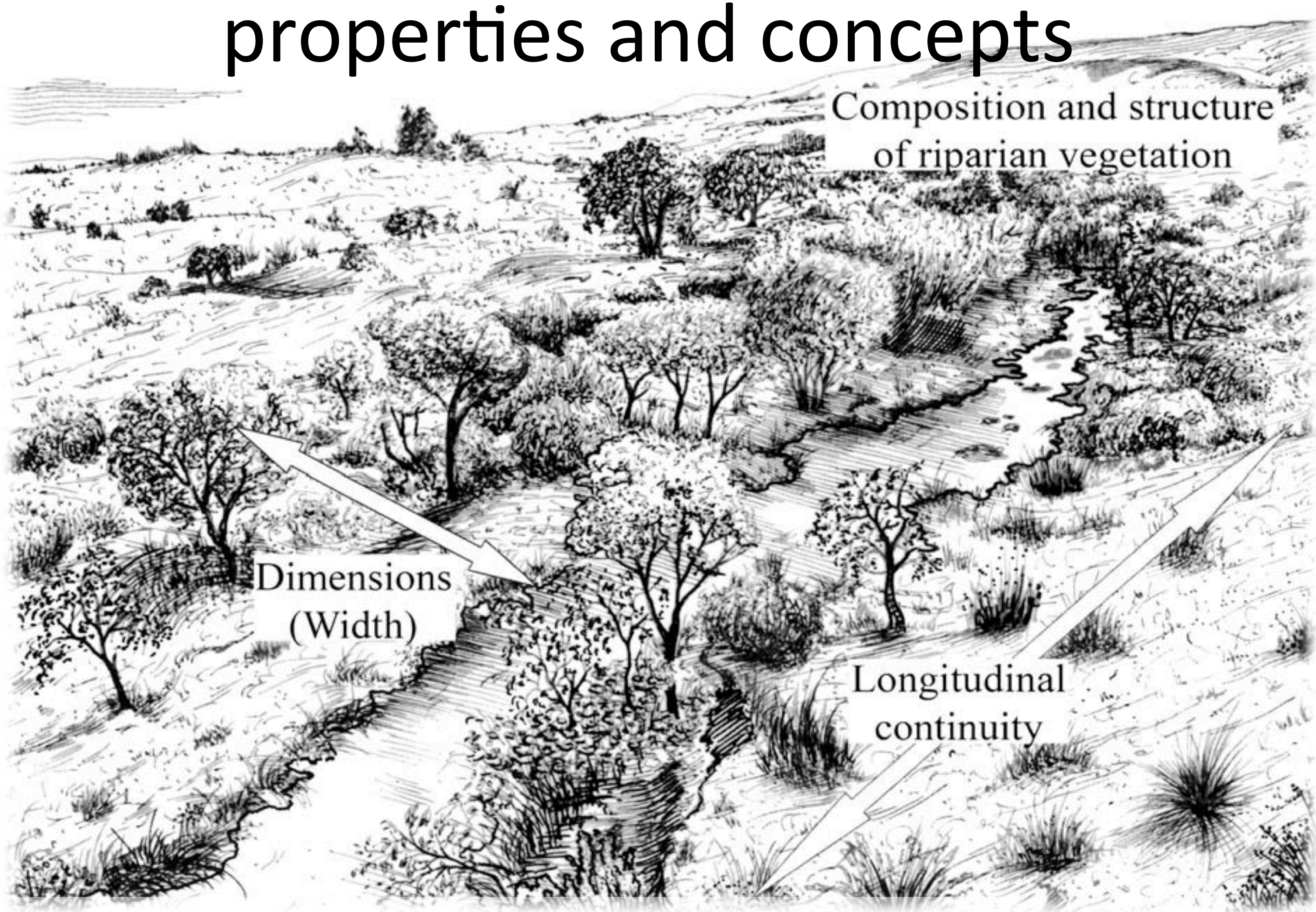


Riparian galleries and NWRM

- **Rainfall Interception by riparian canopy**
  - Reduces direct runoff; delays onset of peak flows.
  - Slower, more indirect route to terrestrial phase of the local water cycle
  - Larger and more complex the riparian gallery >> more efficient interception
- **Riparian Soil condition**
  - Riparian plant root growth and decomposition reduce overland flow (mulch)
  - Increase riparian soil moisture infiltration capacity
- **Riparian Groundwater recharge**
  - Tree roots, woody debris and coarse substrates in the riparian area increase habitat heterogeneity and improve retention
  - Riparian plant filters retain pollutants and prevent groundwater contamination
- **Transpiration**
  - from the soil via uptake by riparian plants to the atmosphere
- **River bank water storage**
  - reduces flood intensity and sustaining stream flow decreases.
  - Slope, rugosity, complexity and state of the river bank are important factors in water storage capacity and retention.

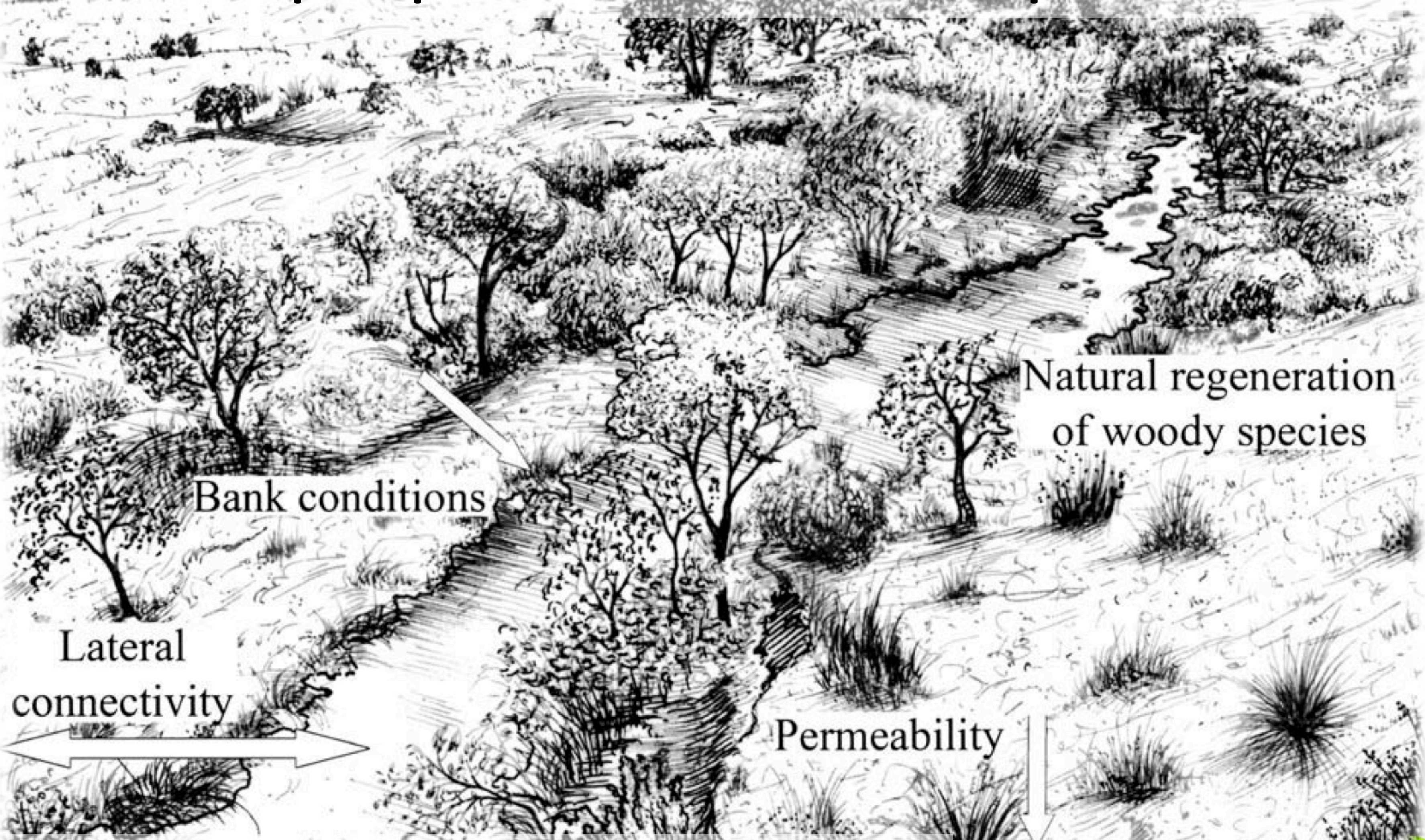
Greater system complexity and diversity = a wider suite of NWRM = greater system resilience

Riparian galleries and NWRM: properties and concepts



González del Tánago & García de Jalón: Limnética (2006)

Riparian galleries and NWRM: properties and concepts



González del Tánago & García de Jalón: Limnética (2006)

Future climate scenarios for Portugal

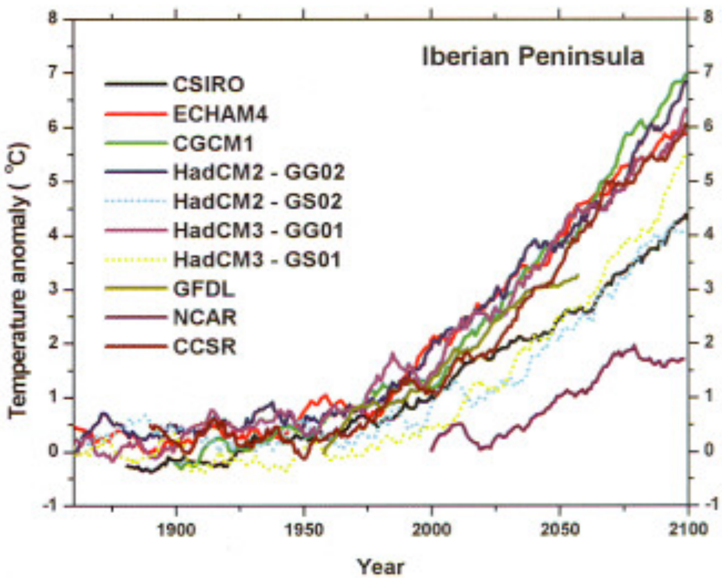


Fig. 2 – Predicted evolution of the mean temperature in the Iberian Peninsula as given by different GCM simulations.

- Global Climate Model simulations
- Clear upward trend
- Significant warming in 21st century
  - Temperature increase of 4-7ºC by 2100
  - Tipping point – 2200?

Climate change in Portugal: scenarios, impacts and adaptation measures (SIAM).
Executive summary and conclusions (2001)

Theor Appl Climatol (2012) 108:217–234
DOI 10.1007/s00704-011-0528-3

ORIGINAL PAPER

Climate change scenarios for precipitation extremes in Portugal

Ana C. Costa · João A. Santos · Joaquim G. Pinto

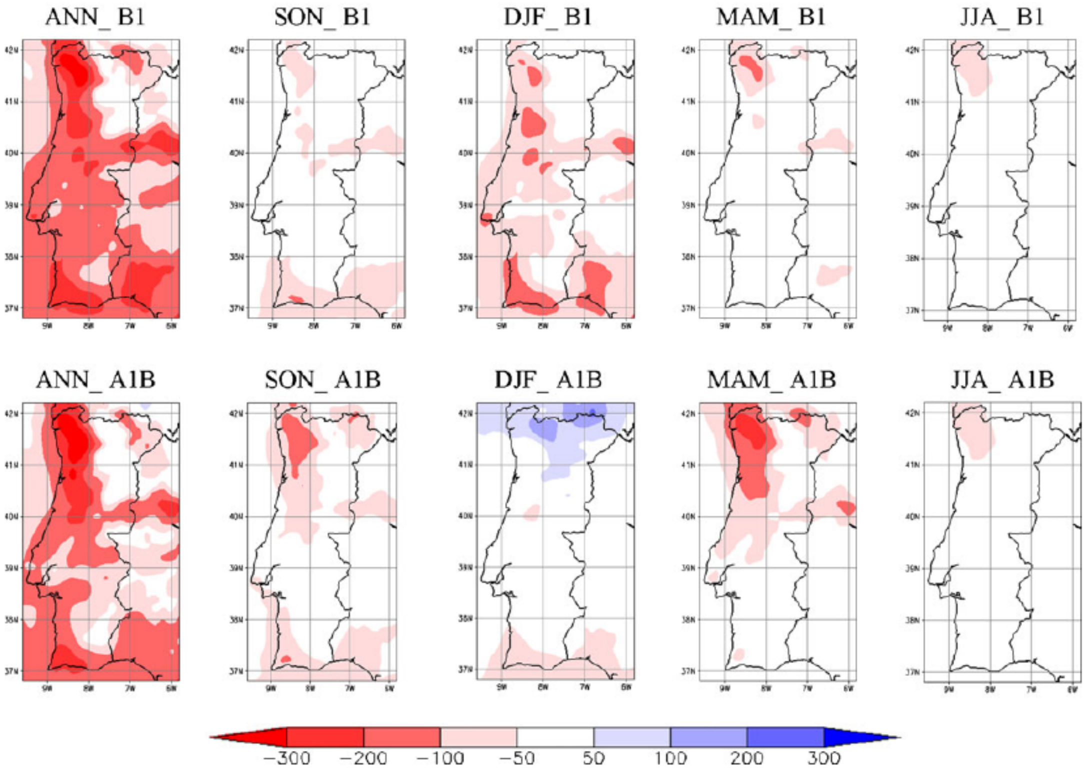
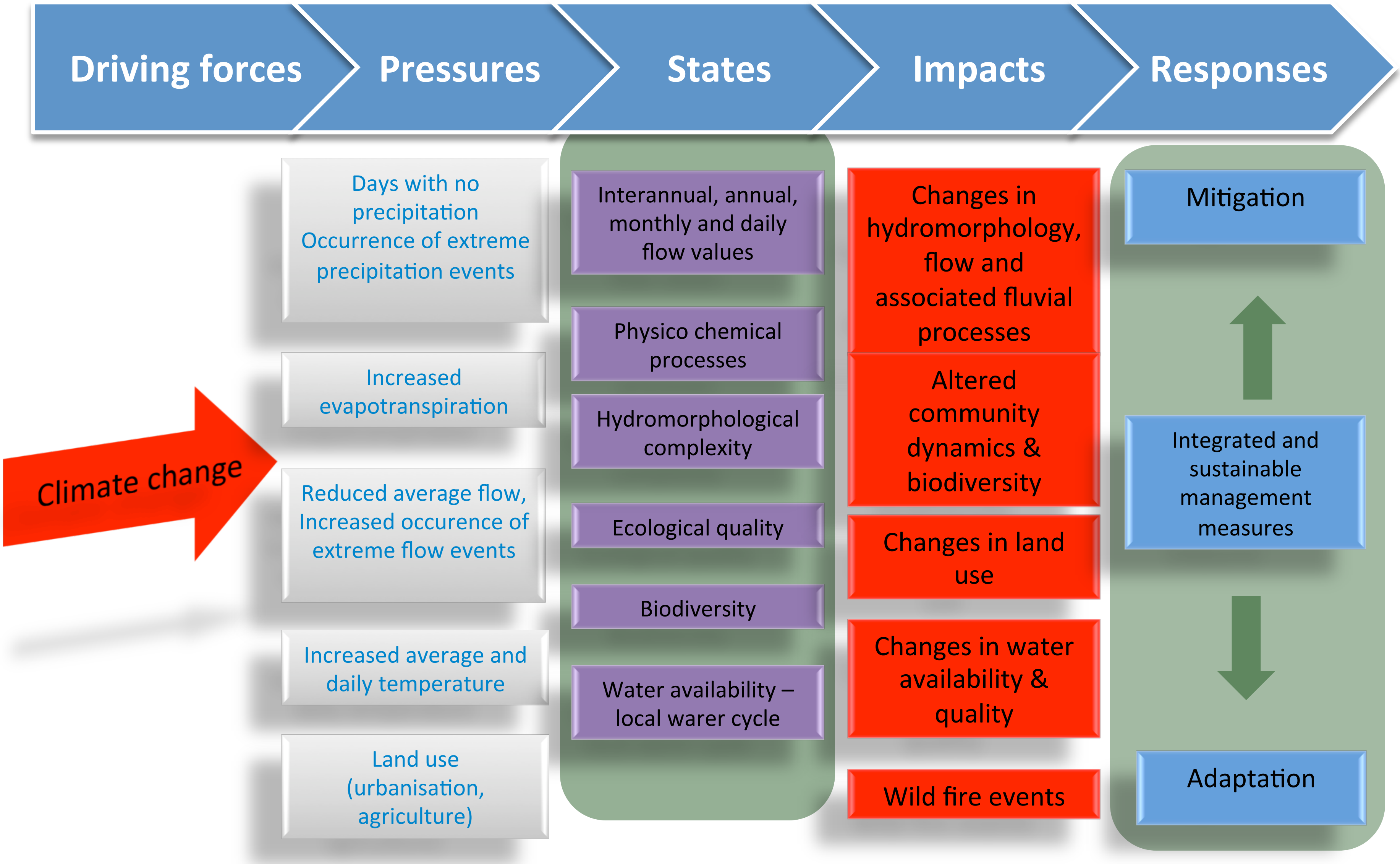


Fig. 2 Mean precipitation totals (two-member ensemble means) over continental Portugal (in millimetres) as simulated for recent–past climate conditions: **a** annual, **b** autumn, **c** winter, **d** spring and **e** summer amounts. The **f–j** maps show the respective differences between future climate conditions under the B1 SRES scenario (2071–2100) relative to recent–past climate conditions (1961–2000). The **k–o** maps are as **f–j** but under the A1B scenario

MEDITERRANEAN REGION:
Reduced water availability, increased drought, increase in extreme events ,severe biodiversity loss, increase in forest fires, reduced suitable cropping areas, increased summer energy demand, reduced hydropower,



Adapted from Ferreira & Brito 2010 "Ecosistemas e Biodiversidade"
Estratégia Nacional de Adaptação aos Impactos das Alterações Climáticas mediados pela Água

Natural engineering and Riparian Afforestation

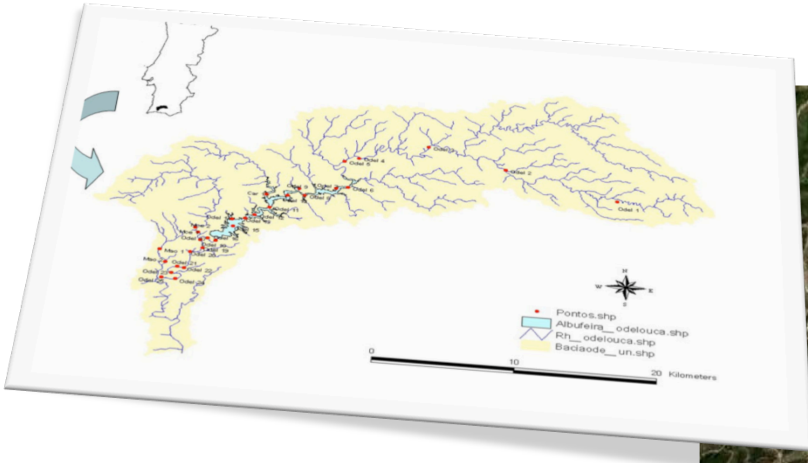
- Mitigation measures at local spatial scale to restore facets of river function
- Iberian Peninsula:
  - Implemented to promote or preserve biodiversity
  - No actions apparently directly aimed at NWRM *per se*
  - NWRM are an indirect a consequence of these actions but have not been quantified
  - Need to include quantifiable NWRM in programmes

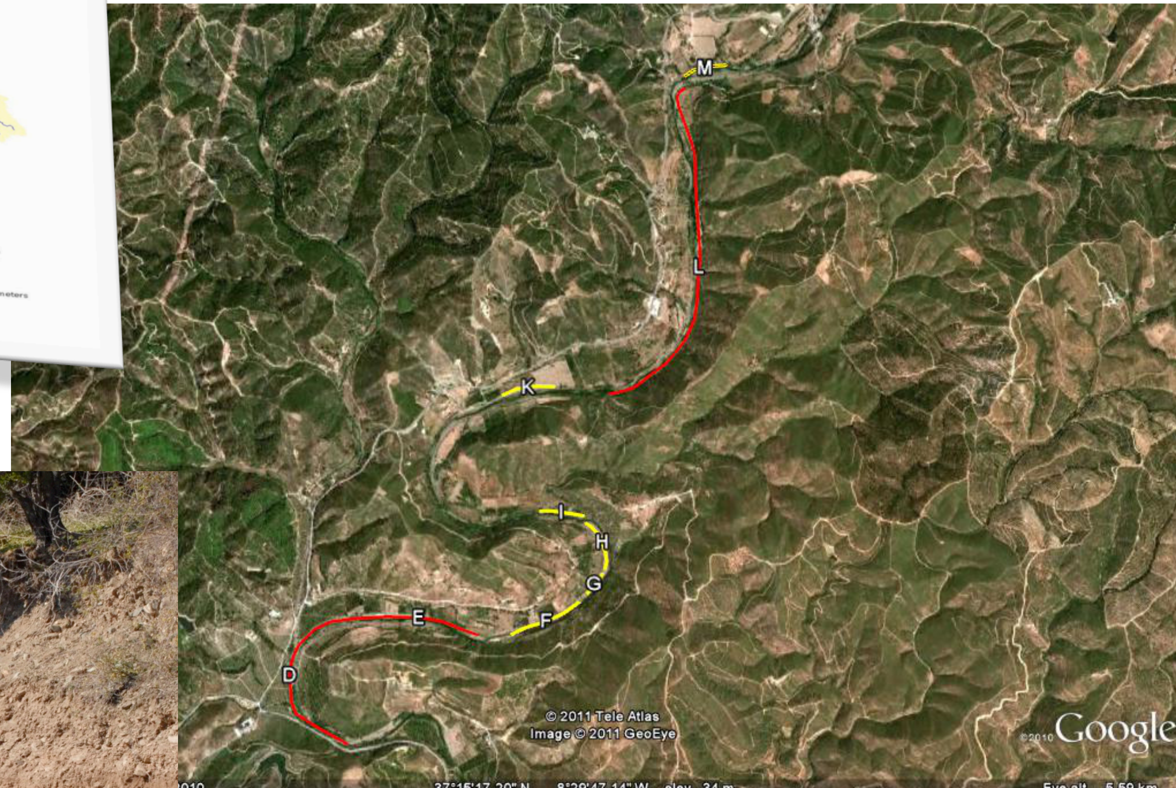
measures that aim to ***safeguard and enhance the water storage potential of landscape, soil, and aquifers, by restoring ecosystems, natural features and characteristics of water courses and using natural processes***

Natural engineering on the River Odelouca, Algarve Portugal

- Increase habitat heterogeneity and quality
  - Biodiversity: 2 highly threatened endemic fish species
- 1º bank side and 2º channel intervention
  - reintroduce natural profiles and vegetation
  - Eradication of invasive plant species
  - Propagation and planting of native species
- Finance
  - EU funded projects and contracted monitoring programmes

Natural engineering and Monitoring, Odelouca River, Algarve Portugal

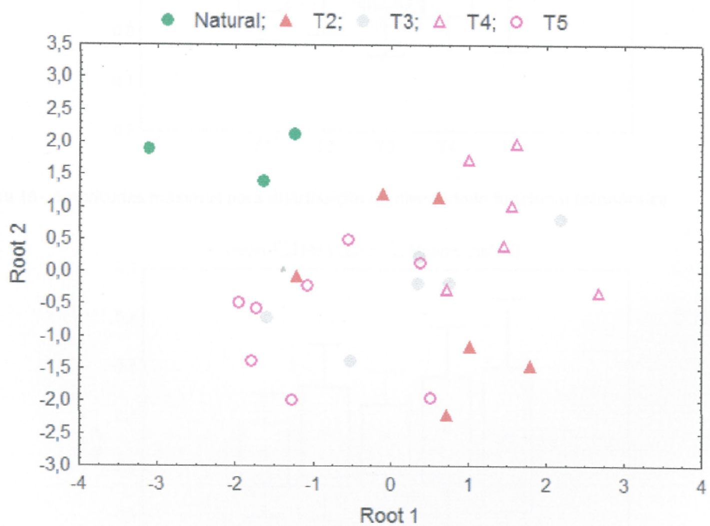




Work started Nov 2011 – Feb 2012

Bank consolidation, planting and weed control

Natural engineering of river banks: floristic studies

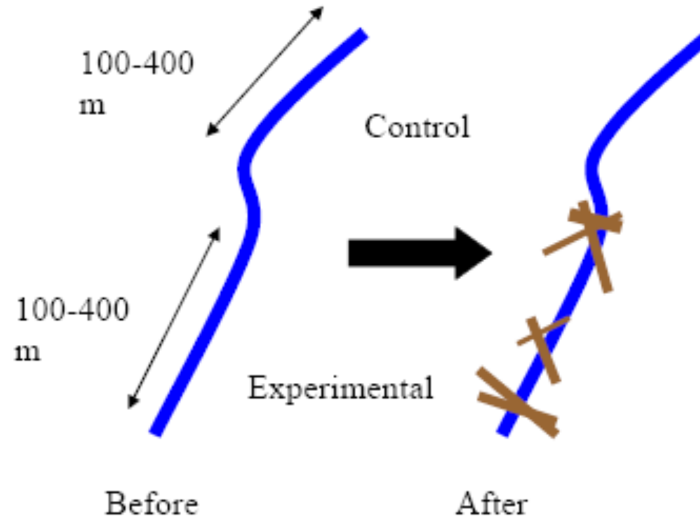


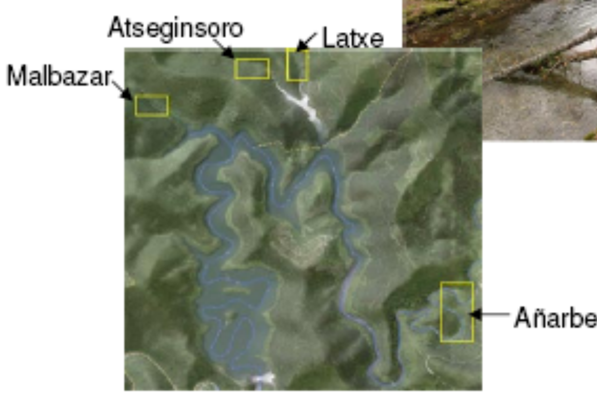
Natural engineering using large woody debris, Basque Country

- To enhance river habitat quality and complexity
- Promote biodiversity

Restoration of dead wood loading

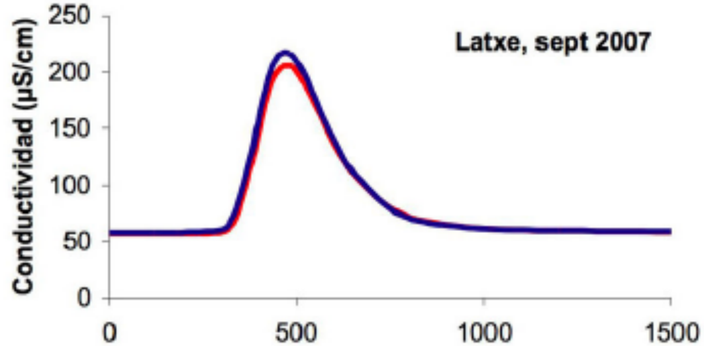
An experimental assessment of the importance of large wood in streams

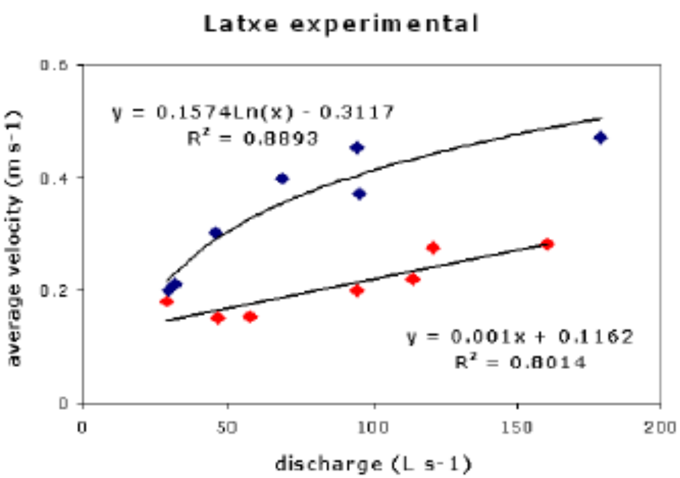




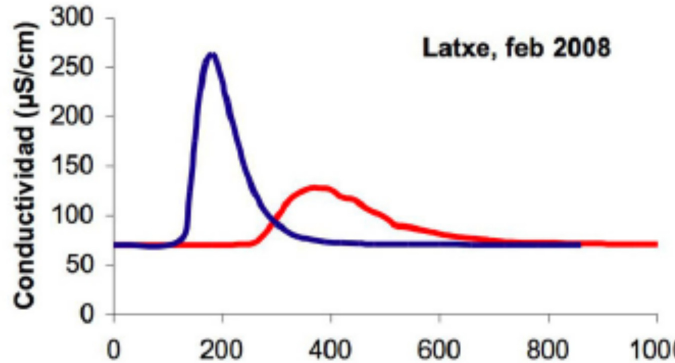
	Atseginsoro	Malbazar	Latxe	Añarbe
Width (m)	3	4	5	15
Length (m)	100	100	100	400
# logs	81	74	53	72
LWD (m^3/ha)	216	239	144	33

Sediment retention





experimental
control



A question of scale

NWRM cut across a range of spatial scales

- Natural engineering at local scale to land use and processes at catchment scale

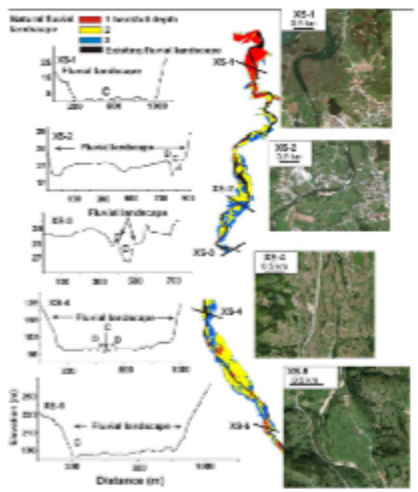
1. Need to prioritize river reaches for NWRM restoration measures within a whole river network (i.e. catchment) for greater environmental return
2. The need to evaluate riparian forest status for all river reaches within a river network
3. Typologically relevant
4. The need to understand how riparian conservation status or integrity affects other processes within the river network
    1. How much degradation of riparian forest is enough to start bank erosion problems? Or affect aspects of NWRM?
5. Application of multiple criteria
    - morphological dynamics should play a major role in such studies
        - Underpin most physical and biological processes
        - Fundamental for building multiscale resilience into NWRM

IH cantabria

River network vision for restoration...

Thus, it is important to prioritise river reaches for restoration within a whole river network (i.e. catchment), so that a larger environmental return could be obtained.

This should be based on multi-criteria, in which morphological dynamics should play a major role, as they form the physical habitat in which riverine fauna and flora thrive.



Hydrol. Earth Syst. Sci., 15, 2995–3015, 2011
www.hydrol-earth-syst-sci.net/15/2995/2011/
doi:10.5194/hess-15-2995-2011

Hydrology and Earth System Sciences

Creating a catchment scale perspective for river restoration

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We have done some advances in this regard, by using synthetic river networks in order to account for river network structure (tributary confluences, tributary effects), sediment budgets, valley forms, valley side interactions and so on..

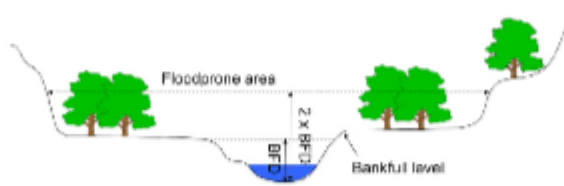
1. Delineation of riparian zones - Methods

We derived a synthetic river network for the northern fourth of the Iberian Peninsula (Ebro river and Cantabric catchments) from a 20m DEM. This river network consisted on more than 660000 river reaches from 100 to 500 m length.

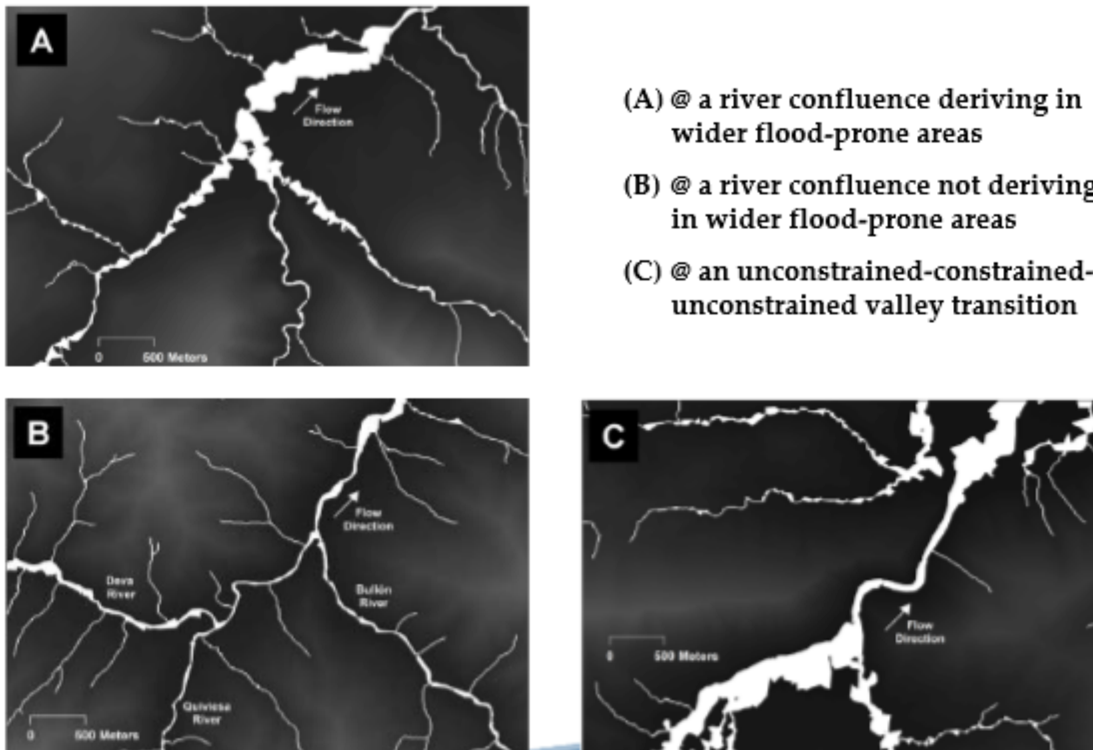
We used a regional regression to model Bankfull Depth (BFD) to all river reaches within the river network.

$$BFD = 0.63 * A^{0.1731} * P^{0.1516}$$

where A= catchment area (km^2) and P= mean annual precipitation (mm)



1. Delineation of riparian zones -Results



(A) @ a river confluence deriving in wider flood-prone areas

(B) @ a river confluence not deriving in wider flood-prone areas

(C) @ an unconstrained-constrained-unconstrained valley transition

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THANK YOU