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REstoring rivers FOR effective catchment Management

SEVENTH FRAMEWORK PROGRAMME

Stakeholder Workshop: ***Linking E-flows to Sediment Dynamics***

Including Resilience & Hysteresis in the design and implementation of E-flows

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*A **discussion presentation** aimed at addressing possible **alternative approaches for e-flows** assessment and identification of best strategies for fluvial restoration in the context of Mediterranean regions*

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1. Ecological flows

- **E-flows** are considered as ***an hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies*** (Guidance Document Nº 31):
  - ***non deterioration*** of the existing status
  - achievement of ***good ecological status*** in natural surface water body
  - compliance with standards and objectives for ***protected areas***

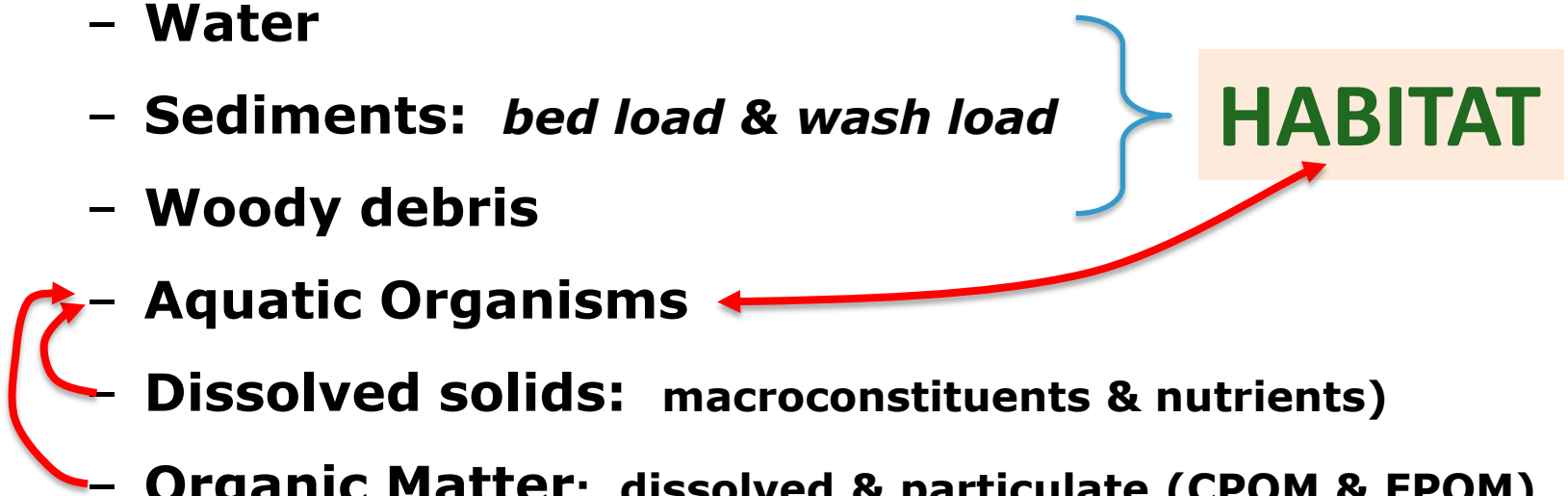
- **E-flows: *Residual flows*** *after* ***Human Needs have been satisfied***

- Concept behind: **Ecosystem Resilience**

1. Ecological flows vs. Natural flows

- **E-flows** Should be only water?

- **Natural Fluvial Fluxes:**
  - **Water**
  - **Sediments:** ***bed load & wash load***
  - **Woody debris**
  - **Aquatic Organisms**
  - **Dissolved solids:** **macroconstituents & nutrients)**
  - **Organic Matter: dissolved & particulate (CPOM & FPOM)**



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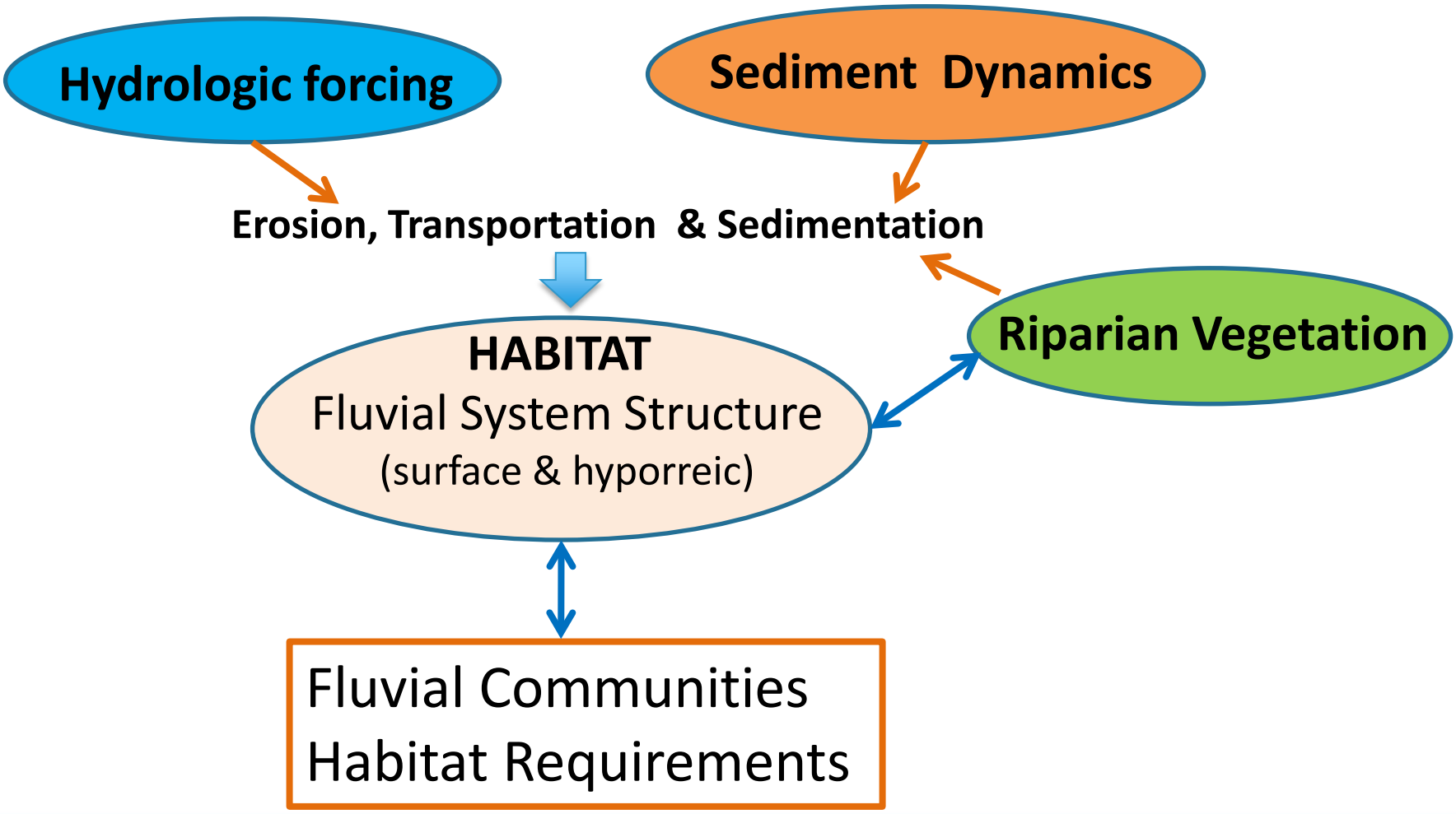
1. Hydromorphological controls of fluvial communities



2. E-Flows considering Resilience

Ecological **Resilience** is the property of an ecological system that determines the persistence of relationships within the system (Holling, 1973)

Setting E-flows assumes that ***changes on Natural Flow is partially compensated by the Resilience*** of the ecosystem that is able to maintain its integrity.

A **fish population** has an ability **to overcome changes in habitat availability**:

- When a stress event reaches a threshold, it may take longer for the population to recover.
- There are extreme stress events that may eliminate the population, however if river reach is connected with other population, they may recolonize it

Fluvial Resilience has two components:

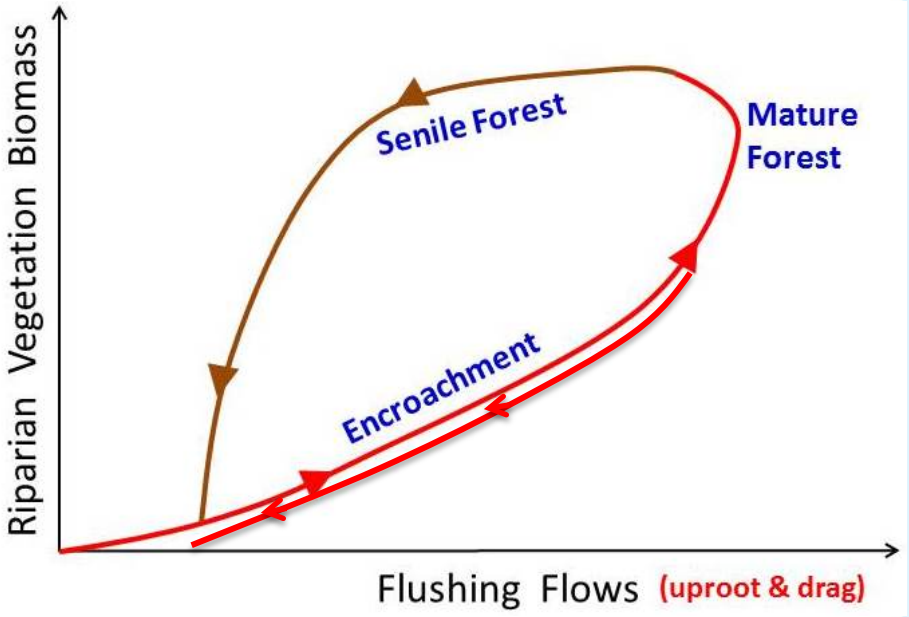
1. **Functional**: depends ***of flow events*** traits
2. **Structural**: depending on ***spatial dimension & habitat fragmentation***

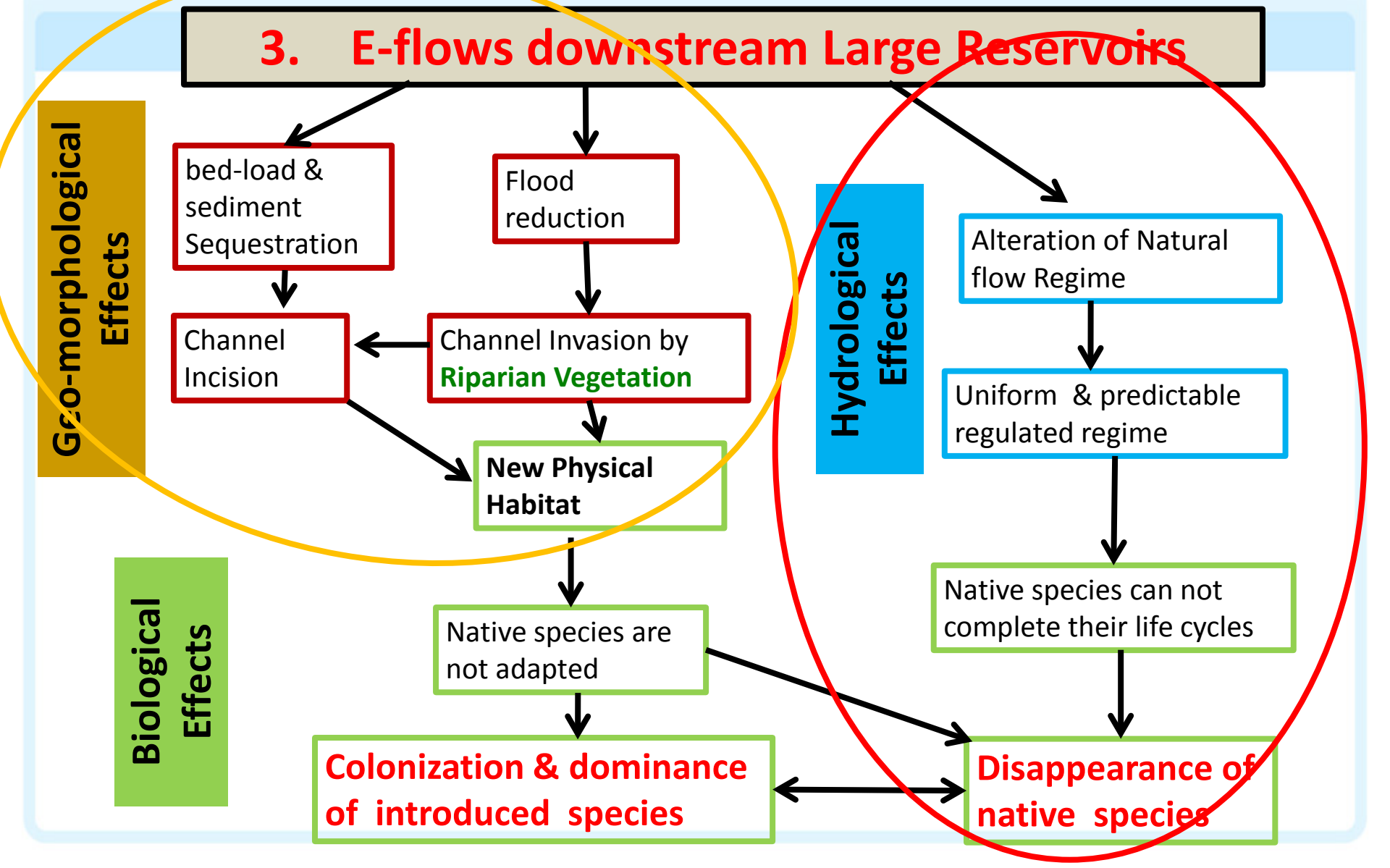
Setting **E-flows methods** should include an **estimation of the E-flow increase** due to river fragmentation

2. E-Flows considering Hysteresis

Hysteresis is the time-based dependence of a system's output on present and past inputs. Represents an asymmetrical process.

- Regulated flows often promote **vegetation encroachment** in river channel
- Once **mature forest** stands are stablished, it is anchored by sediment accumulation and development of a dense root system.
- Setting E-flows is often not enough.
- Alternatives?




3. E-flows downstream Large Reservoirs
Geo-morphological Effects
bed-load & sediment Sequestration
Flood reduction
Channel Incision
Channel Invasion by Riparian Vegetation
New Physical Habitat
Hydrological Effects
Alteration of Natural flow Regime
Uniform & predictable regulated regime
Native species can not complete their life cycles
Biological Effects
Native species are not adapted
Colonization & dominance of introduced species
Disappearance of native species

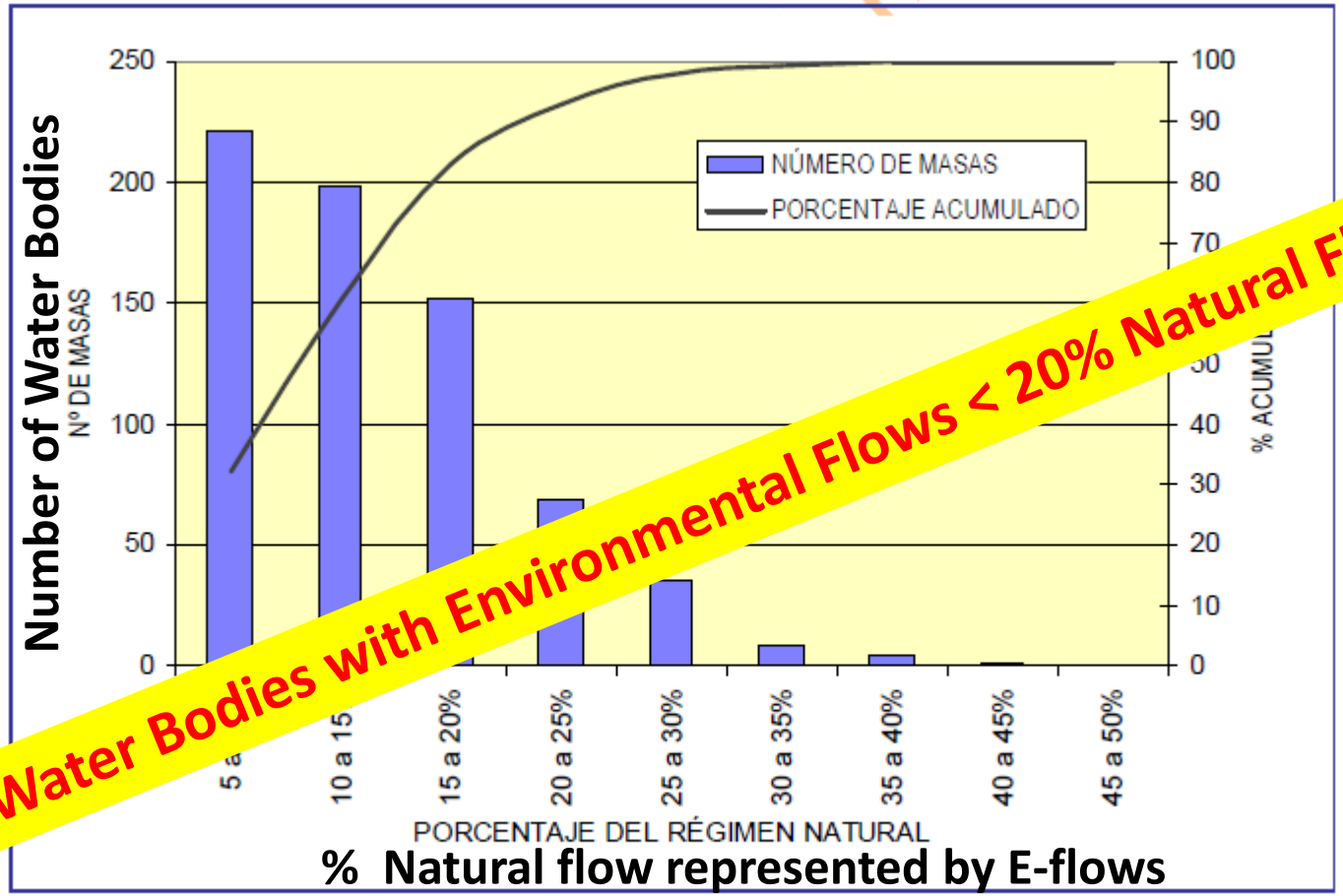
3. effectiveness of designed environmental flows

Are Environmental Flows a 'Panacea'?

- Our knowledge is very simple and purely **qualitative.**
- **Prediction** capacity is low
- **Data** from implemented Environmental Flows Case Studies are very **scarce**

We **must be humble** about our Knowledge on ecological responses to Flow Alterations, … but **not stupid.**

3. Reality: River Duero RBMP



85 % Water Bodies with Environmental Flows < 20% Natural Flows

Figura 107. Histograma que representa los porcentajes de la aportación natural total fijados como caudales ecológicos en relación al número de masas de agua superficial.

3. Ecological Limits of Hydrologic Alteration

- How much water can we extract from the river flow, without degrading their natural communities?
  - 5% of the natural flow? **Qenv. = 95%**
  - 10%? or 25% ? **Qenv. = 90%** or **75%**
  - 50%? **I have great doubts**
  - 80? or 90? **NO WAYS!**

Bonsai River Concept

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3.a Effects of FRAGMENTATION on river basin networks

- Decreases capacity for self-recovery
- Population fragmentation
- Increased susceptibility and fragility
- Potentiation of impacts
- Elimination of species in the basin

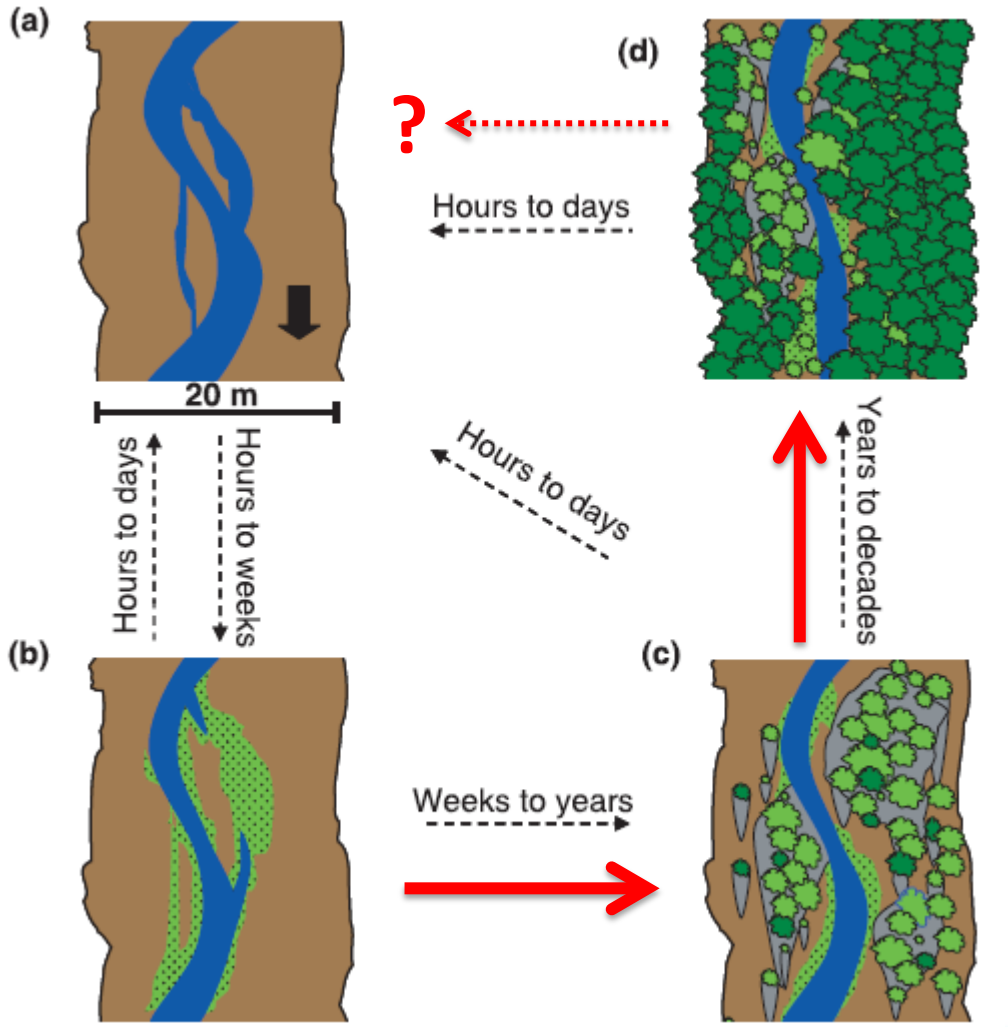
3b. Effects of Sediments Retention

- the reservoirs built act as huge **sediment traps**
- Rivers below dams have lost all most their sediments
- **unbalance** between water and sediments produces channel incision.

3b. Effects of Sediments Retention

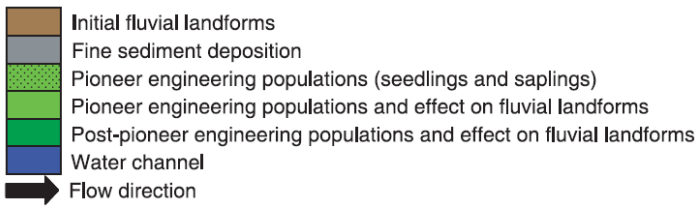
- After dam is closed, released 'hungry waters' drag sediments from bottom in a size selective process.
- Stages of **Substrate Evolution**:
  - Along years there is a '**wave**' of sediment deficit that moves downstream along the river, changing its substrate traits: caliber increase and armoring
  - Later, substrate comes to an equilibrium between the regulated flow regime and sediment input by tributaries.
  - The effects on the biota vary in space and time according to these stages of substrate change
- Setting E-flows (water & sediments) must take into account this substrate evolution for each reach of the river

3c. Effects of Riparian Vegetation Hysteresis



b &c: niche construction sequence induced by pioneer plants (encroachment)

d: succession into a mature riparian forest

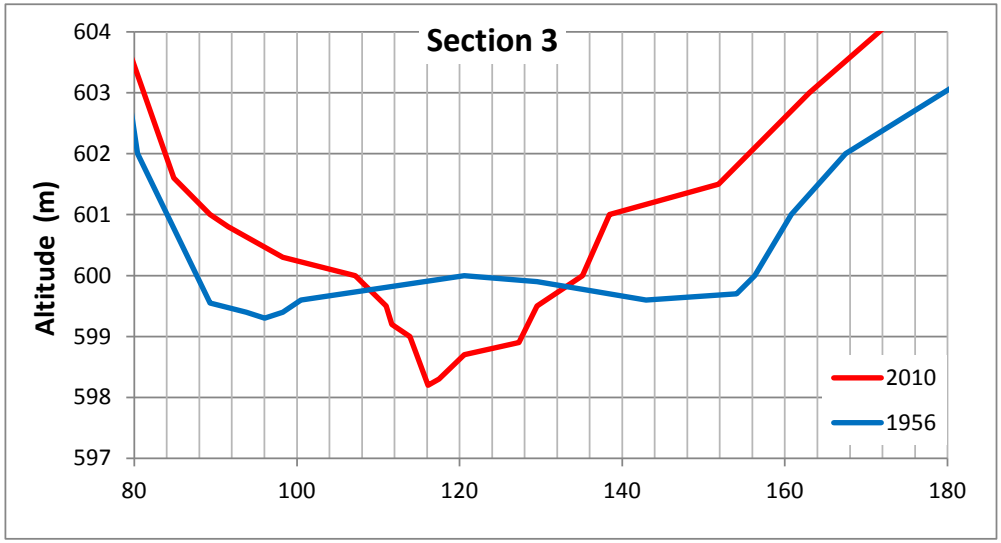


Corenblit *et al*. 2009

3d. Effects of changes on channel morphology

- Below dams river channels become **narrower and deeper** due to gravel bars colonization by riparian vegetation and incision process

- Habitat availability changes with channel morphology, and **native species** habitat requirements are often not fulfill



- Setting **E-flows** must take into account this lost of habitat traits due to geomorpholgical changes.

Río Manzanares (El Pardo)

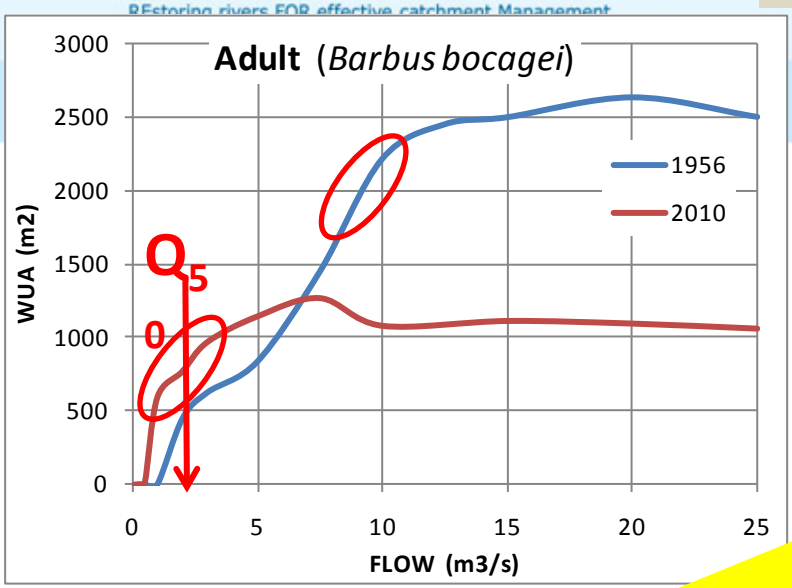
Effects of changes on channel morphology

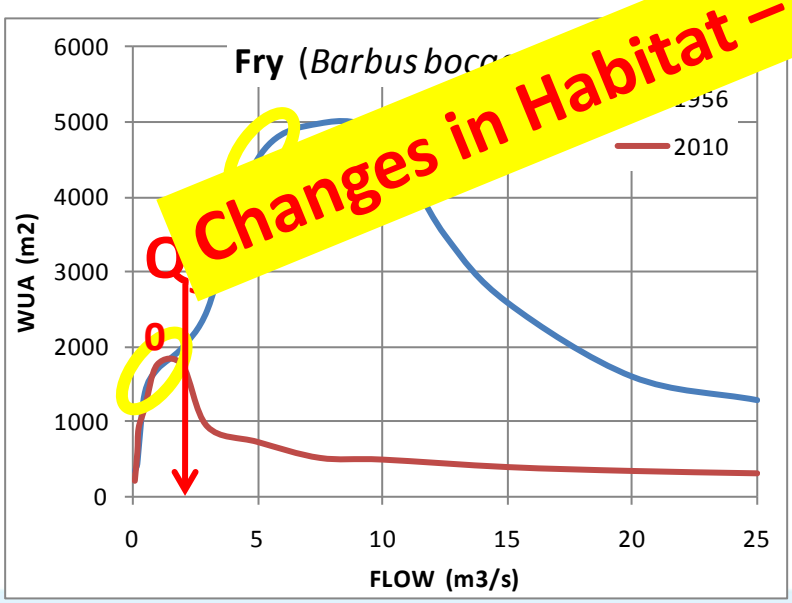
River Manzanares channel changes below El Pardo Dam

CHANGES IN FISH HABITAT

Río **Manzanares** (El Pardo)

below El Pardo Reservoir:





Pre-Dam conditions (1956)

- Higher Habit… …es, but at hig… …s
- …asic **E-flows** have greater values
- At natural flows:
  - Adult barbel habitat is smaller
  - Fry barbel habitat is greater

Changes in Habitat – Instream Flows Relationship

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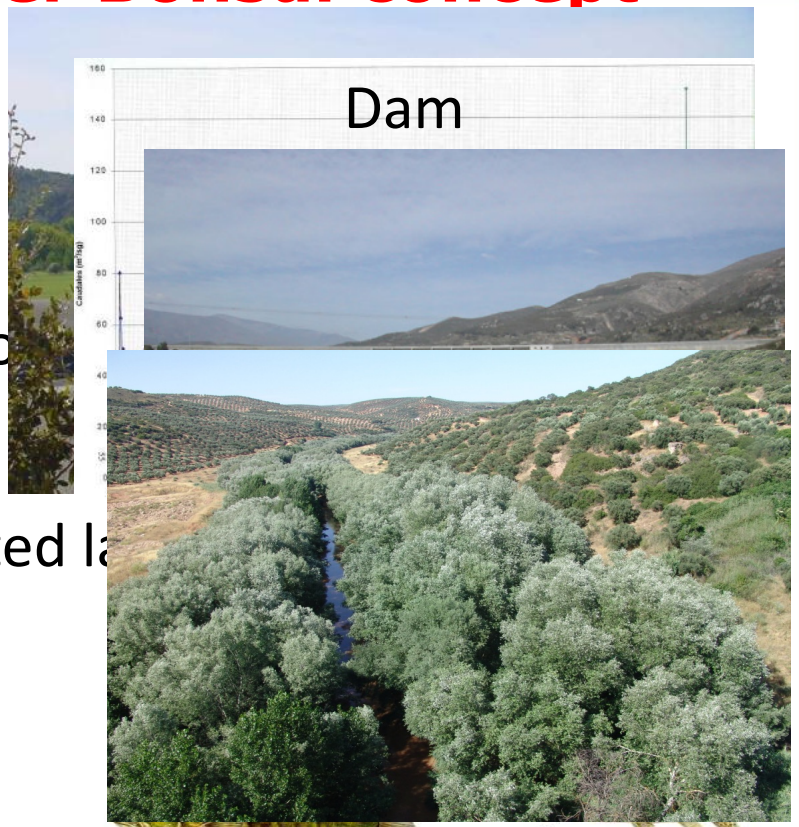
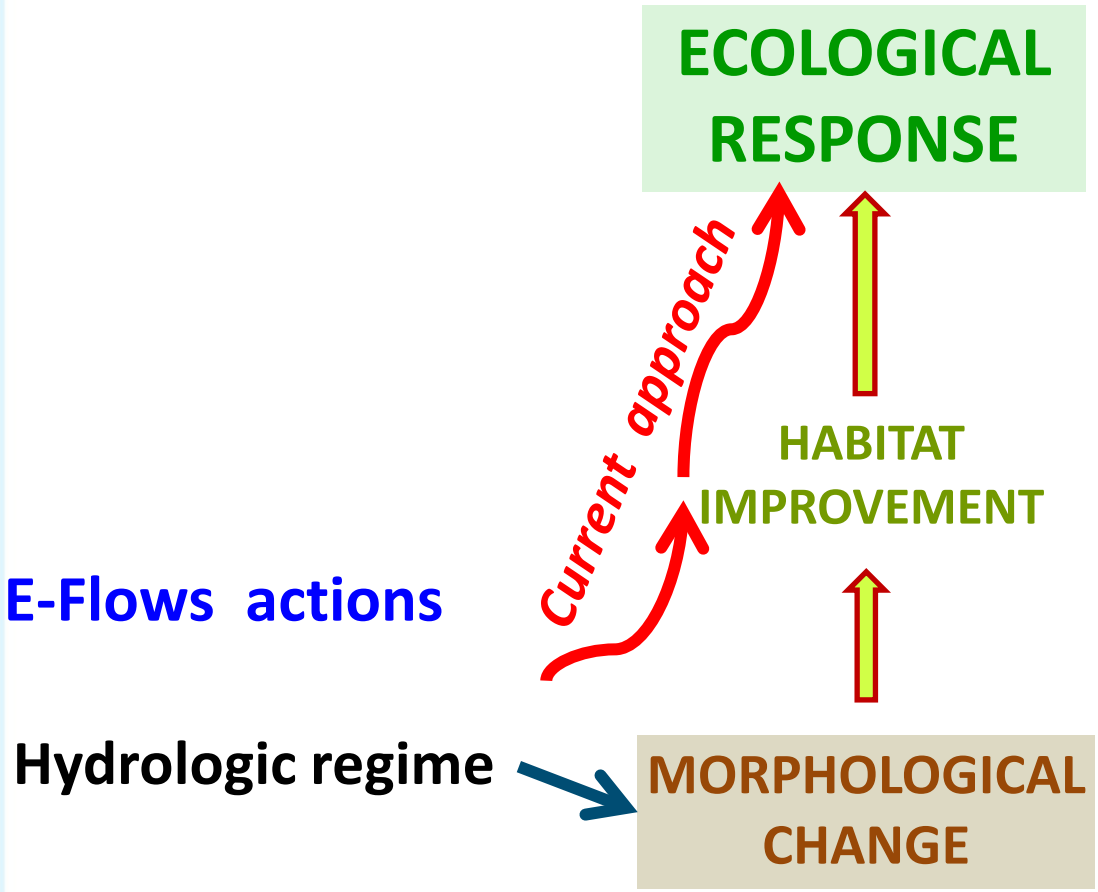
4. E-flows in Mediterranean streams: The river Bonsai concept

- Rivers have lost sediments
- Rivers have lost their dynamism
- Rivers have been fragmented and lo longitudinal connectivity
- Rivers are narrower and disconnected la
- The rivers are immobilized by an overgrown riparian vegetation
- Rivers have reduced their native biodiversity
- Rivers have been invaded by introduced species



Conclusions: Present E-Flows are not useful



Conclusion: We must adopt a new E-Flows template

ECOLOGICAL RESPONSE

HABITAT IMPROVEMENT

MORPHOLOGICAL CHANGE

Potential E-Flows actions

1. Hydrologic regime
2. Sediment Transport regime
3. Woody Debris dynamics

Bonsai rivers need:

Complementary measures

- Removing mature Riparian Forest
- Eliminating/Reducing Barriers
- Direct Morphological reconstruction

Temporal Evolution

Río Ruecas (Badajoz)

Thank you for your attention