LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

SEDIMENT MANAGEMENT IN THE CONTEXT OF WATER POLICIES

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Innovative Sediment Management:
How to do more with less
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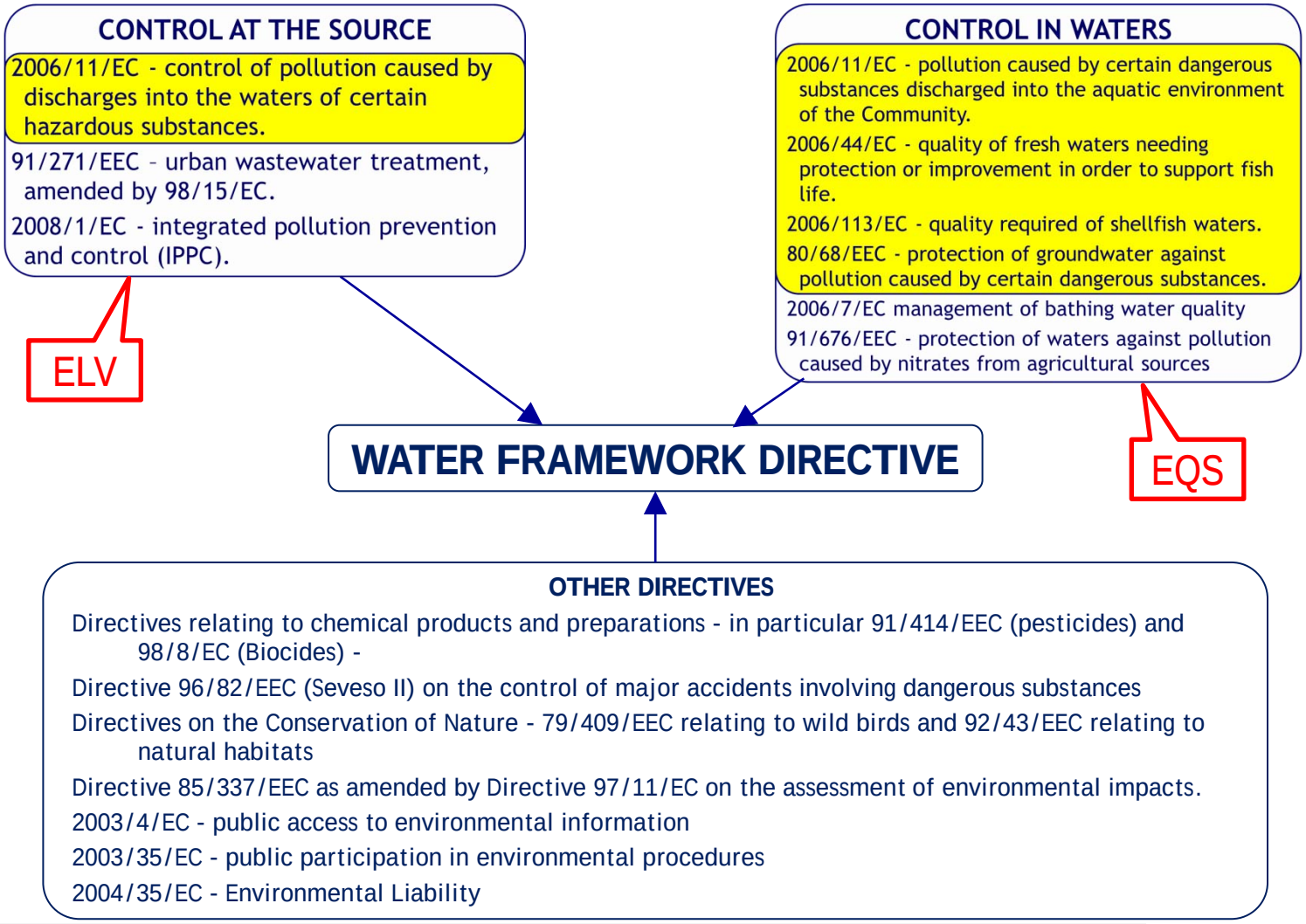
EU Water Policy



EU Water Framework Directive

The environmental objectives of the Directive for surface (inland, transitional, and coastal) water bodies are, in general, to achieve, by 2015:

1. "good ecological status and good chemical status",
2. "good ecological potential and good chemical status" for artificial and heavily modified bodies of water,
3. to prevent deterioration of the status.

EU Water Framework Directive

1. The “ecological status” refers to the quality of the structure and functioning of aquatic ecosystems associated with surface water bodies.
2. The “chemical status” refers to the concentrations of certain pollutants in relation to the environmental quality standards established in relevant legislation setting environmental quality standards at EU level.

EU Water Policy

The objectives of the EU Water Framework Directive are:

- to prevent and to reduce pollution,
- to promote sustainable water usage,
- environmental protection,
- to improve aquatic ecosystems and
- to mitigate the effects of floods and droughts.

EU Water Policy

The legal basis of the Directive is art. 191 of the Treaty on the Functioning of the European Union (ex art.175 of the CE Treaty).

Issues excluded from the scope of the Directive:

- town and country planning,
- quantitative management of water resources or affecting, directly or indirectly, the availability of those resources,
- land use, with the exception of waste management.

Ecological status

Quality elements of the ecological status (rivers):

1. **Biological elements**: Composition and abundance of aquatic flora and benthic invertebrate fauna and composition, abundance and age structure of fish fauna.
2. **Hydromorphological elements supporting the biological elements**: Hydrological regime (quantity and dynamics of water flow, connection to groundwater bodies), river continuity, morphological conditions (river depth and width variation, structure and substrate of the river bed, structure of the riparian zone).
3. **Chemical and physico-chemical elements supporting the biological elements**: Thermal conditions, oxygenation conditions, salinity, acidification status, nutrient conditions and specific pollutants (pollution by all priority substances identified as being discharged into the body of water, pollution by other substances identified as being discharged in significant quantities into the water body).

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Sediment dynamics

Sediment quality

Ecological status

Quality elements of the ecological status (lakes):

1. **Biological elements**: Composition, abundance and biomass of phytoplankton, composition and abundance of other aquatic flora and of benthic invertebrate fauna, and composition, abundance and age structure of fish fauna.
2. **Hydromorphological elements supporting the biological elements**: Hydrological regime (quantity and dynamics of water flow, residence time, connection to the groundwater body), morphological conditions (lake depth variation; quantity, structure and substrate of the lake bed; structure of the lake shore).
3. **Chemical and physico-chemical elements supporting the biological elements**: Transparency, thermal conditions, oxygenation conditions, salinity, acidification status, nutrient conditions and specific pollutants (pollution by all priority substances identified as being discharged into the body of water and by other substances identified as being discharged in significant quantities into the water body).

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Sediment dynamics

Sediment quality

Ecological status

Quality elements of the ecological status (transitional waters):

1. **Biological elements**: Composition, abundance and biomass of phytoplankton, composition and abundance of other aquatic flora, of benthic invertebrate fauna, and of fish fauna.
2. **Hydromorphological elements supporting the biological elements**: Morphological conditions (depth variation; quantity, structure and substrate of the bed; structure of the intertidal zone) and tidal regime (freshwater flow and wave exposure).
3. **Chemical and physico-chemical elements supporting the biological elements**: Transparency, thermal conditions, oxygenation conditions, salinity, nutrient conditions and specific pollutants (pollution by all priority substances identified as being discharged into the body of water and by other substances identified as being discharged in significant quantities into the water body).

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Sediment dynamics

Sediment quality

Ecological status

Quality elements of the ecological status (coastal waters):

1. **Biological elements**: Composition, abundance and biomass of phytoplankton, composition and abundance of other aquatic flora and of benthic invertebrate fauna.
2. **Hydromorphological elements supporting the biological elements**: Morphological conditions (depth variation; quantity, structure and substrate of the coastal bed; structure of the intertidal zone) and tidal regime (direction of dominant currents and wave exposure).
3. **Chemical and physico-chemical elements supporting the biological elements**: Transparency, thermal conditions, oxygenation conditions, salinity, nutrient conditions and specific pollutants (pollution by all priority substances identified as being discharged into the body of water and by other substances identified as being discharged in significant quantities into the water body).

Ecological status

Quality elements of the ecological status (coastal waters):

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Sediment dynamics

Sediment quality

River basin

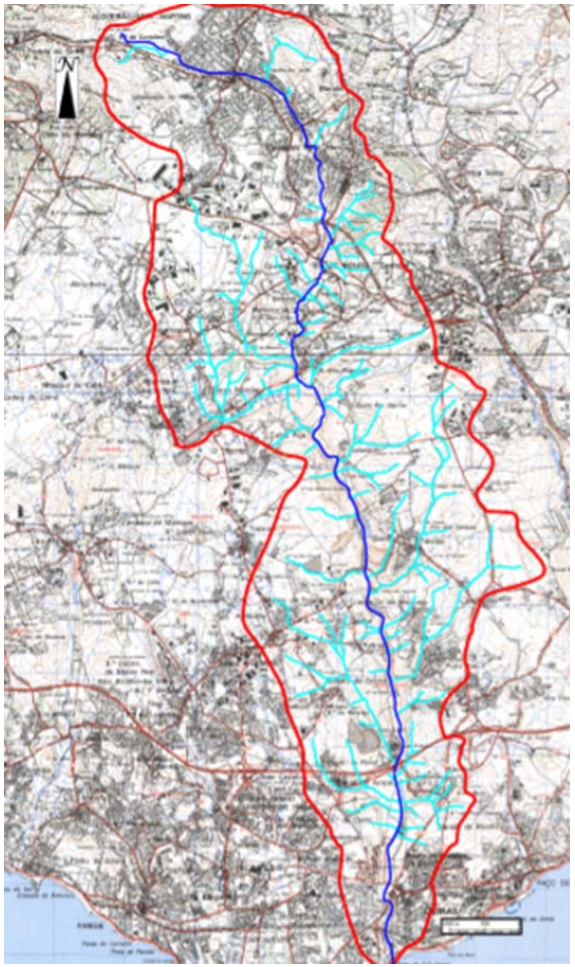
Water bodies should not be considered separately, in isolation.

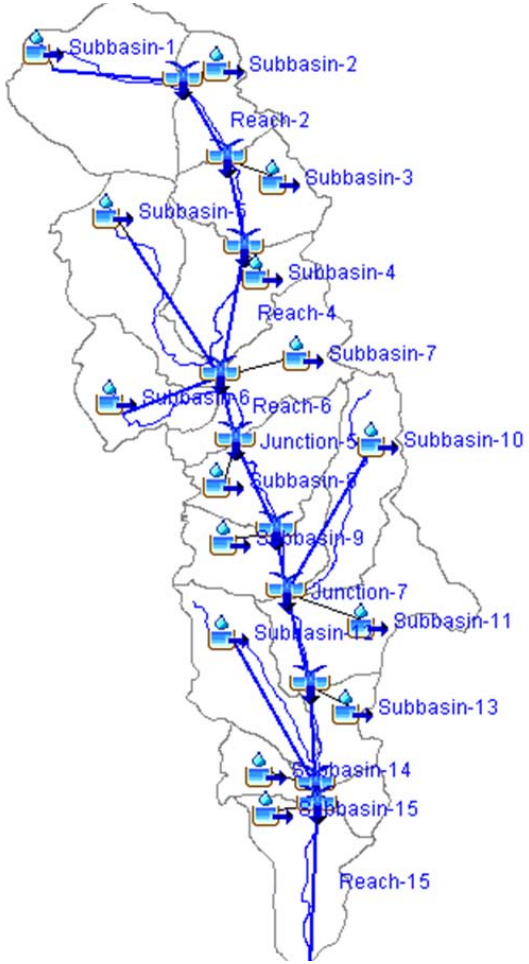
The ecological status and the chemical status of the water bodies within a river basin are interdependent.

A river basin is the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.

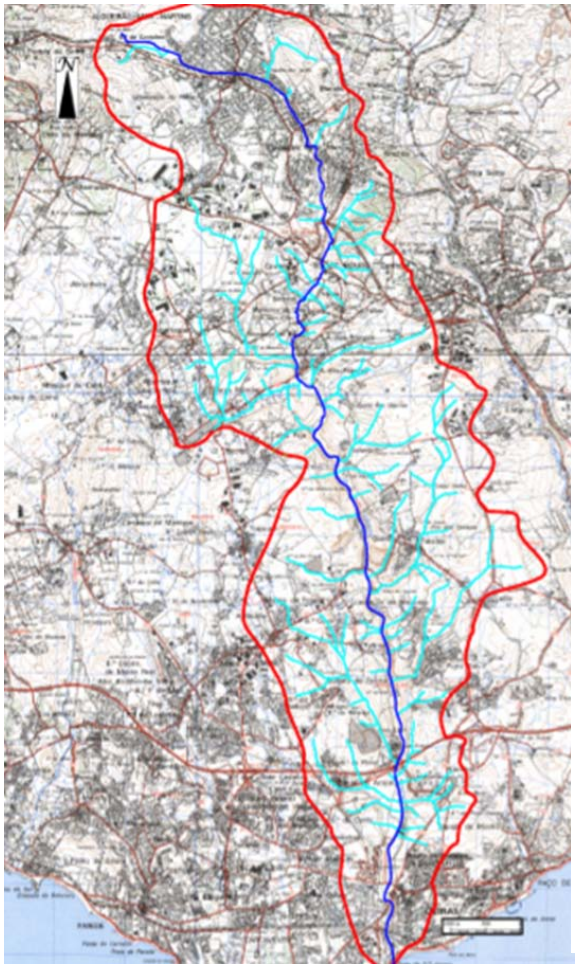
Coastal water bodies are to be associated to river basins to which they are dependent.

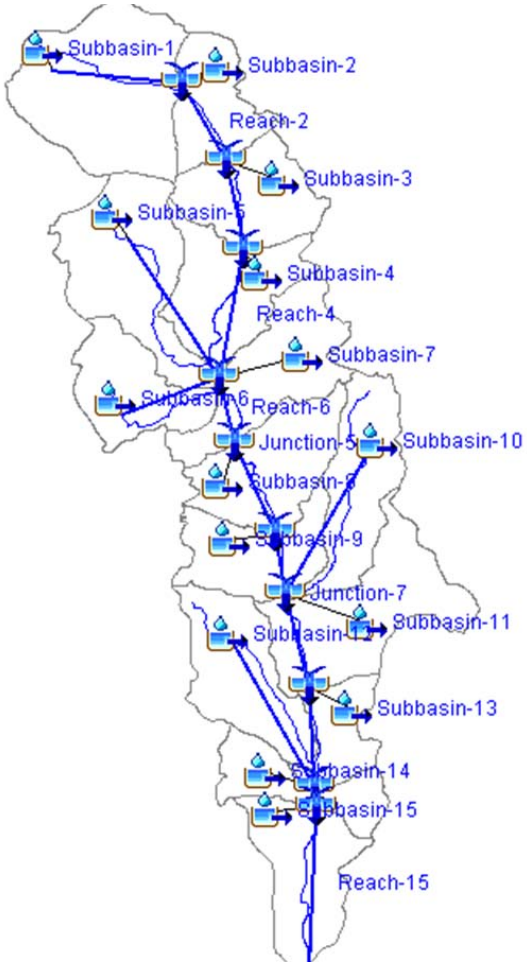
River basin – Hydrological model





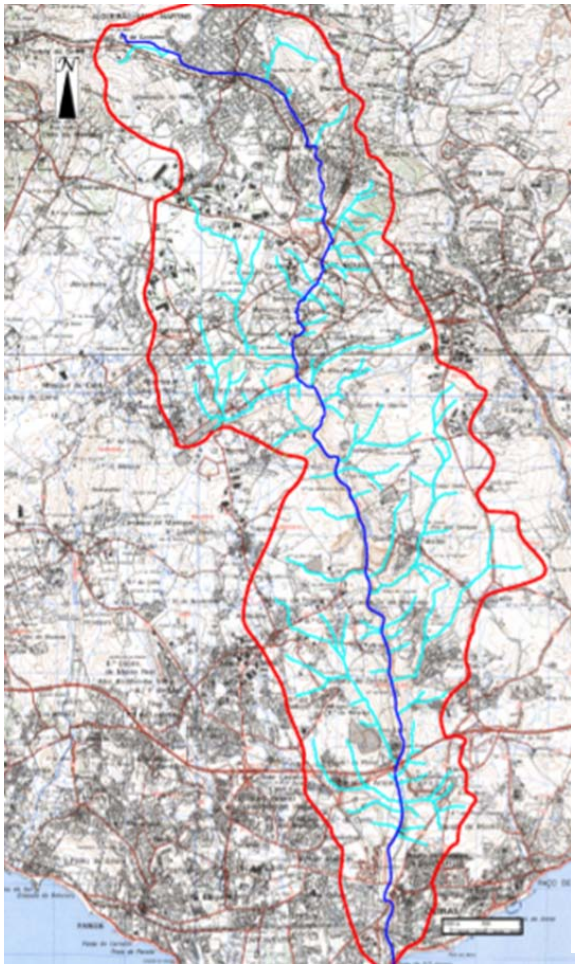
River basin – Sediment model

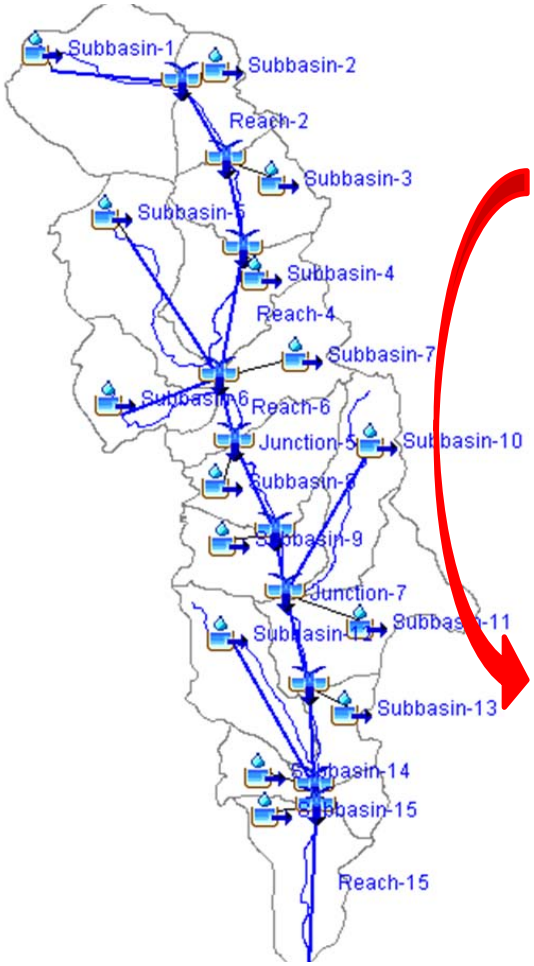




- Erosion
- Sediment yield
- Sediment transport
- Sediment trapping

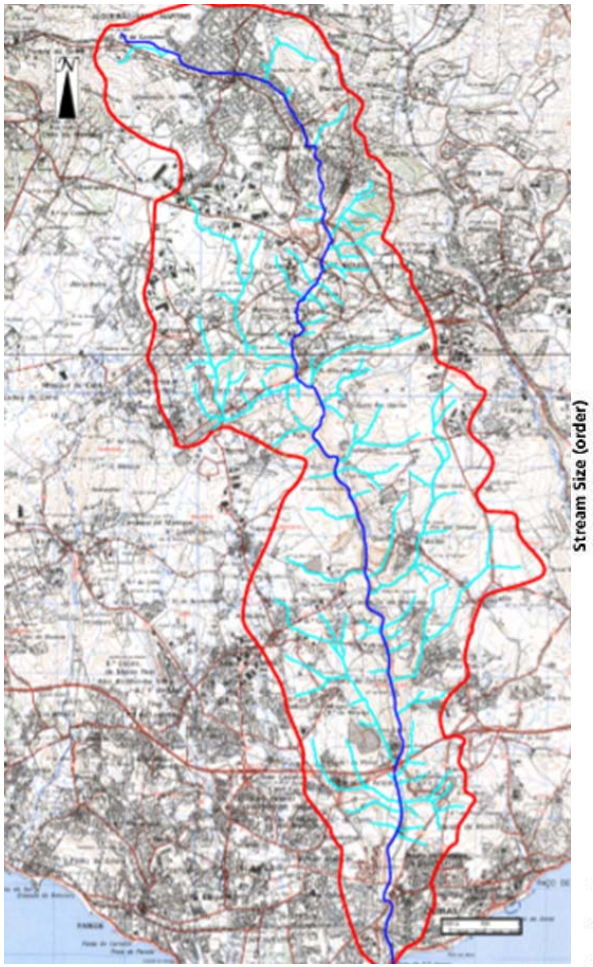
River basin – Sediment model

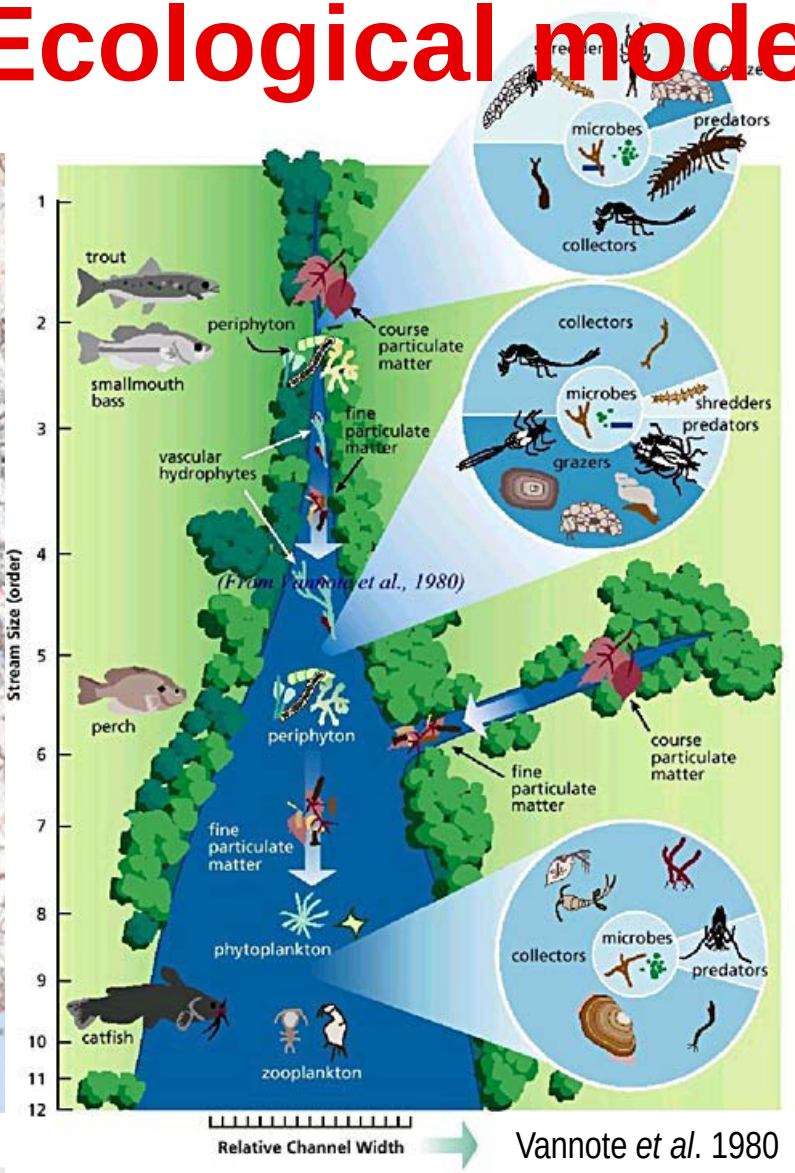




- Erosion
- Sediment yield
- Sediment transport
- Sediment trapping
- Sediment grain size of river bed substrate
- Sediment chemical quality

River basin – Ecological model





Vannote *et al*. 1980

River basin – Complex system

Rivers are entities much more complex than a stream of fresh water, where multiple surface water and groundwater currents converge, where sediments are transported or deposited and where chemical constituents interact.

They are a continuum of flows of **energy, matter and life**, in various forms, from upstream to downstream but also from downstream to upstream.

The heterogeneity of the rivers in space and in time, particularly the river flow regime variation, determines the diversity and dynamics of aquatic habitats and thus biodiversity of the aquatic ecosystems.

River basin – Ecological model

The River Continuum Concept states that biological communities become established in harmony with the dynamic physical conditions that include width, depth, velocity, flow volume, temperature, and substrate of the river.

In headwater streams, shredder communities that consume coarse particulate organic matter dominate.

In mid-sized rivers there is a shift in dominance to grazer communities where sunlight plays an important role in the production of algae growth that the grazer community consumes.

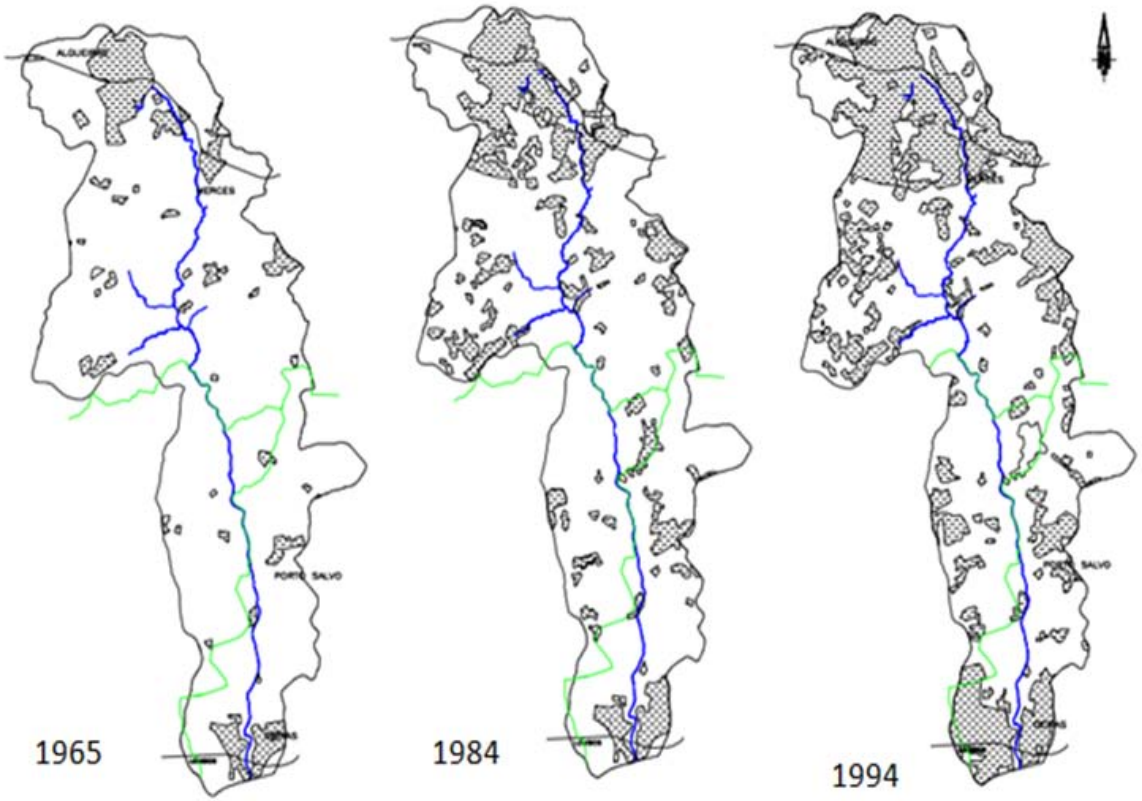
In a large river, grazer communities decrease in dominance and collector communities that consume fine particulate organic matter dominate.

Throughout the continuum, predators are present. Invertivores are predominant in headwaters; mid-sized rivers are piscivorous; and large rivers contain primarily planktivores.

River basin – Ecological model

Along the river the composition of the alluvial bed (namely grain size of sediments) determines the benthic macro-invertebrate community , which determines the fish and higher level biotic communities.

River basin – Land use



Changes of land uses in a river basin modifies river flows, sediment dynamics and aquatic ecosystems

River basin – Ecological model

What would happen to the patterns and processes, as described in the River Continuum Concept, if an instream dam or weir was placed somewhere in the system, blocking the flow?

The **Serial Discontinuity Concept**, proposed by Ward and Stanford 1983, argues that that dams disconnect sections of the river upstream and downstream and displace resource gradients downstream to varying extents.

How the modified distribution of river bed sediments interacts with the biotic communities?

River basin – Ecological model

River basin – Ecological model

The **Flood Pulse Concept**, proposed by Junk 1989, emphasizes:

- the floodplain as an important source of material and energy,
- inundation of the floodplain by a flood pulse as the catalyst for mobilising that material and energy; and
- movement of that material and energy from the floodplain into the main channel as the process that fuels food webs in floodplain rivers.

The emphasis, therefore, is more on lateral connectivity than a longitudinal continuum.

The flood pulse is termed a ‘batch process’, rather than a continuous process – occurring in discrete time periods.

The Food Pulse Concept emphasized the importance of the floodplain for fish breeding and as a nursery habitat, while also relating fish production in the main channel to nutrients draining back from the floodplain as the flood receded.

Sediment processes are important elements for the characterization of water bodies and determining their ecological and chemical status

Sediment dynamics are essential components of aquatic ecosystems in river basins.

Therefore, sediment characteristics and processes are important elements for the characterization of the ecological status and the chemical status of water bodies within river systems.

Whenever human activities interfere with sediment quantity or quality, sediment management may become necessary to achieve the environmental objectives of water bodies.

Nevertheless sediment related issues were overlooked in most river basin management plans.

Catastrophic floods and sediment transport in Madeira in 2011.

Sediment management in the context of water policies.

Thank you!