Main pressures and impacts on rivers

1. Pressures and impacts on rivers and starting points for restoration
2. Causes and problems diagnosis.
3. Canalization.
4. River Incision.
5. Flow regulation.

Main pressures and impacts on rivers

- Atmospheric Pollution
- Watershed Alterations
- Riparian Zones Occupation & Disturbance
- **River Canalization & Dredging**
- **Flow Regulation**
- Water Pollution




CAUSES OF RIVER DEGRADATION

1. Rivers **Environmental Values** not Recognized
   (unbalanced water management activities: river as a source of hydraulic resources)

Water managers with **one-dimensional** Formation,

dominated by traditional hydraulic engineering.

River = Water Canal

→

Prevailing river channel functions:

- pollution wastes **transport**
- Floods fast **drain system**
- Water **storage**

With design of canalization & water transfers systems and dams building, destroying remaining environmental values

CAUSES OF RIVER DEGRADATION

2. **Space speculation**, encouraged by urbanistic plans & agricultural agencies, & favored by hydraulic works

To take control of riverside domain for uses not compatible with fluvial dynamics

River = Space

→

Increase of **Hydrological Risk** and claiming of margin defense works, levees, canalization & dredging

CAUSES OF RIVER DEGRADATION

3. **Excessive Exploitation of fluvial resources and discredit of fluvial conservation functions by water authorities**

Lack of public awareness on rivers health

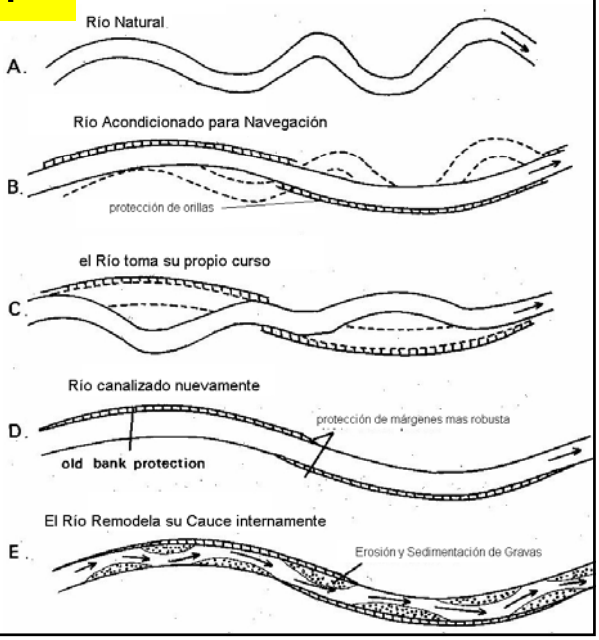
Lack of trained personal on broader issues

→

- Degradation persistence:
  - Water **pollution**
  - Margins **occupancy**
  - Stream disappearance & urban rivers tubing

Canalization

River Rhine History



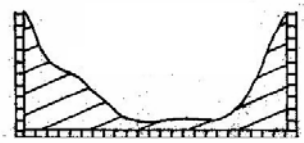
Anthropic Impacts on Fluvial Ecosystems

- Man's activities simplifies Nature
- Transforms natural spatial heterogeneity into an homogeneous landscape.
- Fluvial Habitats are standardized
- Ecological niches are reduced
- Biodiversity decreases

Canalization

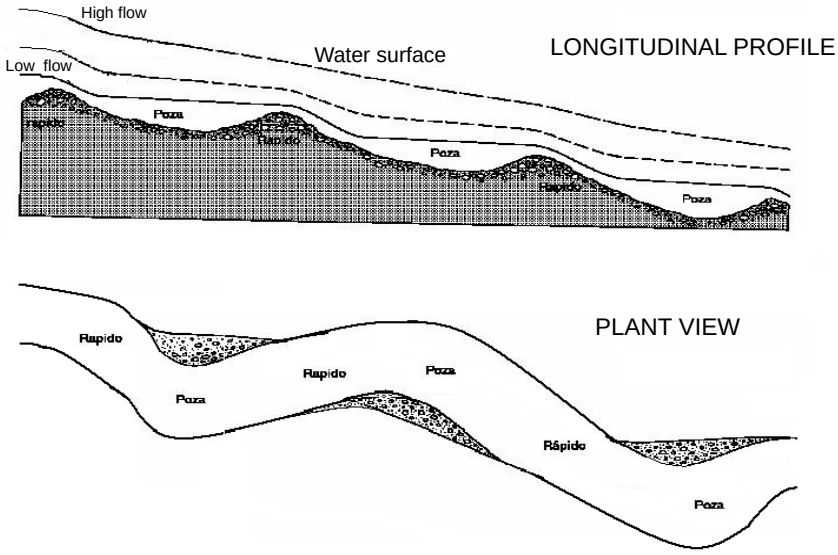
- Channel enforcing, straightening, dredging, bank conditioning,..
- The **straight line** as a design obsession
- Cross Section:

EXCAVACIÓN DE SECCIONES TRAPEZOIDALES

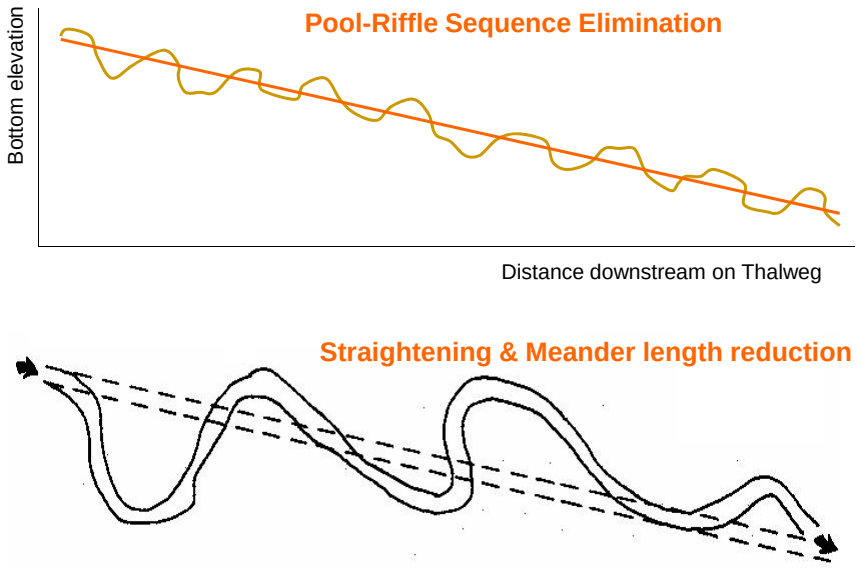


SECCIONES RECTANGULARES HORMIGONADAS

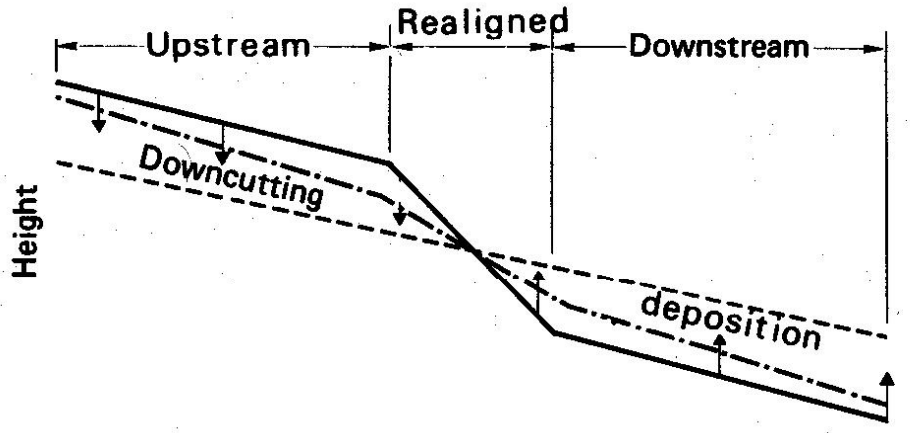
Longitudinal Profile & Plant View



Longitudinal Profile & Plant View

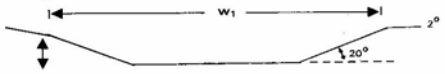


Canalization

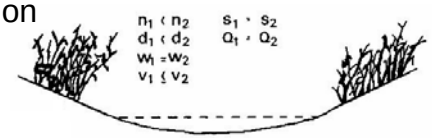


Canalization: Evolution of Cross Section in a Canalized river

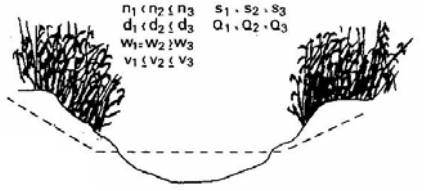
1. Initial Trapezoidal design



2. Margins colonized by vegetation



3. Sediments accumulated on vegetation
4. Increase slope in banks
5. Channel constrained
6. Bottom incision

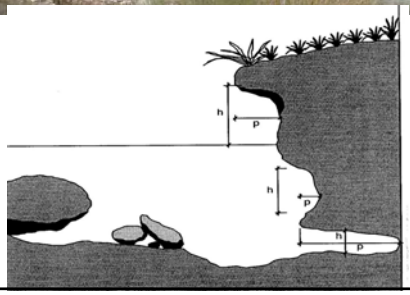


Fluvial Habitat Characteristics disturbed by Canalization

- Riparian Vegetation eliminated
- Refuge and Cover Capacity reduced
- Substrate is standardized and interstitial zone destroyed
- Distribution of water velocities is uniform

Habitat Principal Components

they provide capacity for: refuge, feeding, spawning,…



Bank Vegetation Effect on Channel Stabilization

Canalization Impact Mitigation

- To give more space to the river
- To avoid boxing the channel
- Interventions only where/when is strictly necessary (do not protect sedimentation zones, p.e. convex margins)
- Promote geomorphological processes and let develop the biological community by its own

Canalization Impact Mitigation

Incision Processes

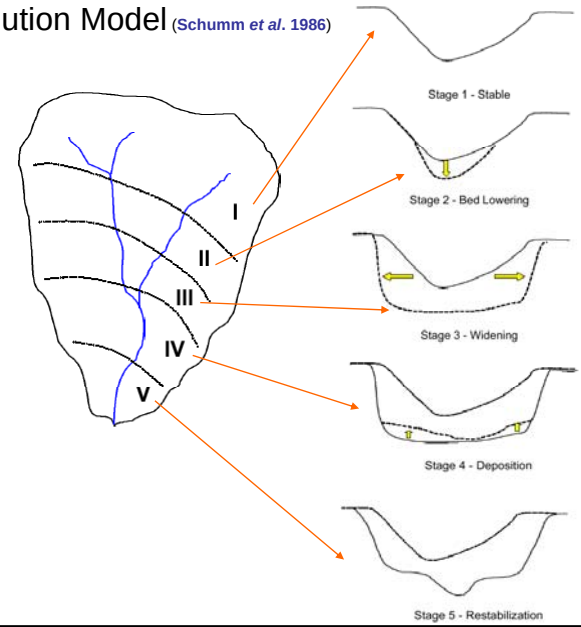
Incision occurs when long- term erosion exceeds sedimentation:

- **Channel modification**: usually enlargement or straightening for flood control (probably the most common cause of incision & also in the most severe cases)
- reduced sediment load due to upstream **dams**
- Increased peak flows caused by **urbanization** & **deforestation** of the watershed.

Incision Process:

The Channel Evolution Model (Schumm *et al*. 1986)

1. Stable
2. Bed lowering: the streambed degrades until the critical bank height is exceeded and the bank starts to fail
3. Widening: increasing channel width and sediment load
4. Deposition:
5. Restabilization: Over time, the stream will move toward a new equilibrium and incision will cease



Channel incision can be **initiated** by a variety of conditions:

1. by watershed changes that affect the hydrology or sediment yield, (*upstream-down*).
2. by base level lowering or grade changes that initiate headcuts that move upstream, leading to rapid channel incision (*downstream-up*).

The incision **stops** when one or a combination of the following conditions develops:

- **Changes in the channel slope and geometry** alter the hydraulic conditions such that sediment continuity is restored.
- Fine sediments are selectively eroded, and the **streambed is armored** preventing further incision.
- The degradation is arrested by **bedrock or man-made structures** prior to the compromise of bank stability.
- Recovery of **riparian vegetation** increases streambank stability, and bed stability is provided by one or more of the above factors.

Planning Incision Restoration

- Geomorphological investigation:
  - causes of the incision processes
  - Character & extension
  - identify reaches that are still incising
- Space limitations (aerial photos)
- Historic hydrologic condition
- Sediment yield of the watershed
- Program of Activities:
  1. Address the problems that initiated the incision
  2. Allow or promote the stream to adjust toward a new equilibrium
  3. Promote regaining stability.

INCISED CHANNEL RESTORATION

This rehabilitation can follow three general pathways *(Fischenich & Morrow, 2000)* :

1. allow the channel to establish a new equilibrium condition on its own
2. accelerate the process characterized by the CEM and promote reaching a new equilibrium,
3. restore the hydraulic grade of the system to reestablish the hydrologic connection to the historic floodplain.

- A new enlarged or degraded channel (lowered)
- historic floodplain becomes a terrace
- A new floodplain is reestablished, but often with smaller size

- restores the hydrologic interactions between the stream and floodplain (overbank flooding)
- often fails to restore the physical or hydraulic conditions within the channel

1.- Allow nature to reach a new equilibrium

- The endpoint or final channel configuration is **difficult to predict**
- additional bank and bed **erosion** must be accepted
- the process may require **decades** to be completed

2.- Restoration of a new balanced channel

- The endpoint is more determinant
- consists of:
  - Promoting Erosion: incision in stage 2, enlargement in stage 3
  - Stabilization by developing a stable low-flow channel with adjoining psuedo-floodplains within the existing channel
- "natural" floodplains functions may be recovered partially

3.- Rehabilitation of hydraulic grade & the connection of channel to its floodplain

- it may be necessary to accelerate the recovery of habitats that were impacted by the reconstruction and stabilization of the channel
- Techniques:
  - modifying the **flow or sediment regime**
  - construction of grade control **structures**
  - **armoring** streambanks and streambeds
  - increasing or reestablishing channel sinuosity
  - construction of new floodplains to attenuate high flows

Effects of Reservoirs and Dams on Fluvial Ecosystems

Effects of reservoirs depend from factors like:

- **Dam Mechanisms to regulate out flows**
- **Types of regulated flow regimes**
- **Natural Characteristics of the river**
- **Land Uses**: **synergies with other human activities**

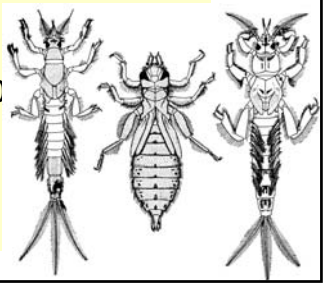
Regulation Mechanisms:

Types of Regulated Flow Regimes

- **Instream Flow Reduction** (water transfers)
- **Instream Flow Increase** (Water Supply)
- **Seasonal Constancy** (Irrigation)
- **Short Term Flow Fluctuation** (hydropower)

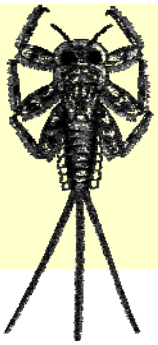
Instream Flow Reduction

- Aquatic Area Diminished
- Water velocity decreases:
  - Lentic species are favored
- Fines Sediments deposition o bottom:
  - Interstitial Habitat clogged



Instream Flow Increases

- Greater Aquatic Area
- Water Velocity increases:
  - Lotic species favored
- Channel may be destabilized: erosion processes in substrate and at river banks
- Thermal Effects are strengthened



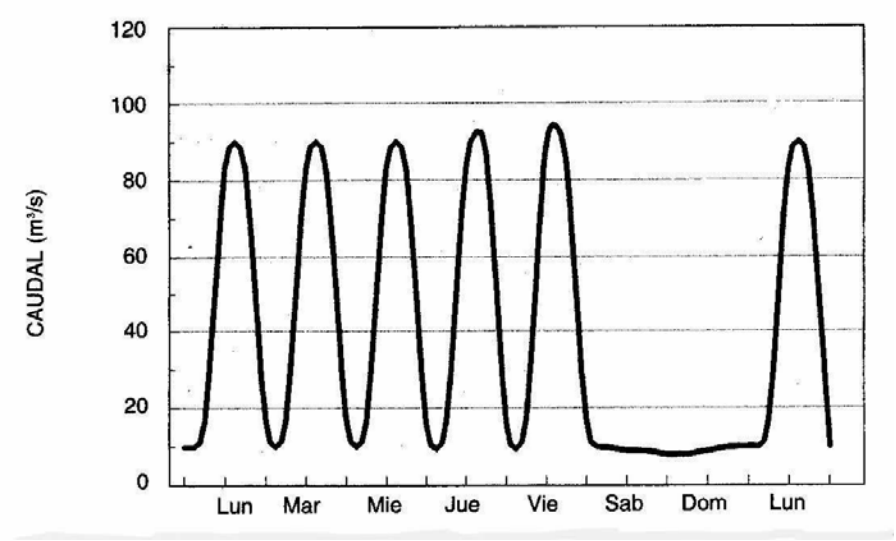
Seasonal Constancy Flows

- Winter floods are eliminated or reduced
- Channel Stabilization:
  - Riparian Vegetation is greatly promoted
  - Turbidity diminishes
- Summer cold waters

Short Term Flow Fluctuation

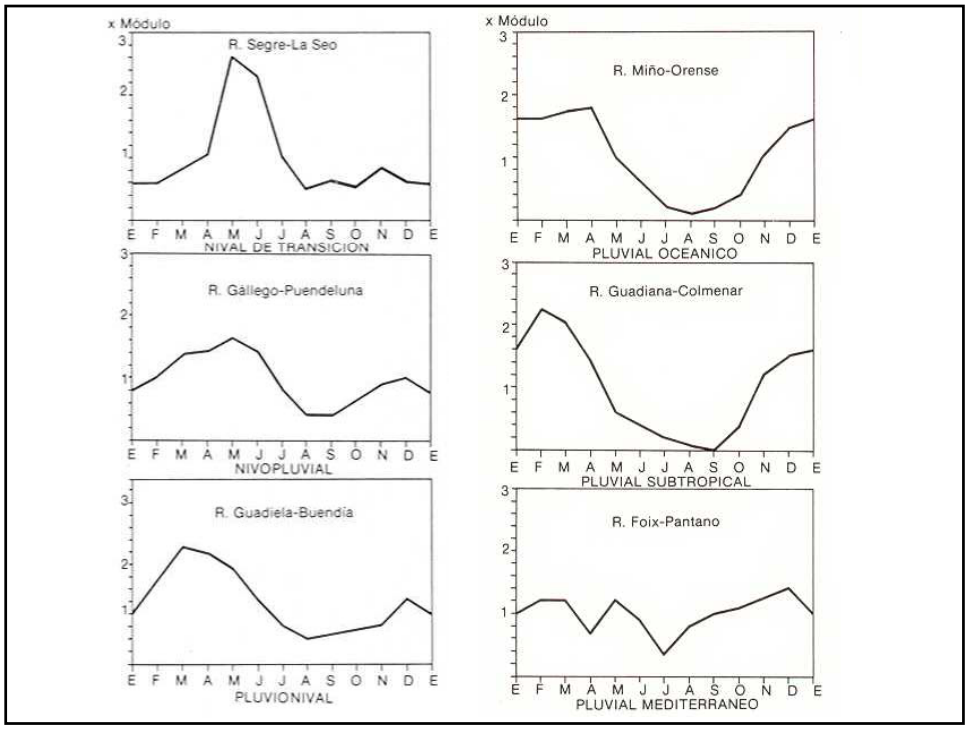
- Benthic Animals are flushed away with high flows
- Aquatic organisms are dried out due to fast water level lowering
- Both, lentic and lotic species are disturbed

Weekly hydroelectric regime

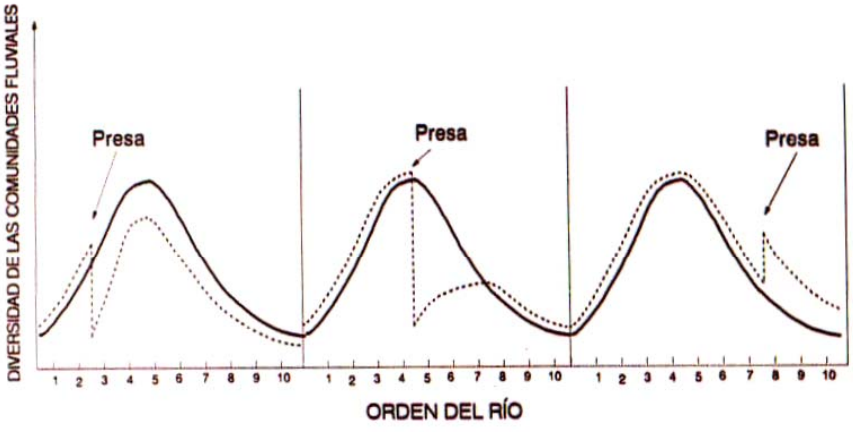


River Natural Characteristics

- **Natural Flow Regime**
- **Channel Erosionability**
- **Capacity & Permeability of the alluvial phreatic**
- **Fluvial Ecosystem Fragility**
- **River Natural Biodiversity**



Effects on biodiversity due to dam localization



Land & Water Uses

- Pollutants Concentration / dilution
- Urban run-off
- Rivers Canalization &tubing
- Water Supply, Water Depuration, Sewage Treatment
- Irrigation: canals networks, infiltration & retorns to the river

Flow Regulation Effects

- Channel Geomorphological Changes
- Water Temperature regime Changes
- Water Quality alteration
- Biological Responses:
  - Riparian Vegetation
  - Aquatic Communities
  - Man

Channel Geomorphological Changes

- **Alteration of erosion/deposition processes:**
  - **Reduction**
  - **Unbalance**
- **Decrease on Channel Size**
- **Channel Stabilization (apparent)**

Erosion & Sedimentation Processes

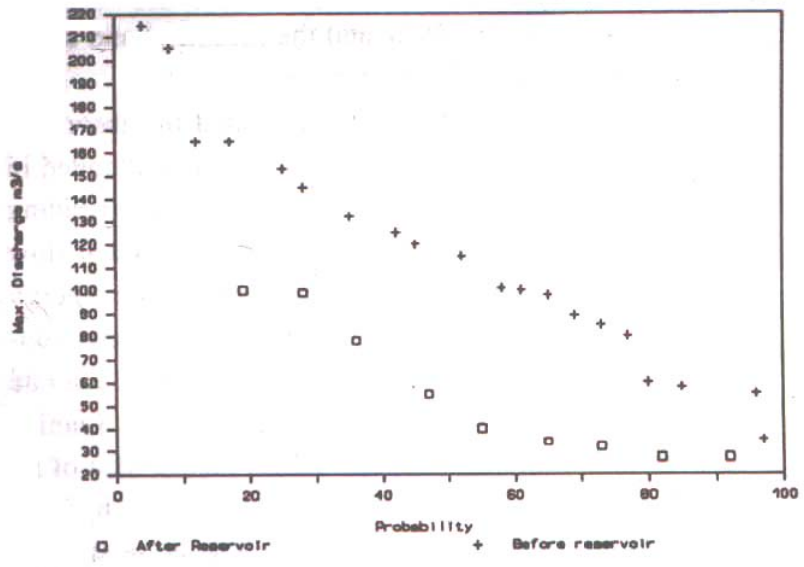
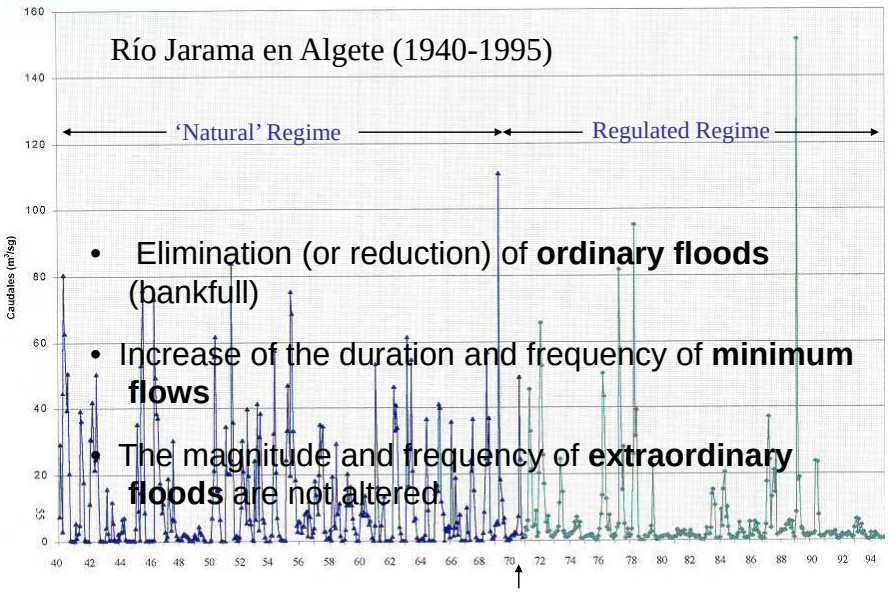


Figure 1. Frequency of annual floods for the river Duero at Peñafiel comparing before reservoir regulation (1931-45) and after regula-



- Elimination (or reduction) of **ordinary floods** (bankfull)
- Increase of the duration and frequency of **minimum flows**
- The magnitude and frequency of **extraordinary floods** are not altered

Sediments Trapp

Water Temperatures

- Seasonal Constancy
- Daily Constancy
- Winter Temperatures rises
- Cold Summer Temperatures
- Delay on annual maximum temperatures

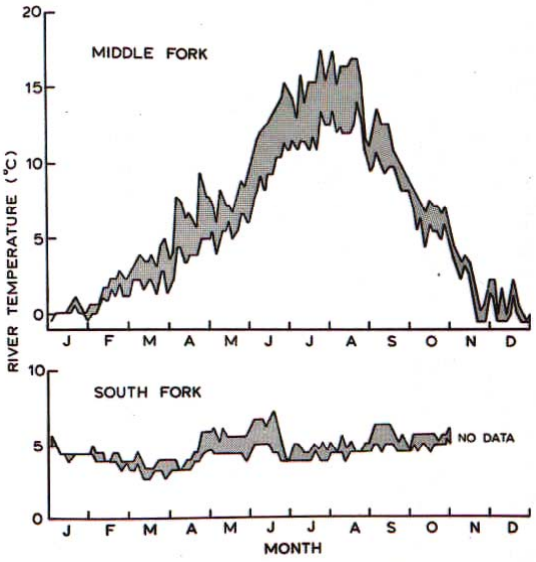
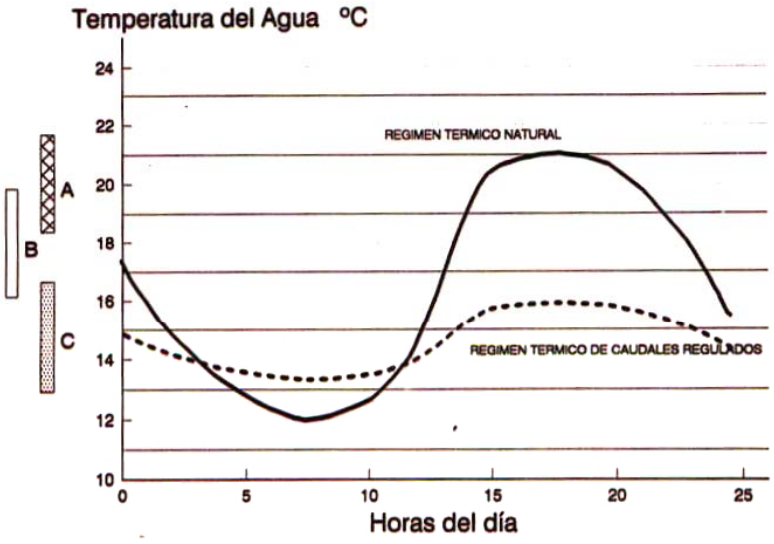


Figure 2. Thermal regimes of the unregulated Middle Fork and the regulated South Fork of the Flathead River during 1977 (Stanford, unpublished).

diversity diminishes by competitive exclusion
(ecological niches overlap)



Water Quality Degradation

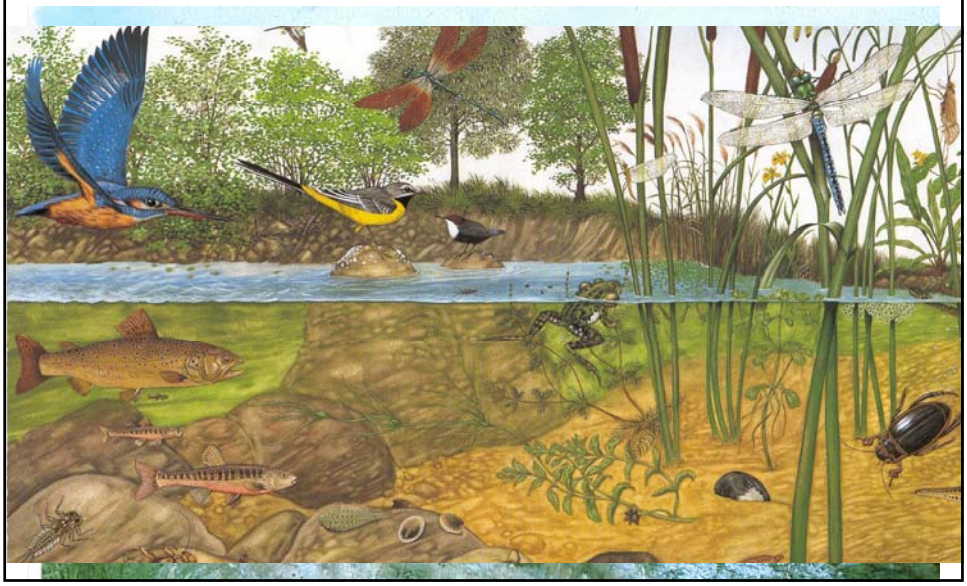
- Dissolved gases supersaturation
- Oxygen depletion
- Toxic Substances
- Increases on ratio Ca/Na

Riparian Vegetation

- D

- N
  S

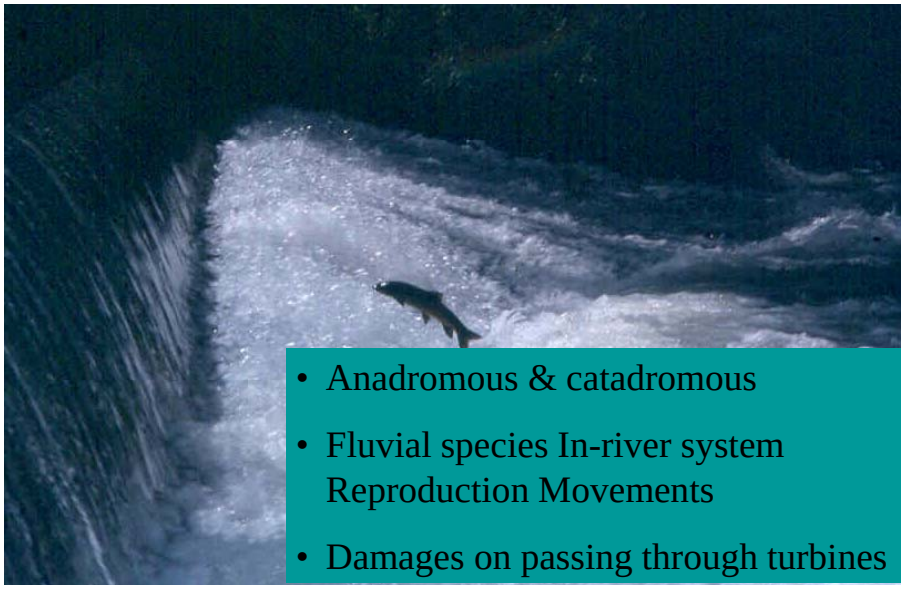
Aquatic Communities



Aquatic Communities

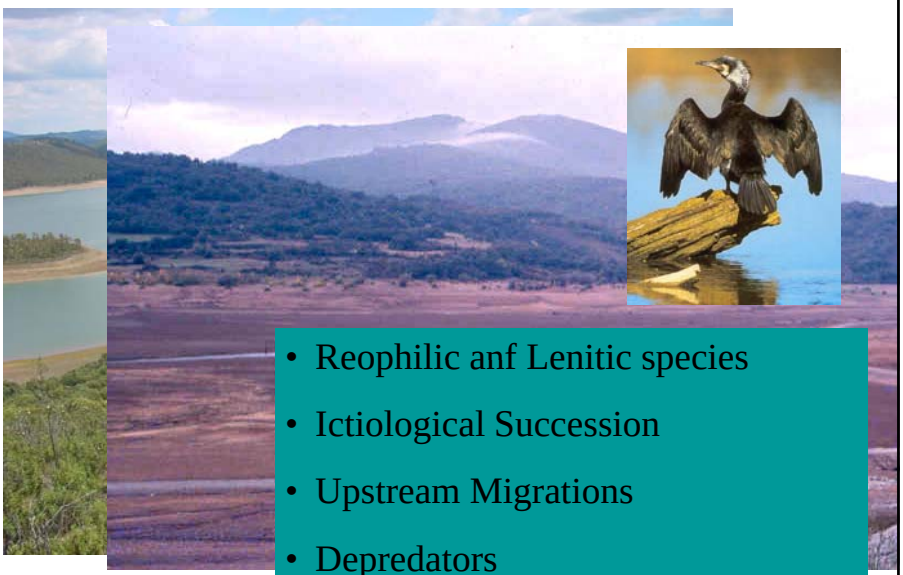
- **Barrier on the fluvial continuum**
- **Effects of the reservoir as a new habitat**
- **Changes in riverine habitat:**
  - **Loose of torrentiality**
  - **Increase on its environmental Predictability**
  - **Increase on water mineralization and eutrophication**
- **Native Species not adapted**
- **Introduced Species Invasion**

Effects on fish migrating species

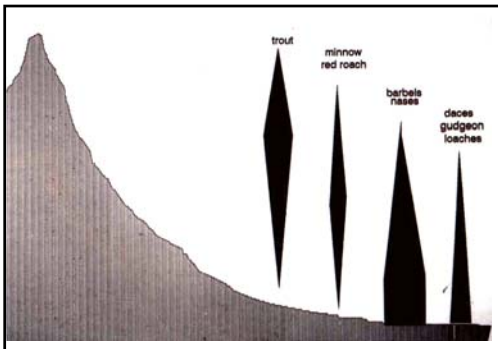


- Anadromous & catadromous
- Fluvial species In-river system Reproduction Movements
- Damages on passing through turbines

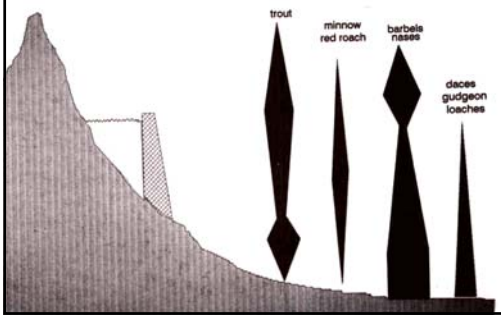
The Reservoir as a new habitat



- Reophilic anf Lenitic species
- Ictiological Succession
- Upstream Migrations
- Depredators



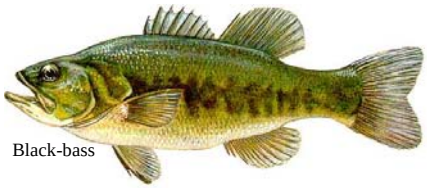
Effects on fish species longitudinal distribution



Introduced Species

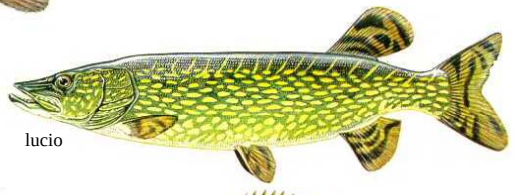

carpin


carpa


Black-bass


gobio


gambusia


lucio


Pez-gato


Pez-sol

Man's Activities on regulated rivers

- **River Invasion & permanent occupancy:**
  - **Cultivation of riparian systems**
  - **Gravel Extraction and pitts**
  - **Urbanization**
  - **Woody Vegetation Elimination**
  - **Levee Construction and y vertido de escombros**

REFERENCES

Fischenich, J.C., & Morrow, J.V., 2000. *Reconnection of floodplains with incised channels.* Technical Notes Collection (ERDC TN-EMRRP-SR-09), U.S. Army Engineer Research and Development Center, Vicksburg, MS.1077-1080.

Schumm, S. A., Darby, D. E., Thorne, C. R., & Brookes, A. B. 1984. *Incised channels: morphology, dynamics, and control.* Water Resources Publications, Littleton, CO.