MANAGEMENT OF NATURAL HAZARDS
IN MOUNTAIN BASINS

River channel morphology: Long-term and flood-event changes

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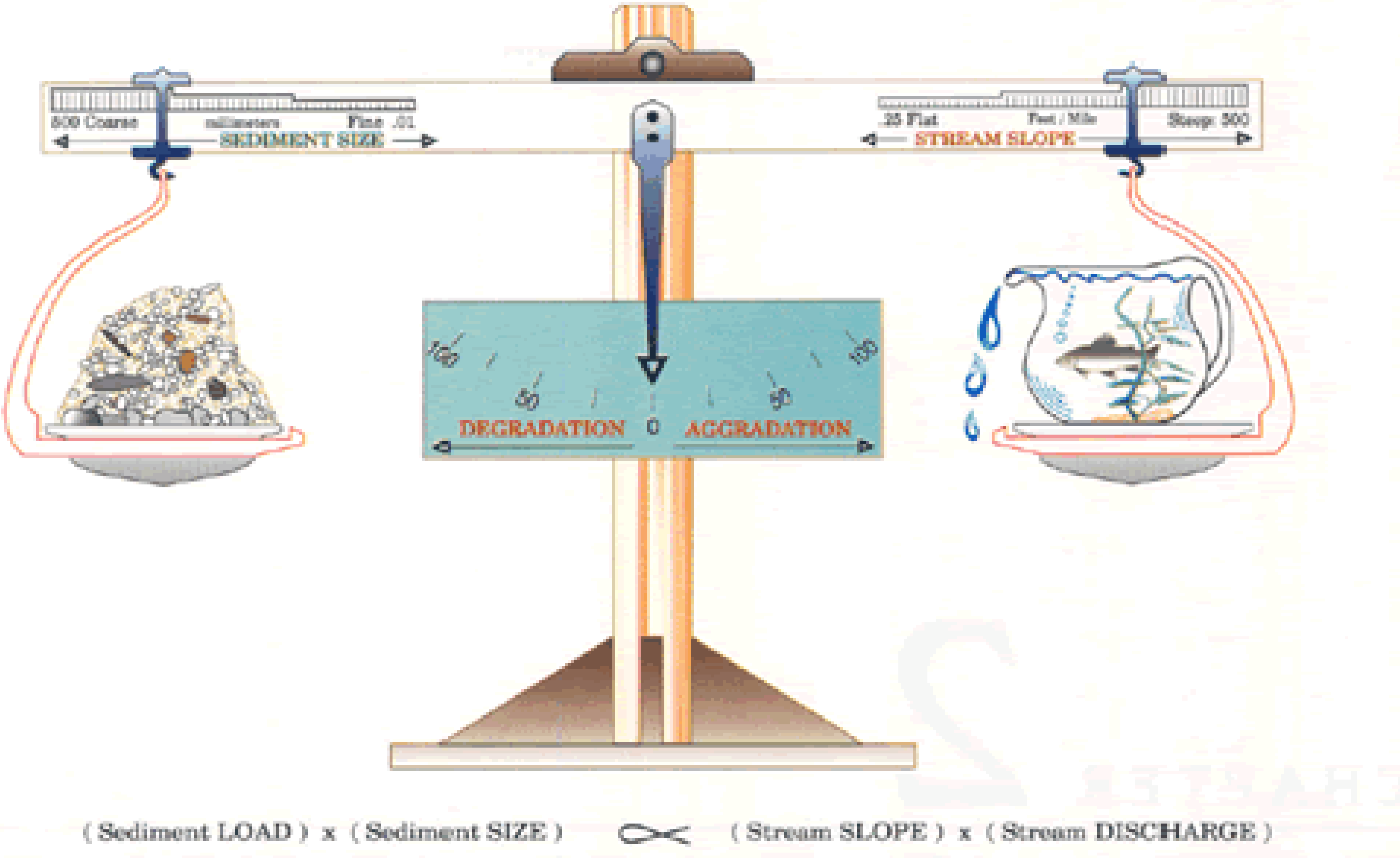
Credits to:
P.R. Bierman, D.R. Montgomery (2014) «Key concepts in Geomorphology»

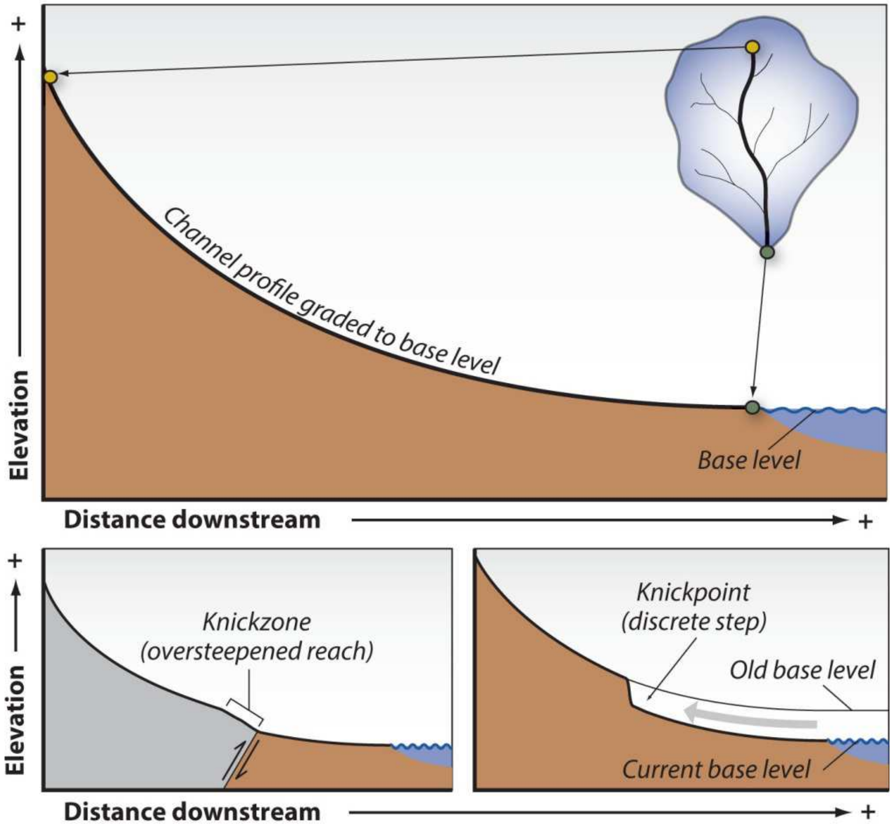
Sediment transport and channel dynamics

- The concept of dynamic equilibrium (Lane's balance, 1955)



Longitudinal profile

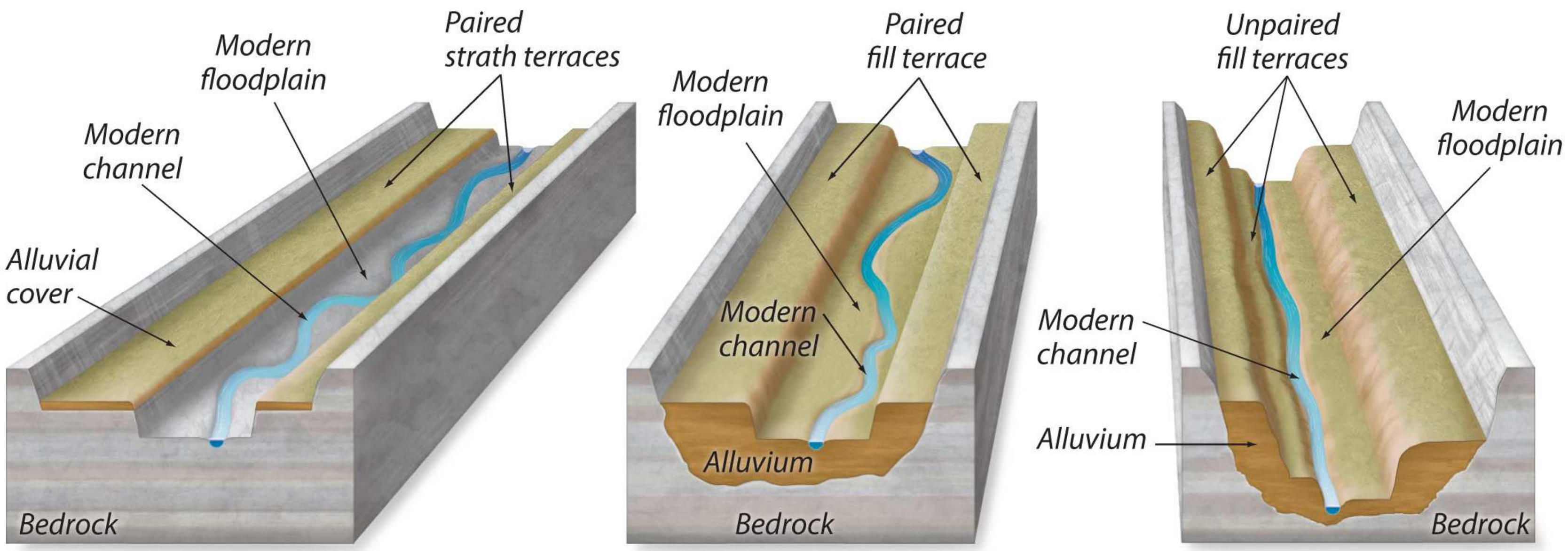
Examining the longitudinal profile of stream channels can be geomorphically informative. Channels with gradients that smoothly decrease downstream are considered **graded.** Channels with abrupt changes in steepness are thought of as being out of equilibrium and responding to changes in external conditions such as **base-level** change. However, channels can also establish a dynamic equilibrium where steeper reaches may reflect more resistant bed material.



Knickzones are areas where the bed of the river is steeper than up or downstream—a cascade or area of fast water. Such oversteepened reaches can reflect faulting or the presence of strong rocks that are resistant to erosion.

Knickpoints are discrete jumps in elevation along a river's bed, or waterfalls. Such jumps commonly retreat and grow less steep over time. Knickpoints can result from base level change, faulting, resistant rocks, or the lingering effects of valley glaciation.

Terraces



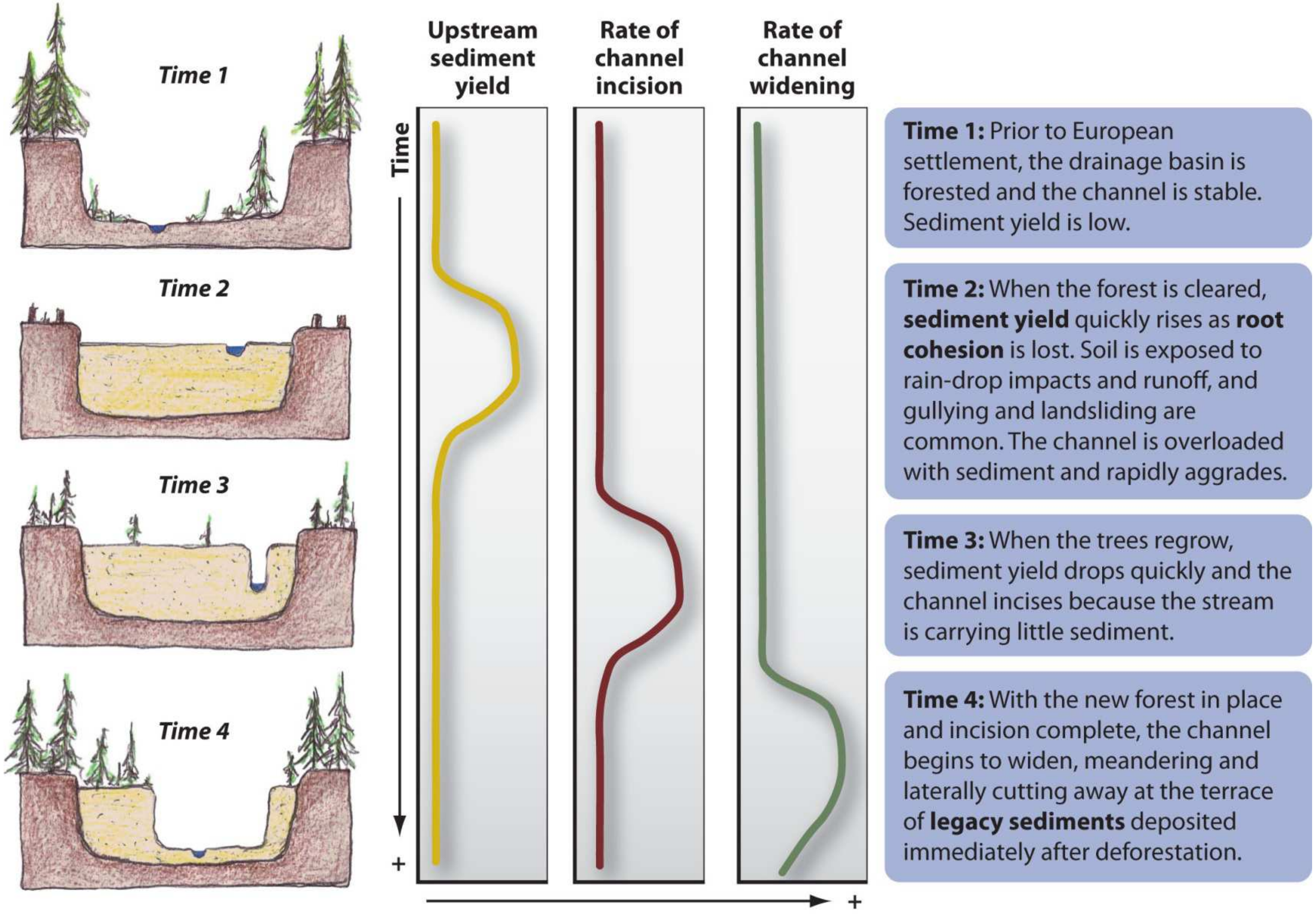
Erosional fluvial terraces are indicative of a geomorphic regime in which the river has sufficient energy not only to move the sediment load supplied to it, but to cut into the material that makes up the channel bed. Terraces formed by erosion are referred to as **straths.** Such terraces are frequently found in areas where active uplift or tilting provides the potential energy for incision. Straths can be covered by a thin layer of alluvial sediment.

Depositional fluvial terraces are indicative of river systems where sediment supply once exceeded the capacity of the river to transport sediment. The excess sediment was deposited in valley bottoms, filling them. At later times, if the sediment transport capacity increases (from more water, or steepening of the river gradient by tectonic tilting) or the sediment supply decreases, then the depositional surface can be incised.

Paired terraces are found at the same elevation across the width of a valley. Paired terraces form when river migration rates across the valley are rapid in comparison to incision rates. **Unpaired terraces** are found on only one side of the valley and result when rivers incise much more rapidly than they migrate across the valley bottom. Unpaired terraces also can result from stream erosion removing the terrace from one side of the valley but not the other.

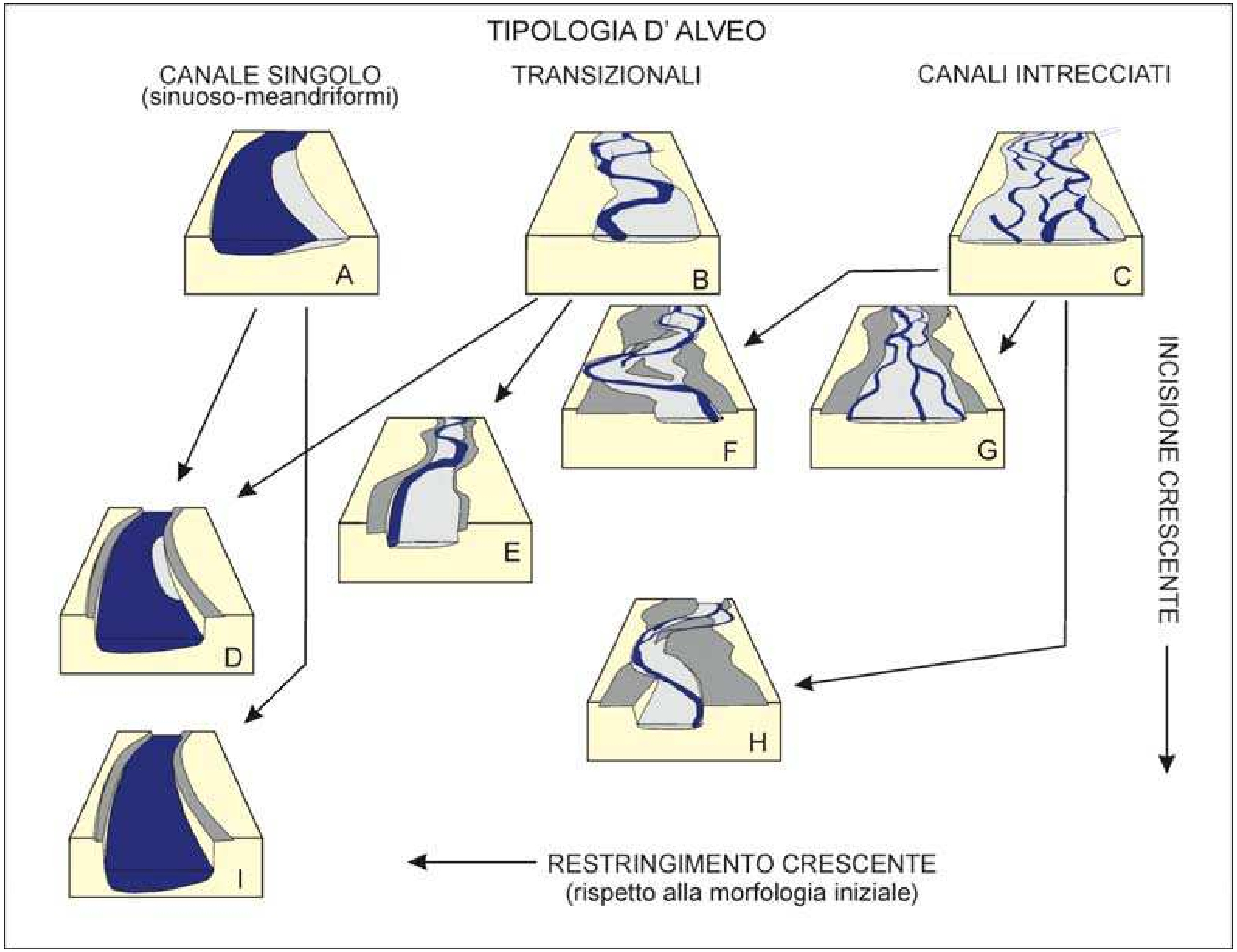
Terraces

Terraces and complex response

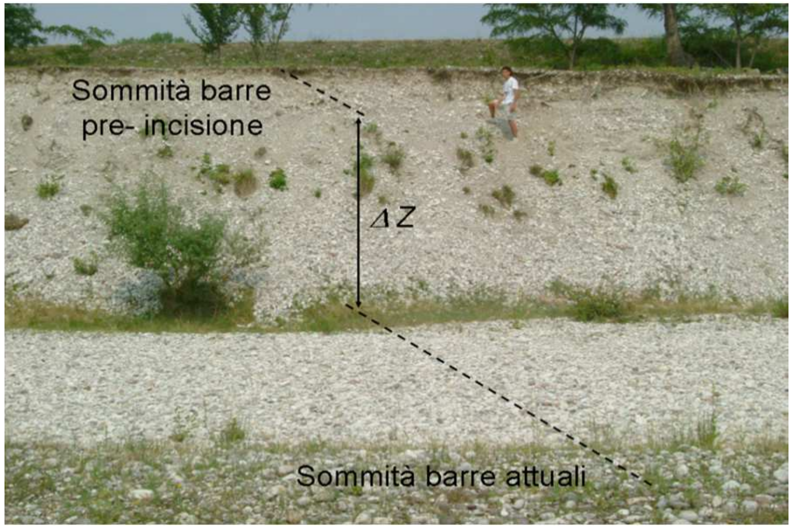


The channel evolution that resulted from European landscape disturbance in North America is a prime example of **complex response.** An initial perturbation, deforestation and other land-use changes such as agriculture, changed hillslope erosion rates and sediment supply to channels. Crossing a **threshold,** channels aggraded. When forests returned, another threshold was crossed and channels incised before starting to widen. The effects of land clearance several centuries ago are still reflected in a complex and interrelated set of landscape scale process and landform changes.

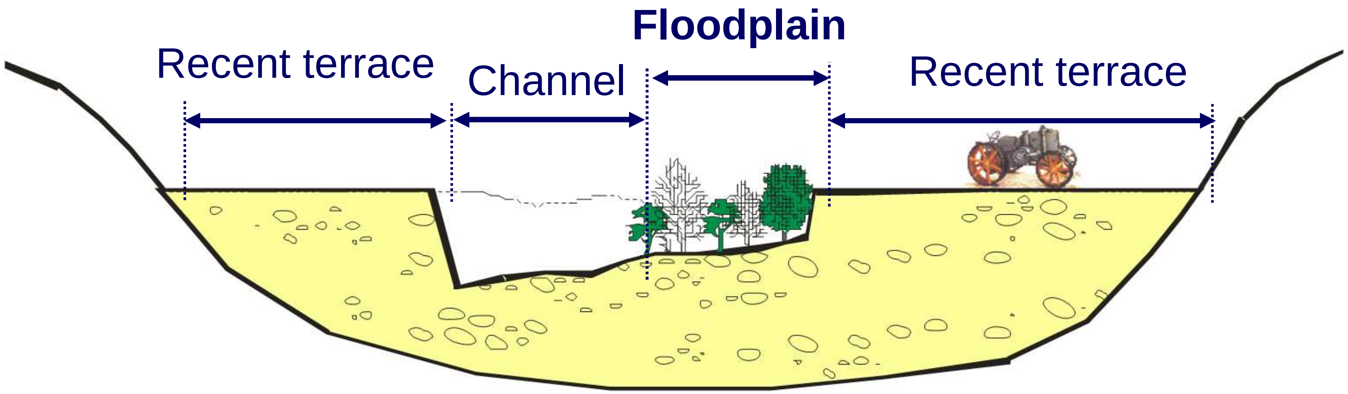
Channel narrowing and incision in Europe



Channel narrowing and incision in Europe



(Surian 2006)

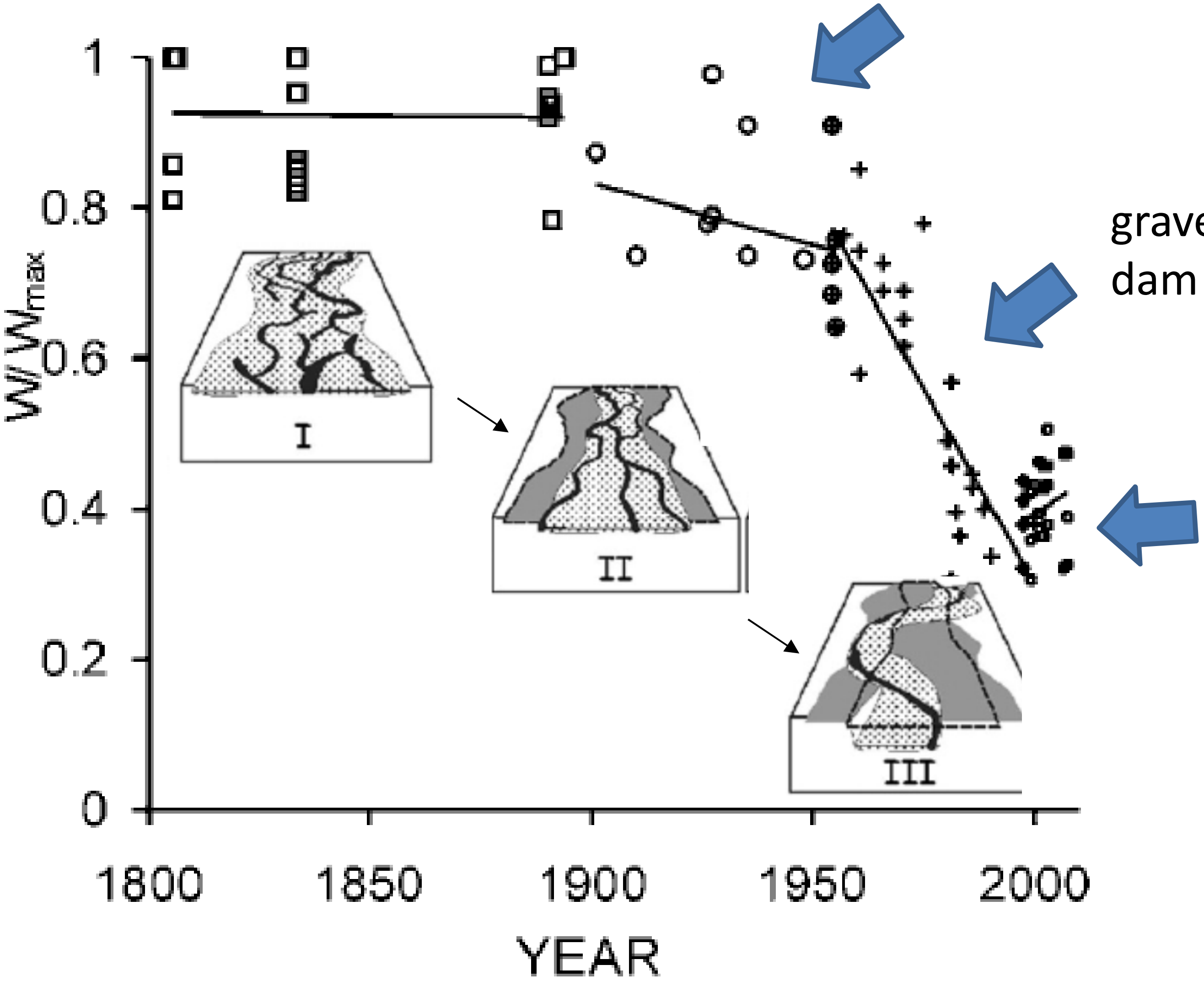


Channel narrowing and incision in Europe

Incresed forest cover (land abandoment)?
Milder climate ?
First control works ?

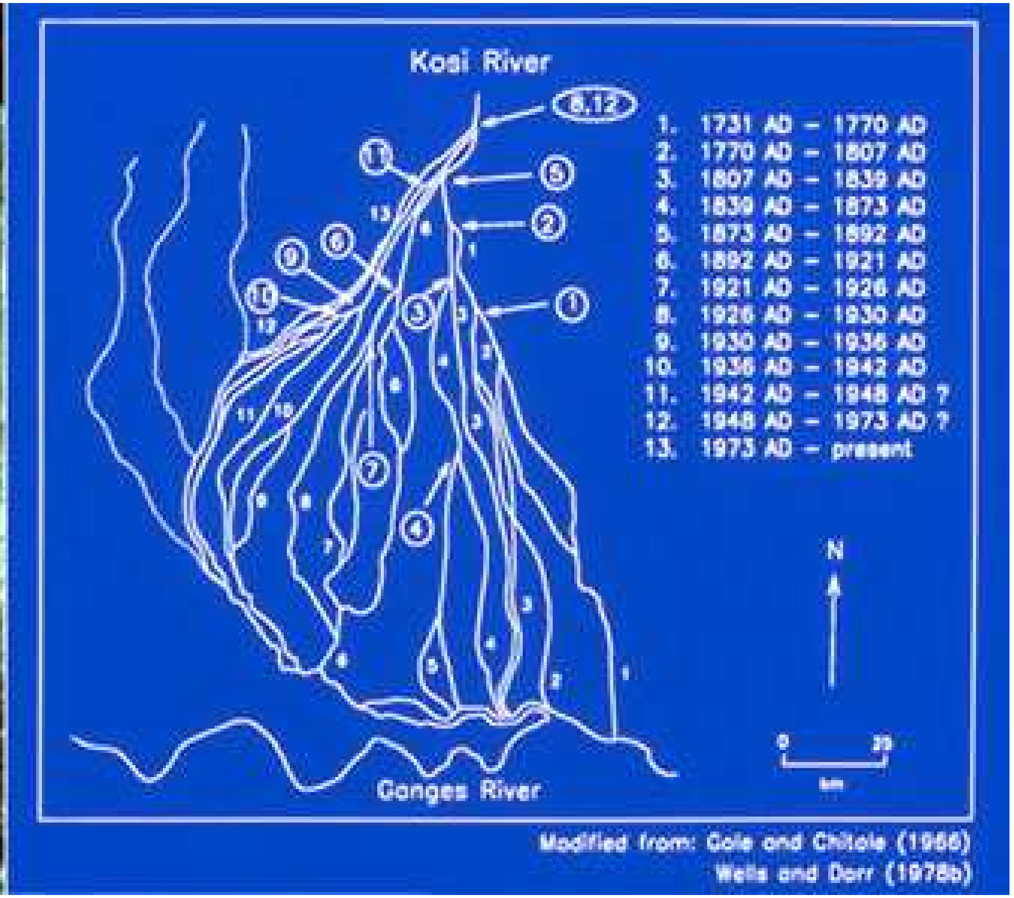
gravel mining and
dam building

Stop to gravel mining

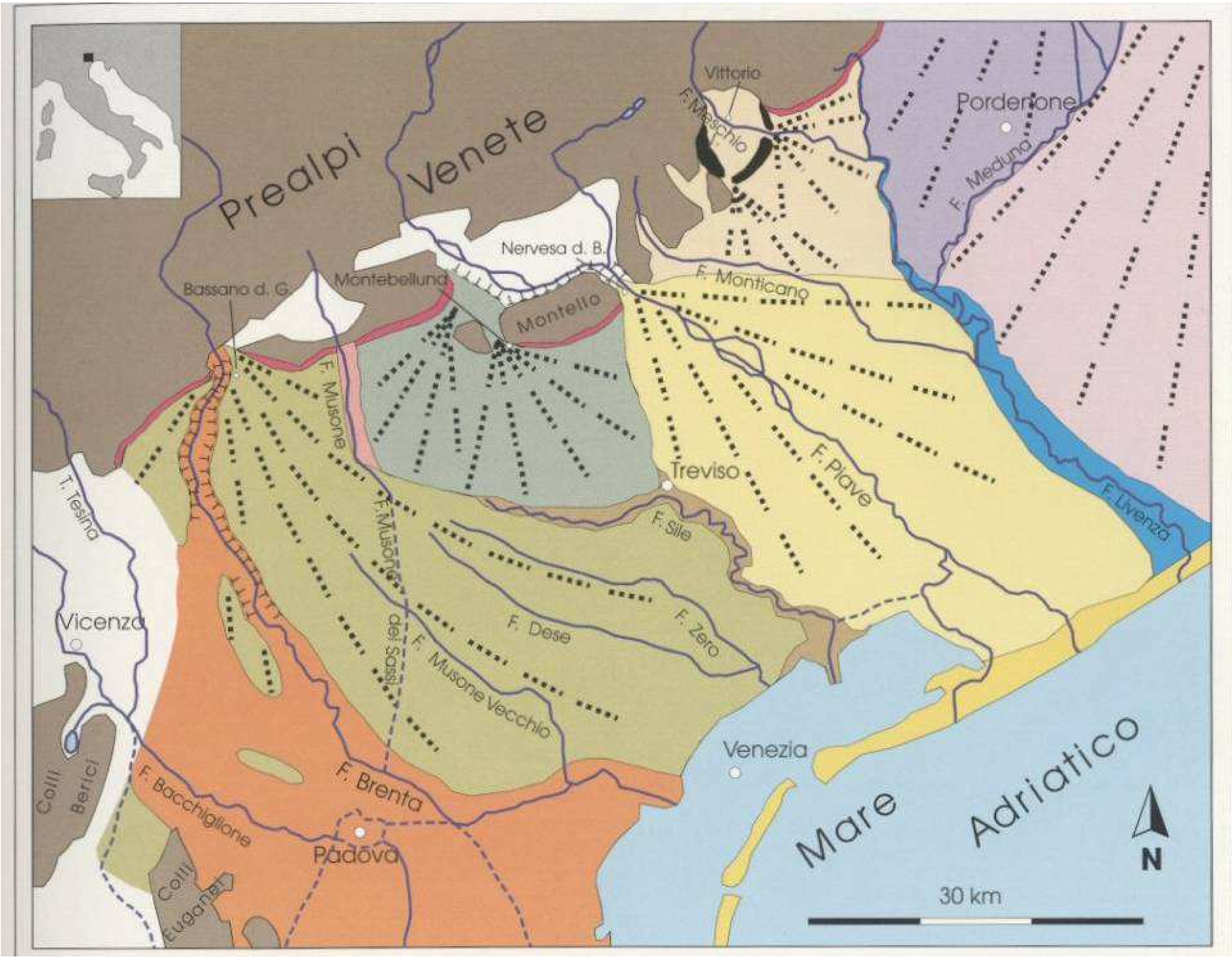


Long term fluvial dynamics: fan formation

• Channels change direction over time (avulsion events), gradually building up a slightly mounded conical alluvial fan landform.



Long term fluvial dynamics: megafans

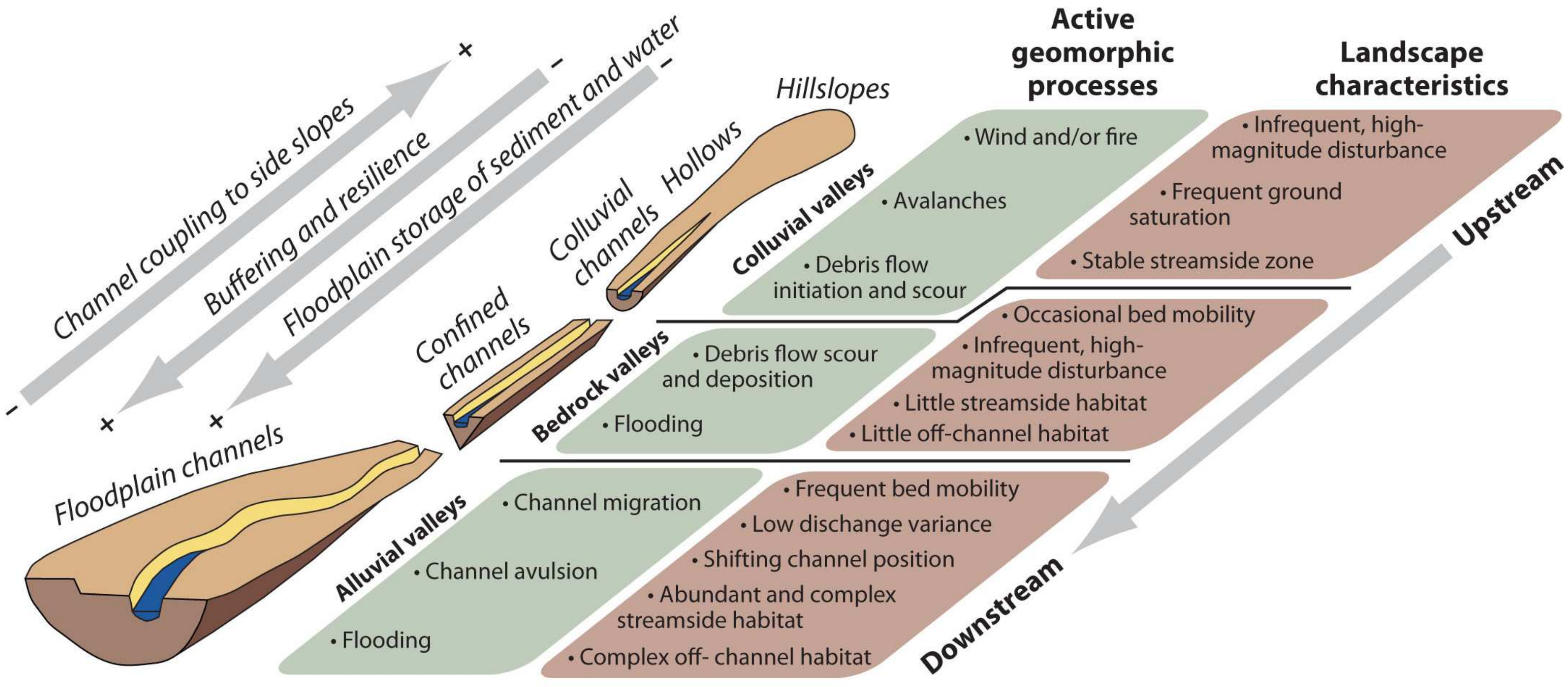


Long term fluvial dynamics: paleochannels

• Evidence of past river courses visible on the floodplain, recent terraces, and alluvial fans

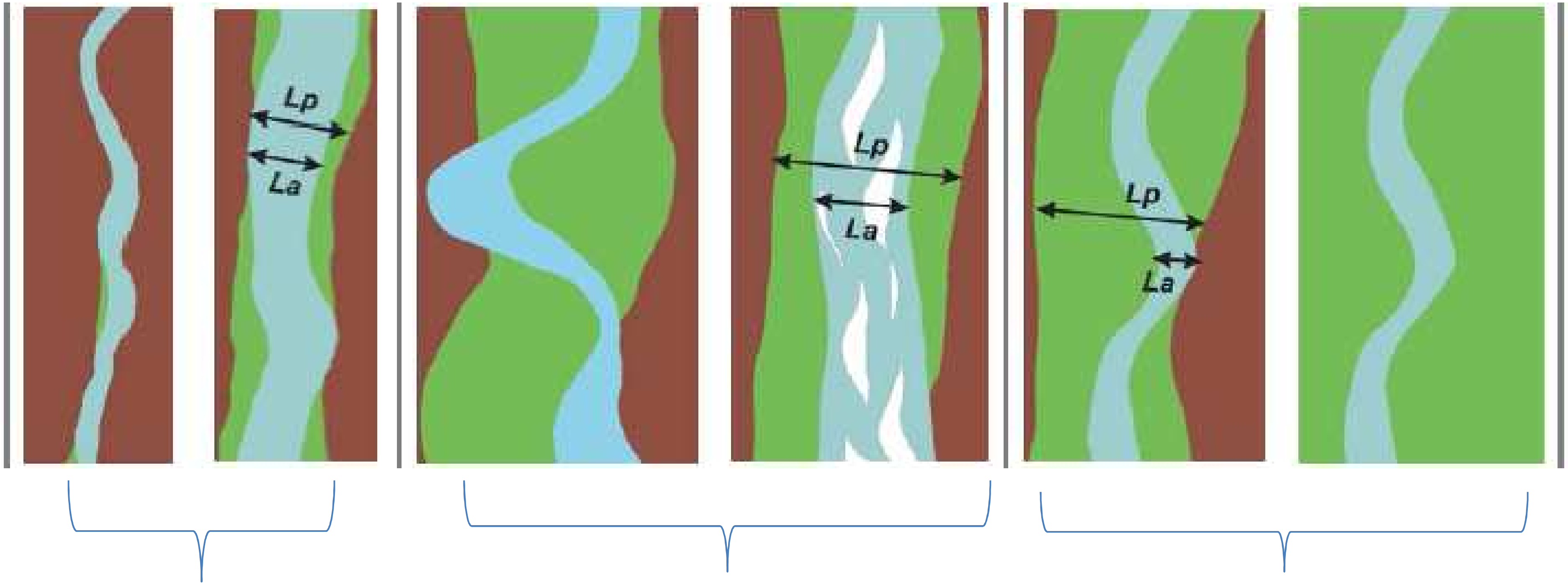
• Channels abandoned following avulsions or river captures

Geomorphic processes in the channel network



- The main long-term and flood-event fluvial adjustments differ from confined to un-confined (floodplain) channels

Confined, partly- and un-confined channels

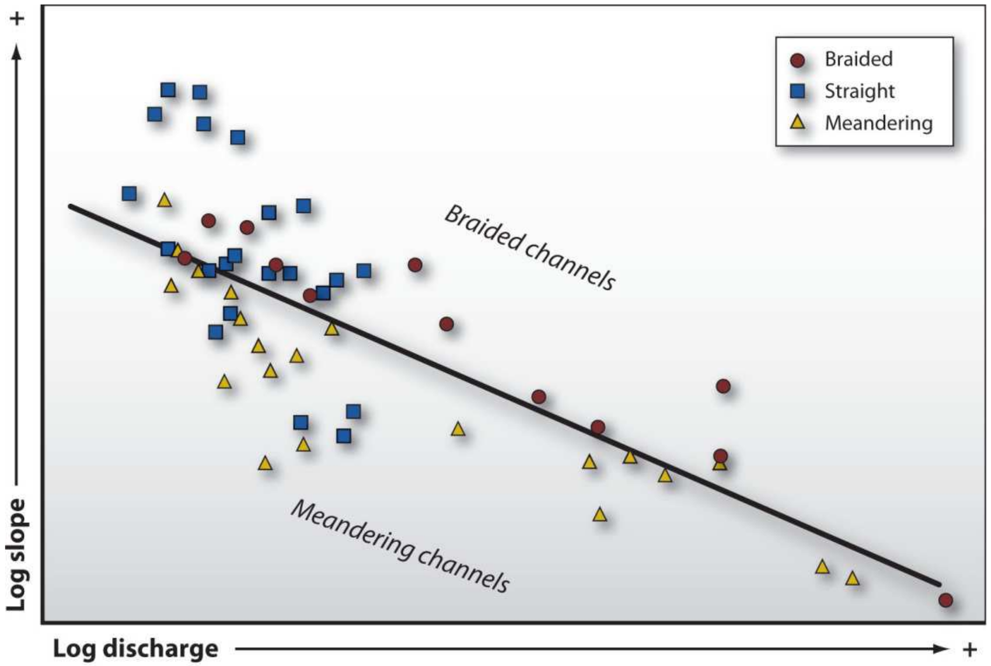


confined

partly-confined

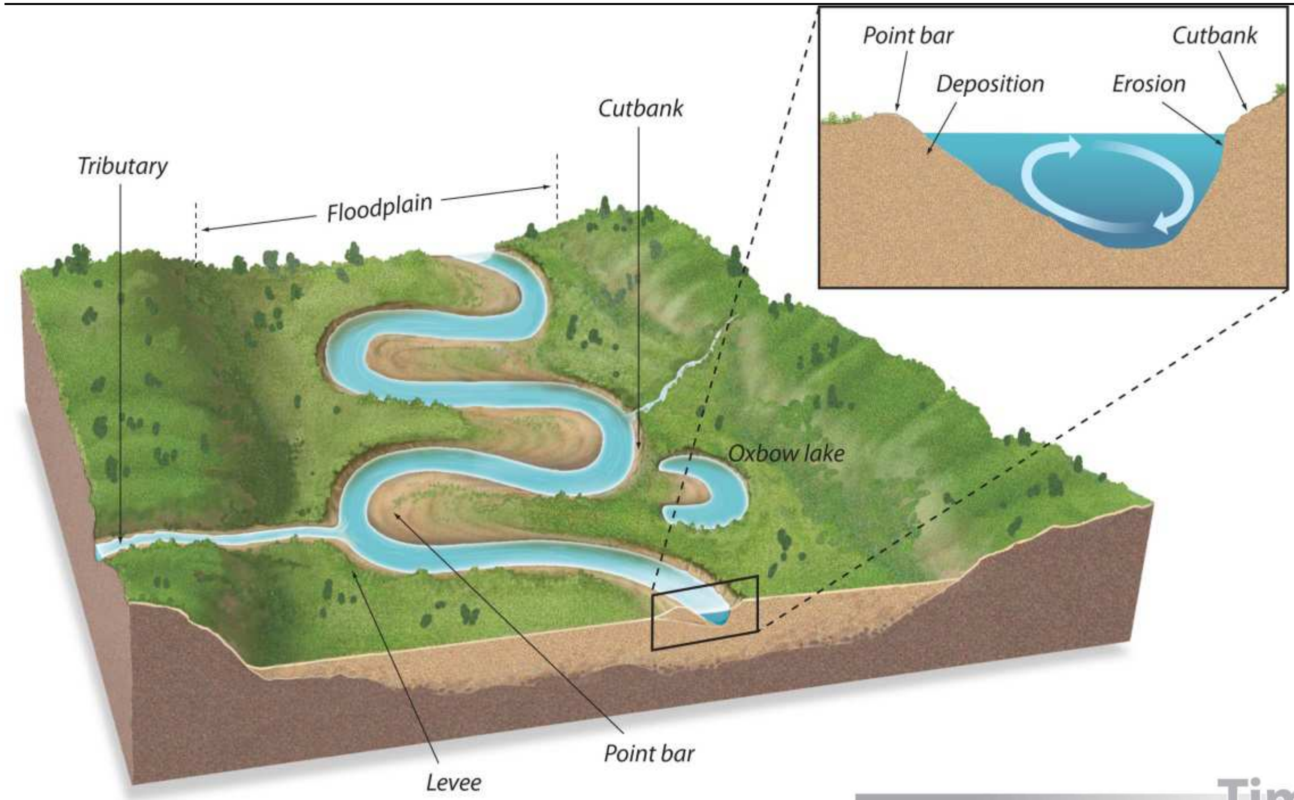
unconfined

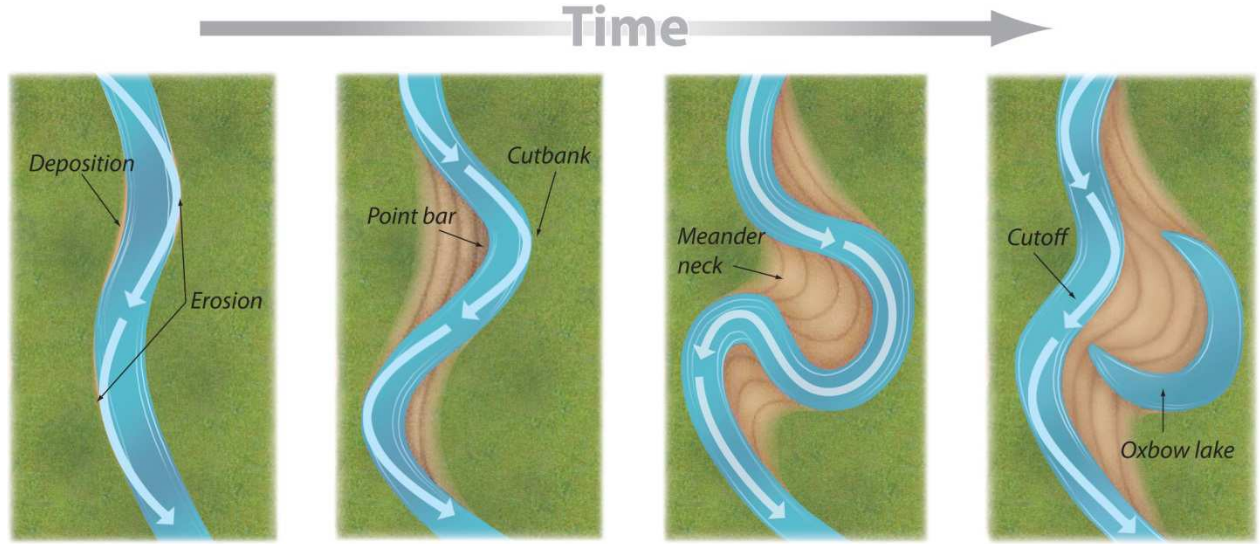
Channel morphology: planform types



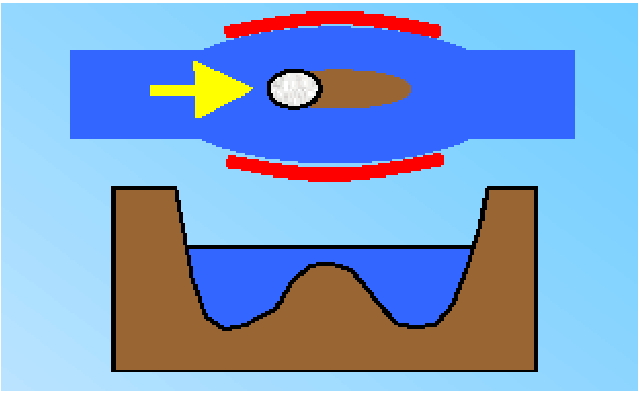
Discharge and slope influence channel planform patterns. At a particular slope, higher discharges are likely to produce **braided channels.** Likewise, for a particular discharge (or stream size), **meandering channels** tend to have lower slopes than do braided channels. **Straight channels** occur at low discharges over a variety of slopes. Sediment supply and the variability in discharge also play a role in determining channel form.

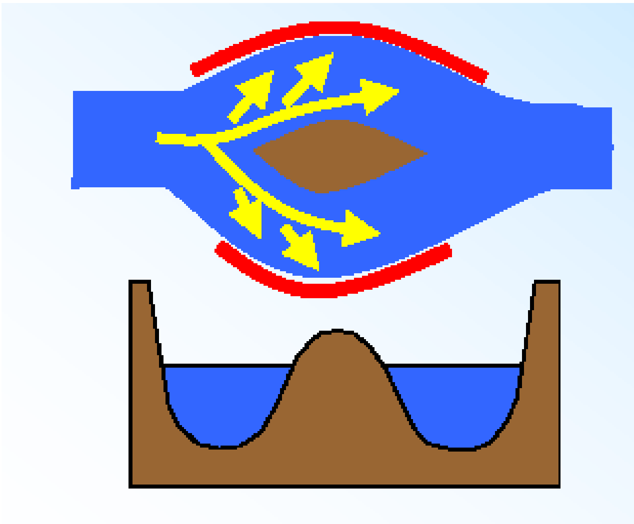
Channel morphology: meandering dynamics

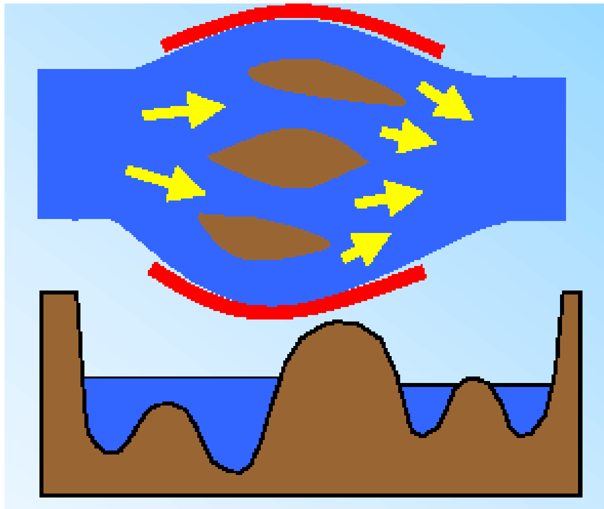




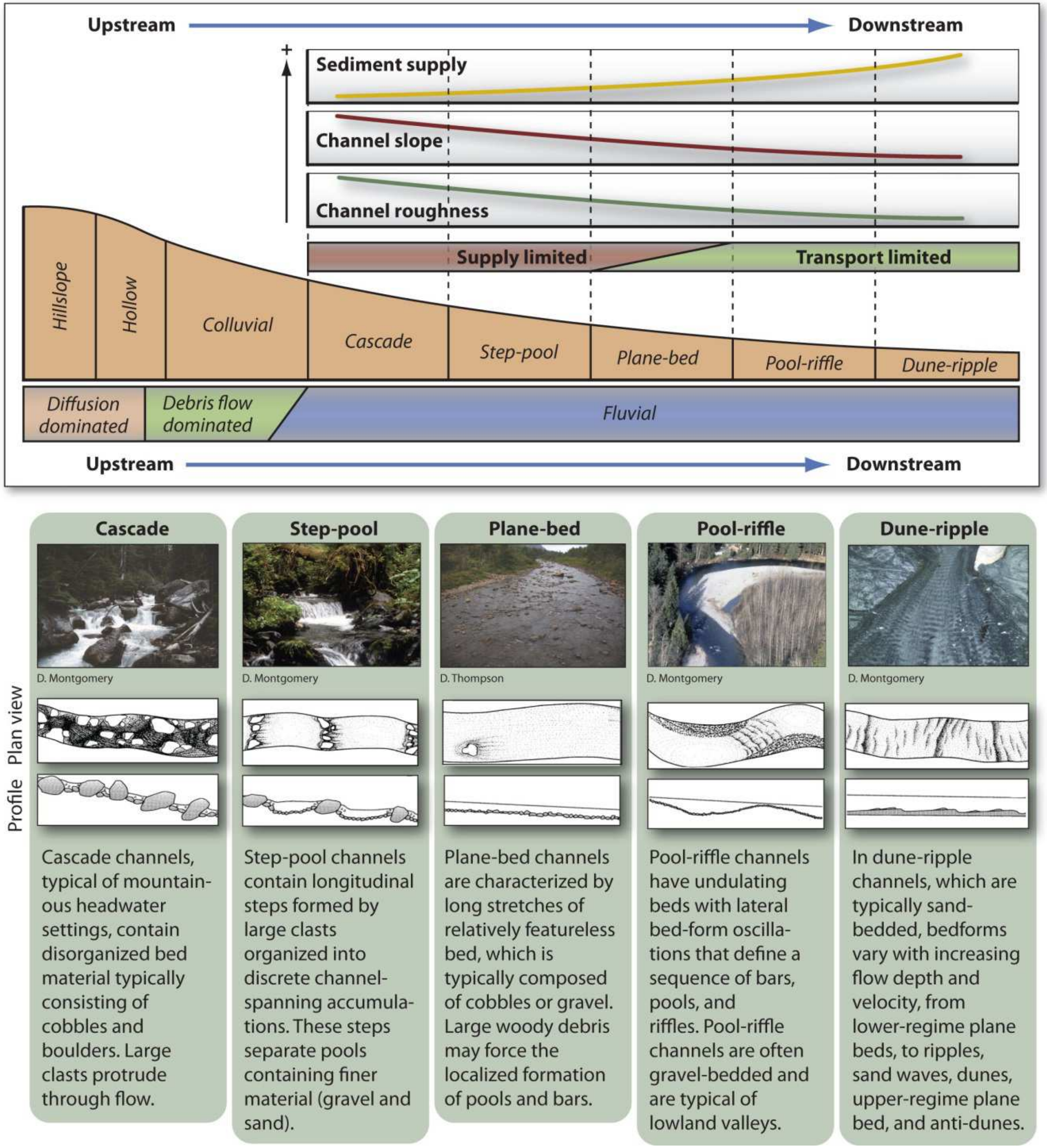
Channel morphology: medial bars and braiding







Morphology of single-thread confined channels



Floods in mountain basins: what happens ?

In steep reaches (>2-4%)

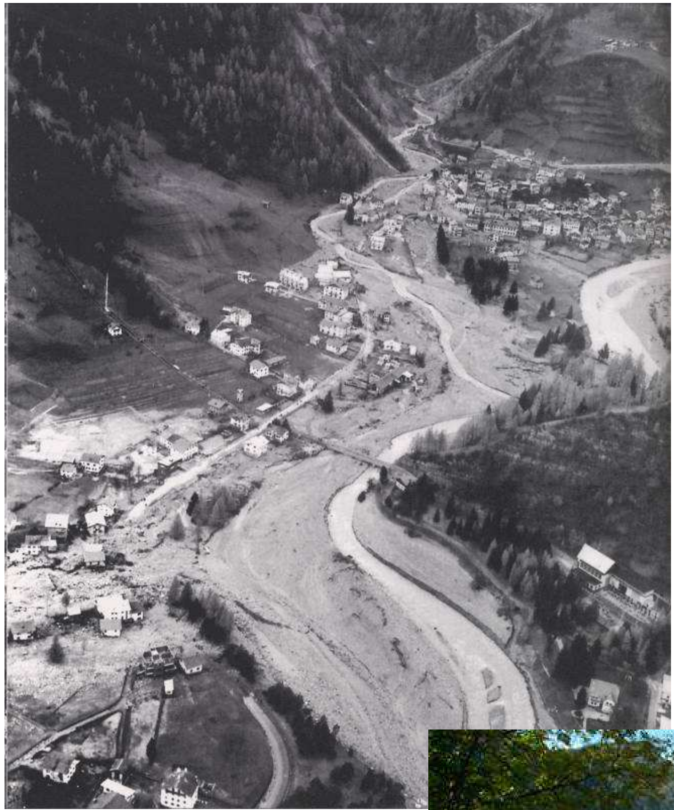
• Bed incision

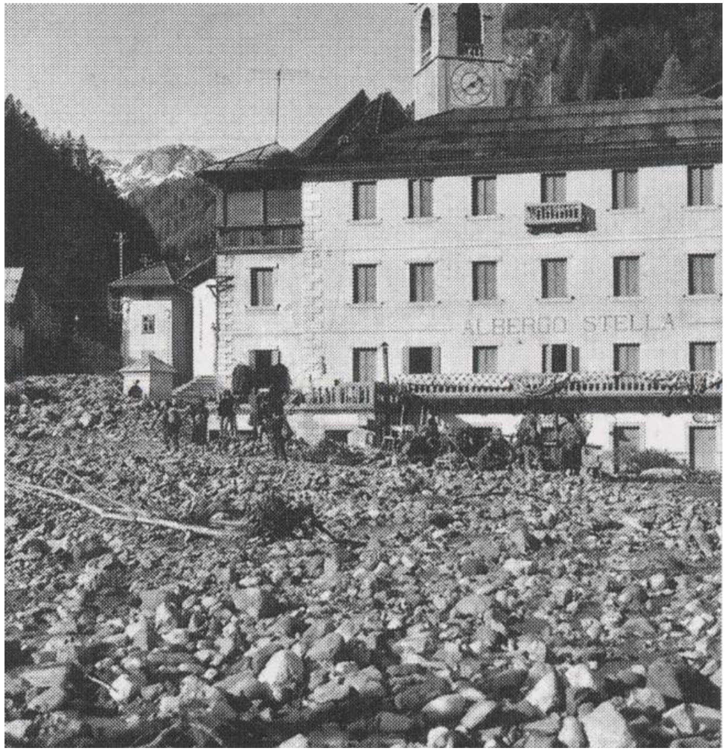
Floods in mountain basins: what happens ?

Floods in mountain basins: what happens ?

In mild reaches (<2-4%)

- Deposition of coarse sediment
- Avulsions (on fans or in less confined reaches)

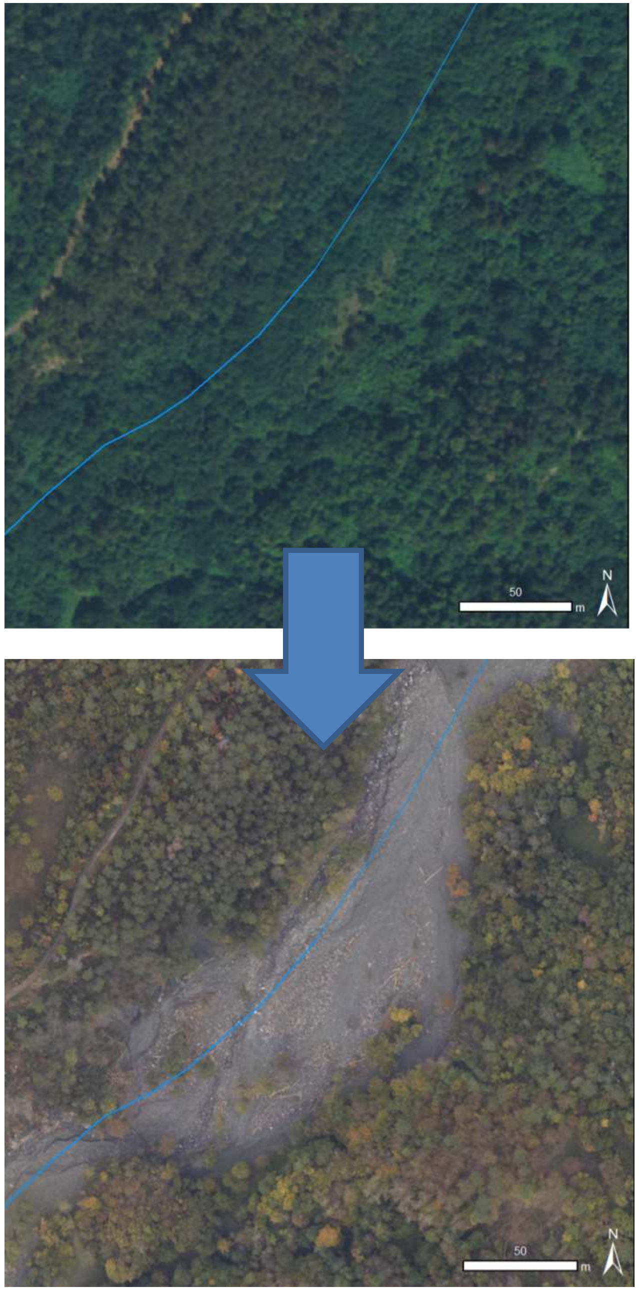


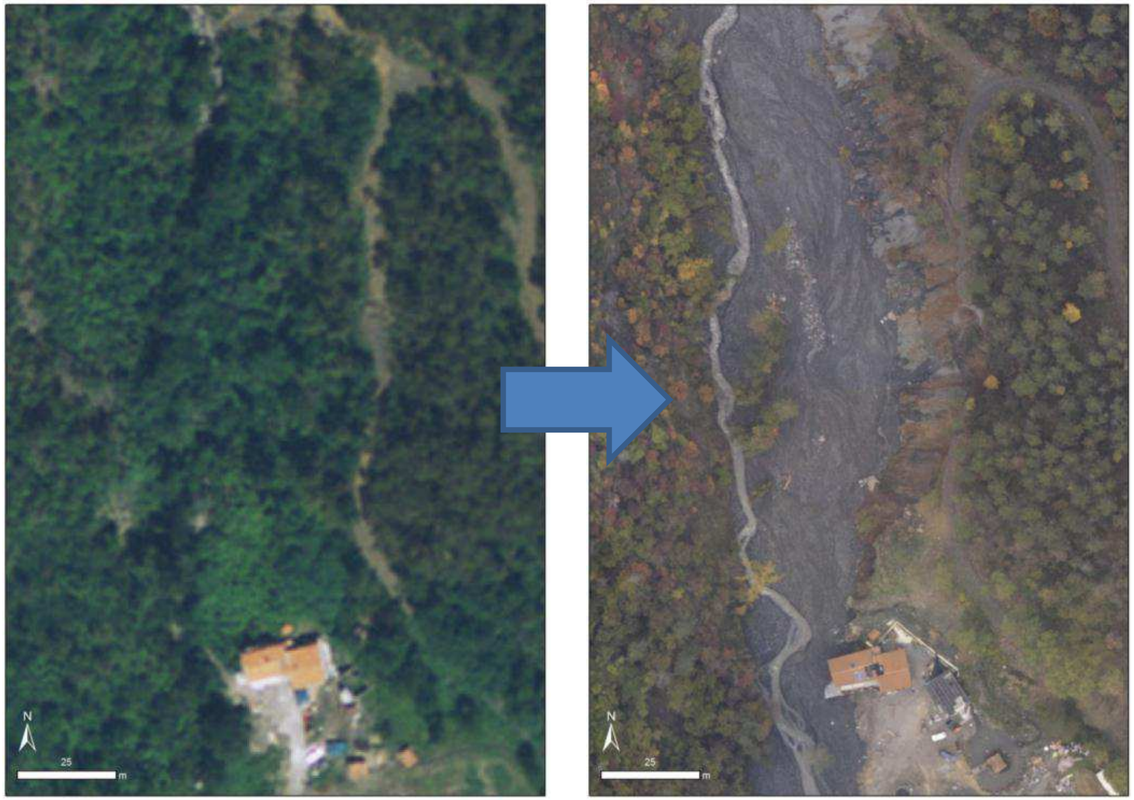


Floods in mountain basins: what happens ?

In partly- to unconfined reaches

- bank erosion
- channel widening





Floods in mountain basins: what happens ?

In confined or partly-confined reaches

- Landslide dams

✓ Dam-break flows downstream

✓ Backwater and aggradation upstream

Floods in mountain basins: what happens ?

In forested basins

- Wood jams at bridges and other structures

↓

✓ Avulsions
✓ Backwater effects