River morphodynamics

Part 2: Longitudinal profile

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The river system

Drainage basin or watershed is a fundamental landscape unit in fluvial geomorphology. It contains a primary river and its tributaries.

- **Upper Basin**

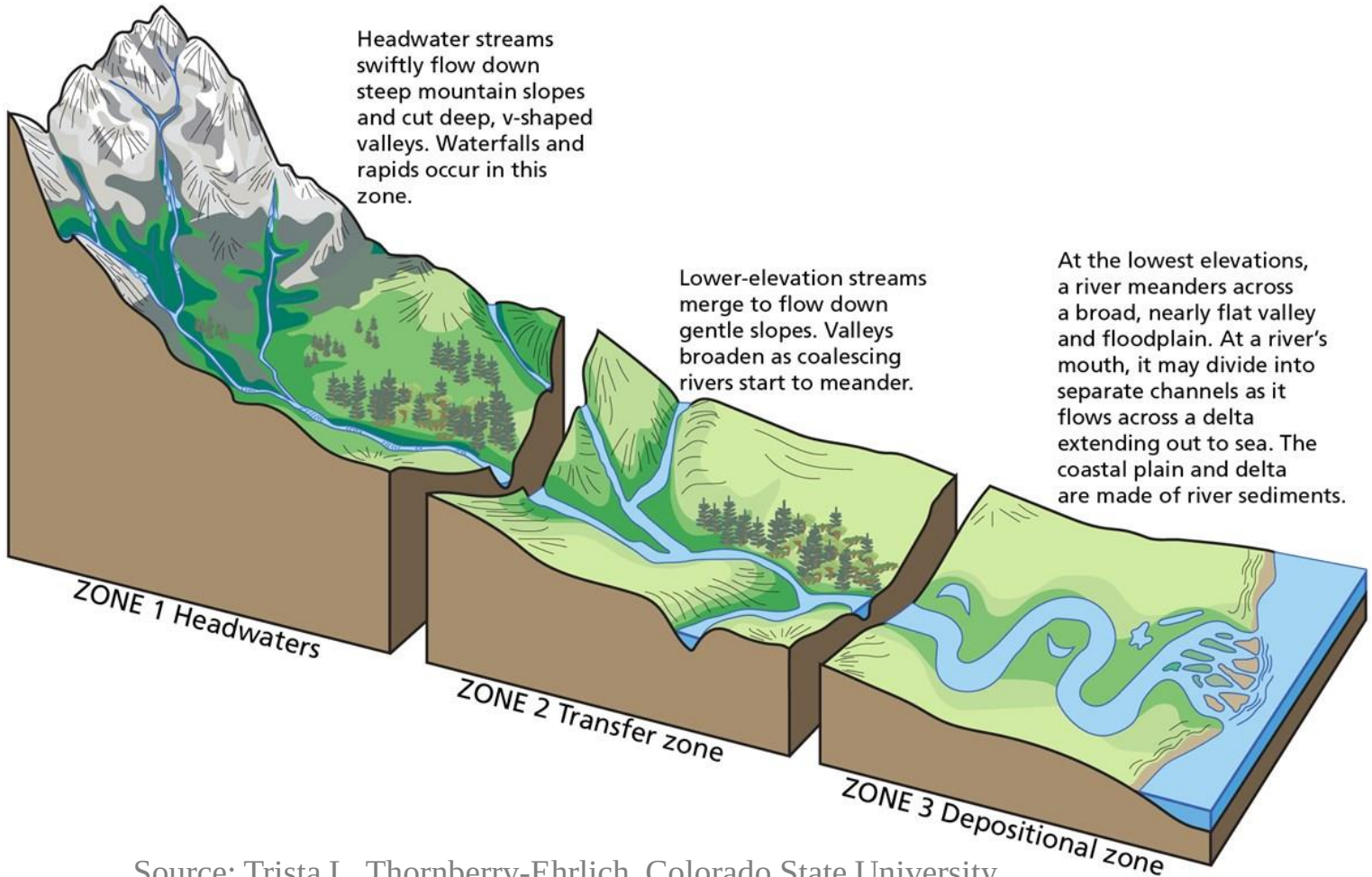
  headwaters

- **Mid-basin**

  low gradient valleys and flood plains (Transfer zone)

- **Lower Basin**

  depositional zone



Source: Trista L. Thornberry-Ehrlich, Colorado State University.

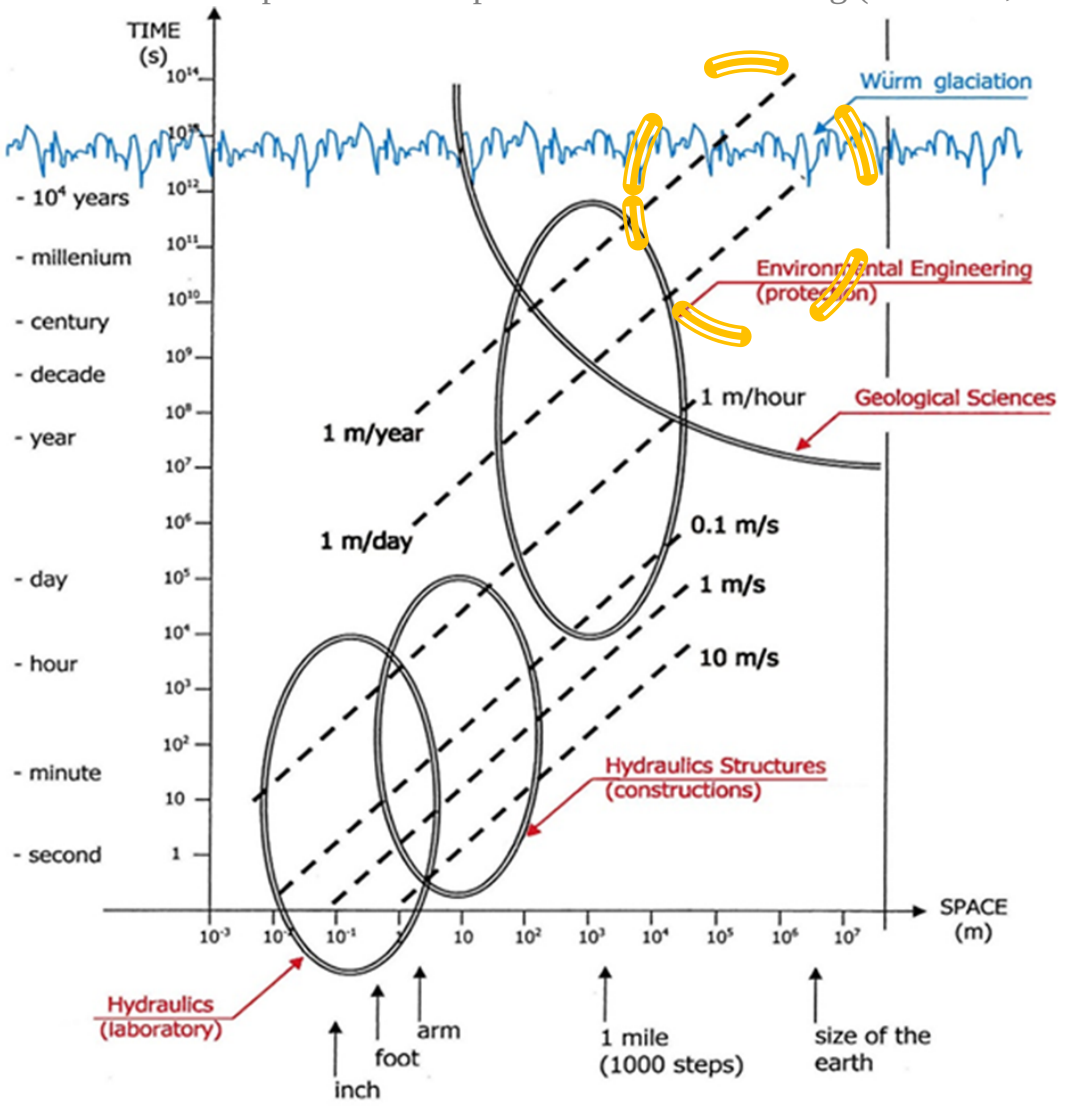
Time scales

The evolution of longitudinal profile for alluvial rivers is a slow process over a large spatial scale.

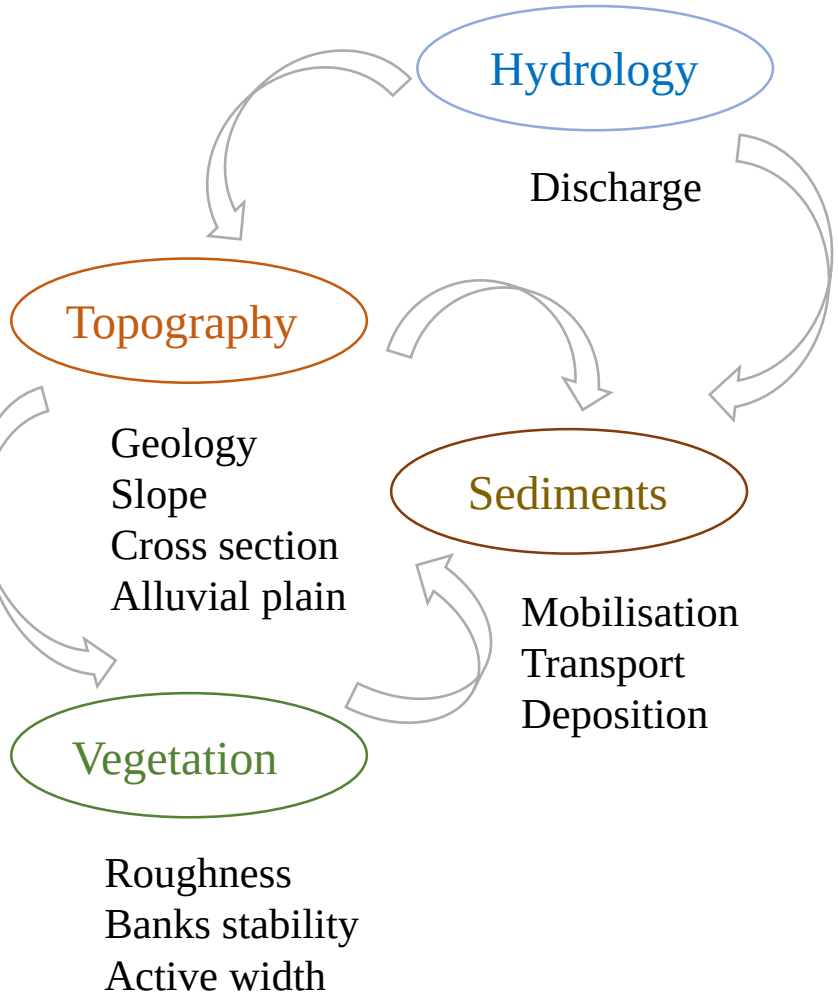
Typical ranges span from:

- 10^3-10^5 small rivers and stream
- 10^4-10^6 medium size alluvial rivers (Adige river, Spree river)
- 10^5-10^8 large alluvial rivers (Amazon river, Congo river, Ganges river, Yangtze river)

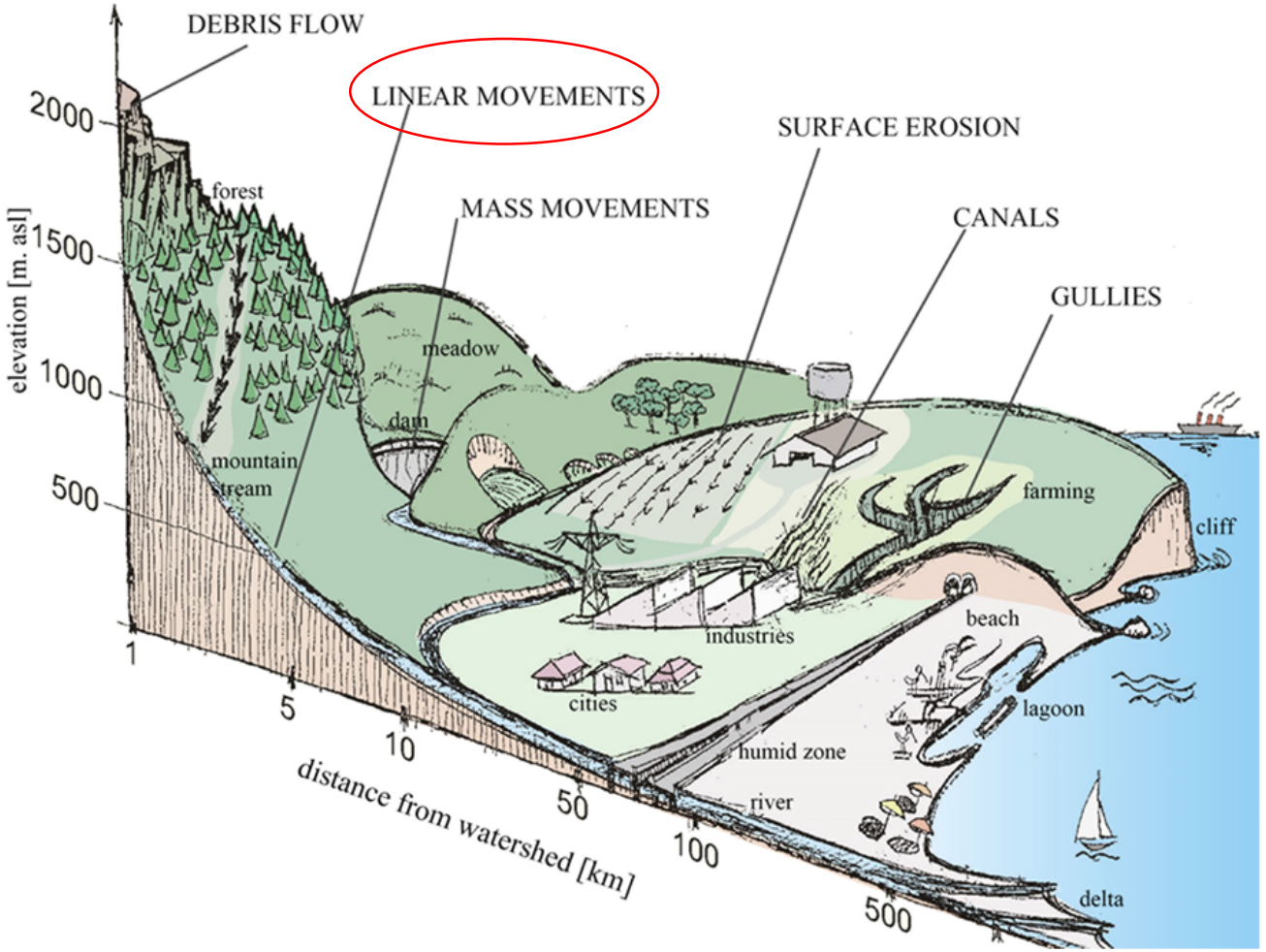
Spatial and temporal scales in modelling (Di Silvio, 2006)



The river system



Sedimentary systems: main sediment motions type (Di Silvio, 2006)



Longitudinal profile

Defined as the gradient of its water surface line from source to mouth

Graded rivers tend to maintain balance between erosion & deposition

– input = output (what rivers would like to do)

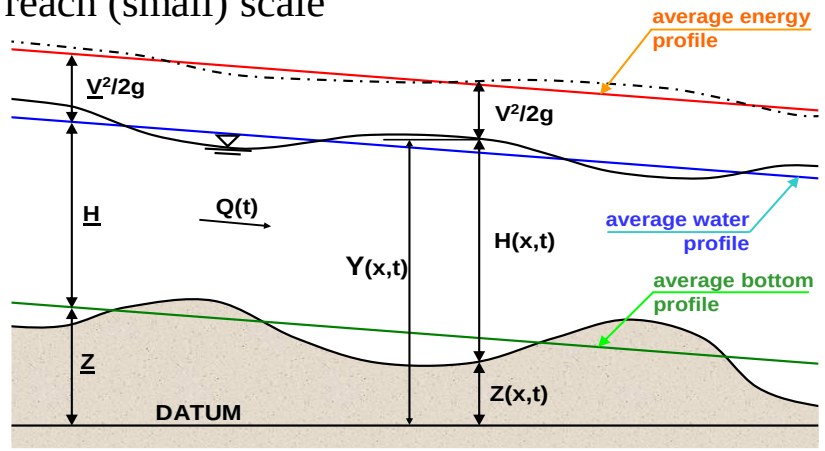
and river profiles (source to base level) are ‘concave up’

– represents balance between increasing discharge and lower slopes to maintain equilibrium

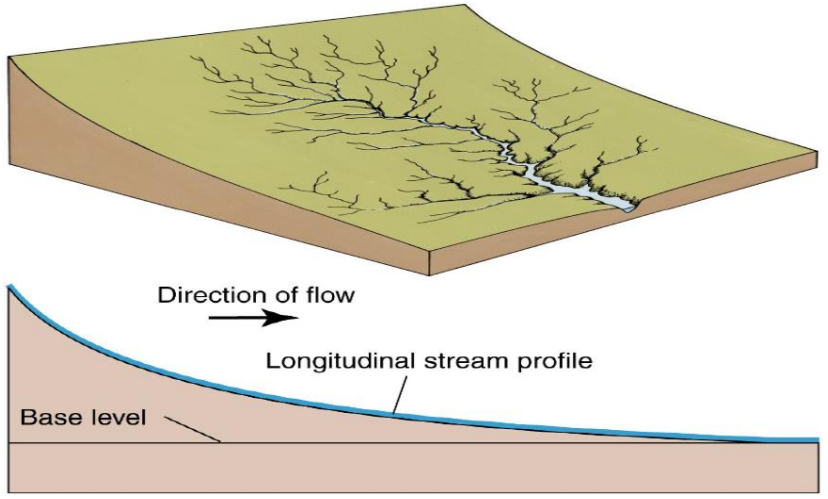
Definition (Mackin, 1948) : Graded River

“one in which ... slope is delicately adjusted to provide, with available discharge and with prevailing channel characteristic, just the velocity required for transportation of the load supplied from the discharge basin (and the river bed).”

At the reach (small) scale



At watershed (large) scale



Longitudinal profile

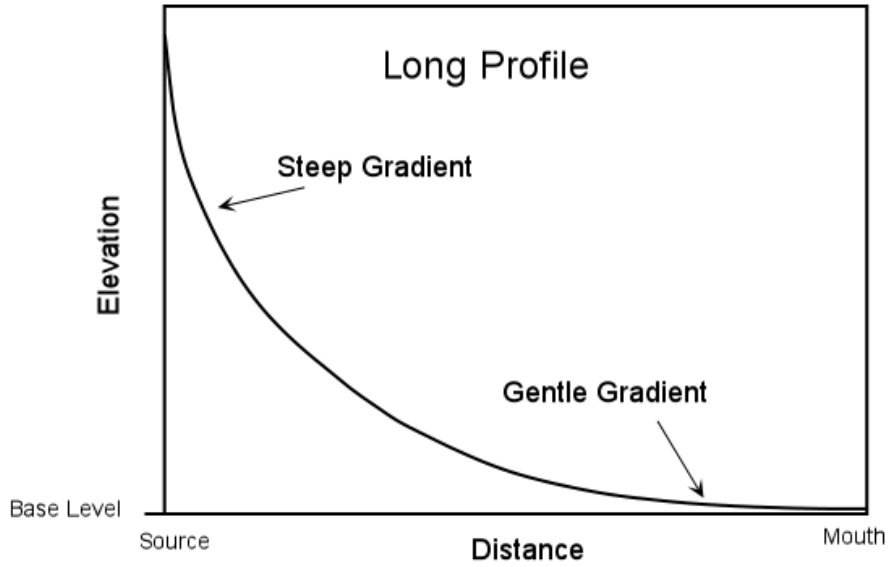
In alluvial rivers: higher discharges can carry more sediment →

but river systems typically do not supply enough →

so rivers creates lower slopes…

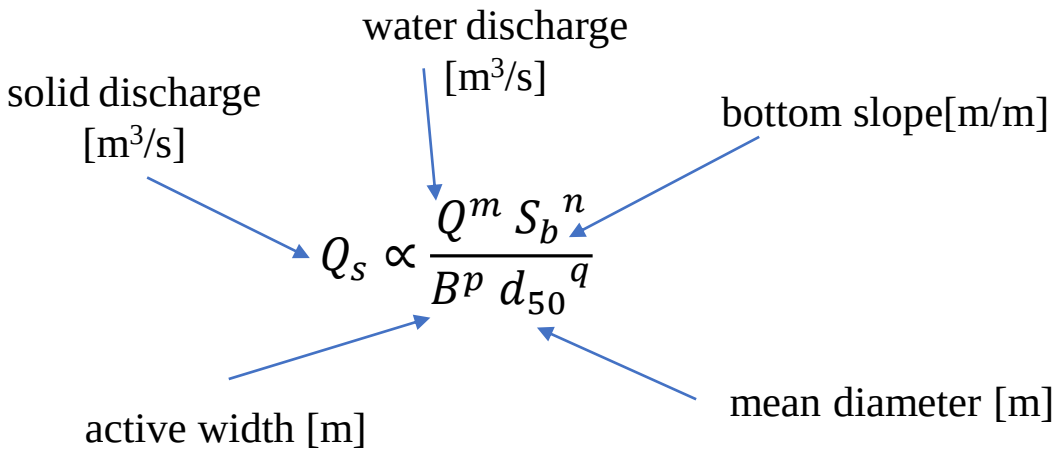
who cares about river profiles?

- Practical: how will river profiles (and sediment yields) react to engineering modifications (dams, dredging, straightening, etc...)?
- Theoretical: essential element of landscape evolution; useful in reconstruction of past landscapes and rates of landform change (e.g., terrace remnants).

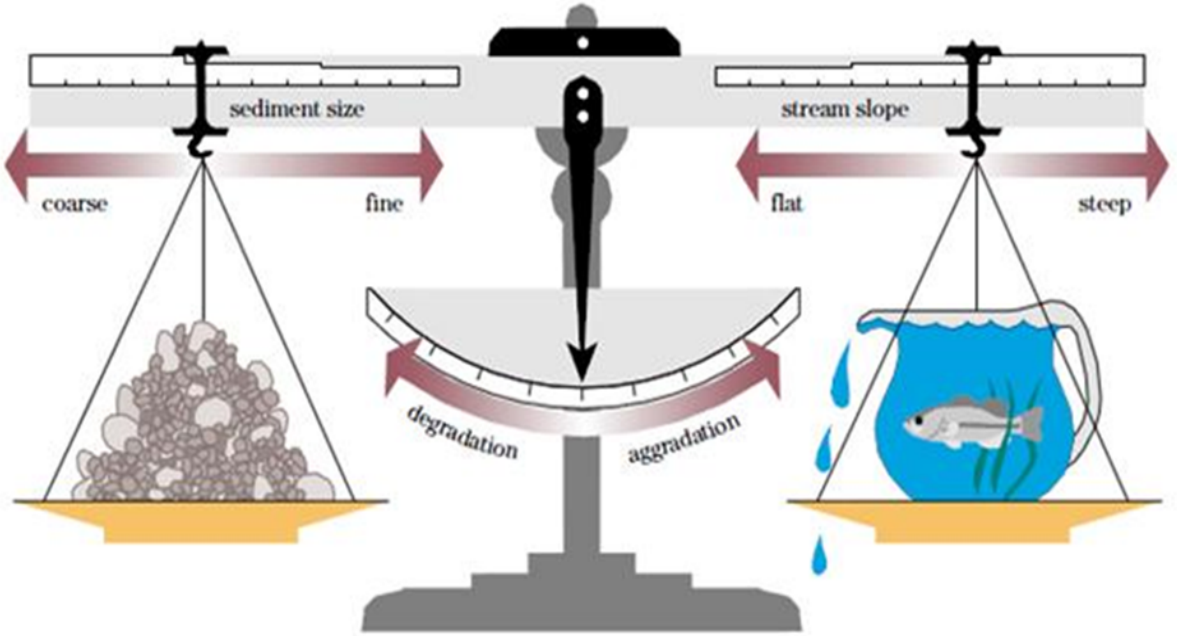


A delicate balance

Lane's balance (1953) describes equilibrium conditions for a stream.



Interplay between main morphological controls (Rosgen, 2006)



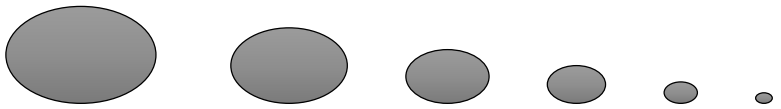
It can be used for qualitative prediction of erosion/deposition at reach scale

Downstream sorting: fining

The size of river sediment normally decreases downstream

→ we find boulders and cobbles in mountain streams

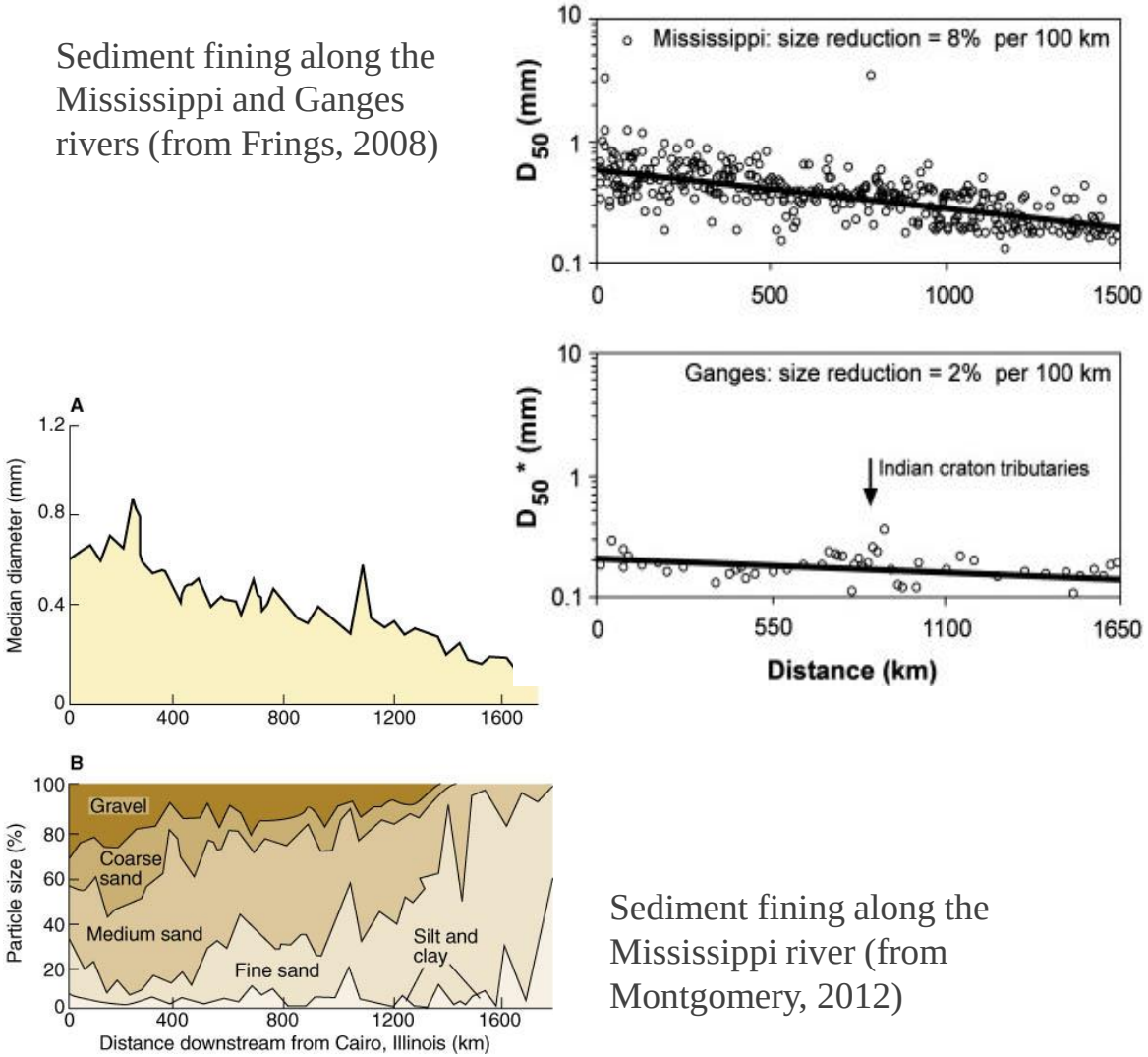
→ and silt and sand in major rivers and at the mouth



This is due to two primary reasons:

- **Abrasion**: coarse bed load is gradually reduced in size by scraping and downwearing
- **Selective transport**: coarser, heavier materials generally settle out first

Sediment fining along the Mississippi and Ganges rivers (from Frings, 2008)



Sediment fining along the Mississippi river (from Montgomery, 2012)