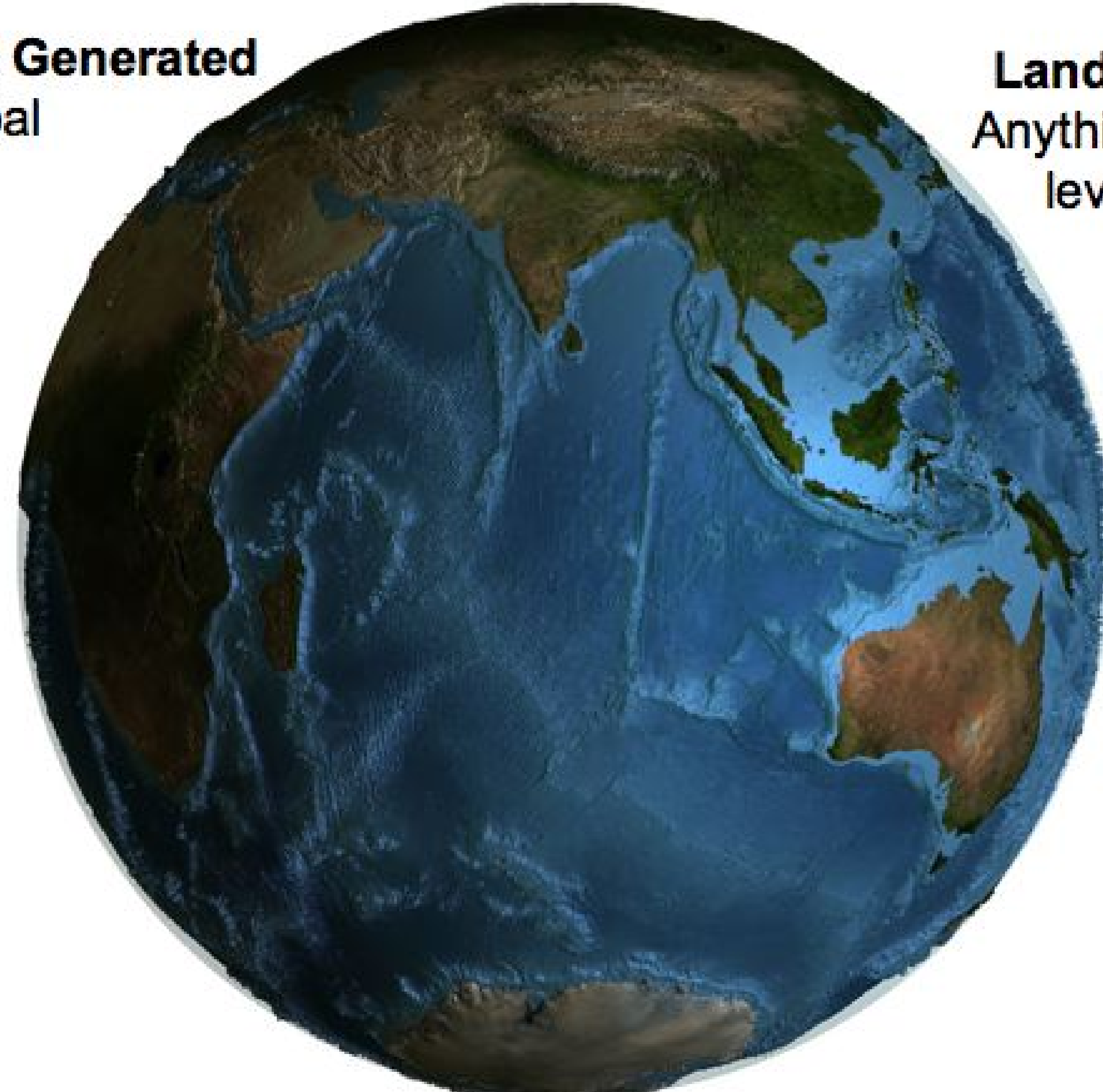
Fluvial Processes and Morphology:

- Landscapes and Drainage basins
- Driving and resisting forces
- Energy and work in river channels
- Spatial and Temporal Scales
- Thresholds
- River taxonomy and flow patterns
- Streams in equilibrium
- Streams in disequilibrium

The Simple Big Picture:

Landscapes Generated
Through global Tectonics (Endogenic Processes)

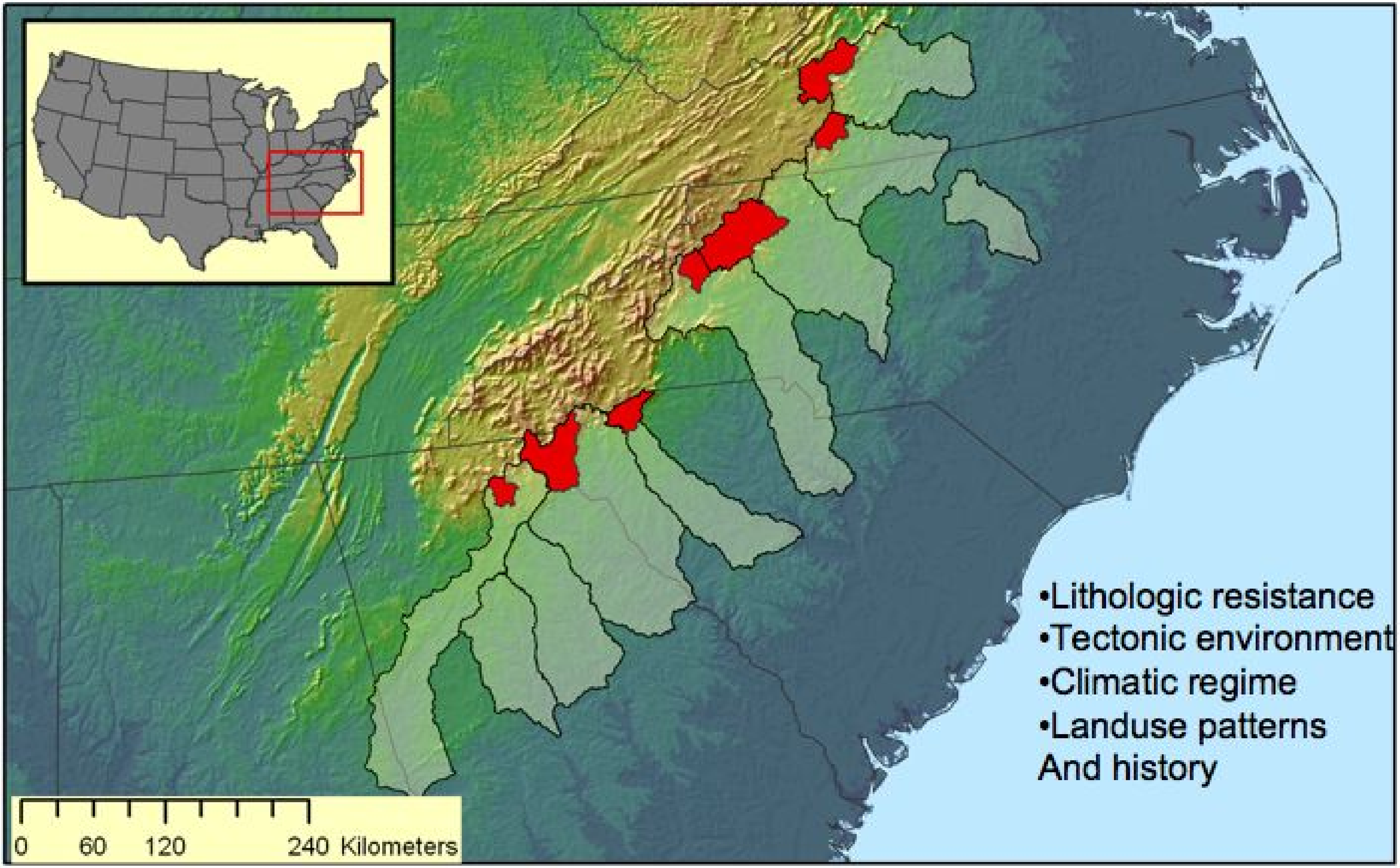


Landscapes Erode
Anything above Sea-level is constantly dismantled

Geomorphic Agents:

- Ice
- Wind
- **Water**

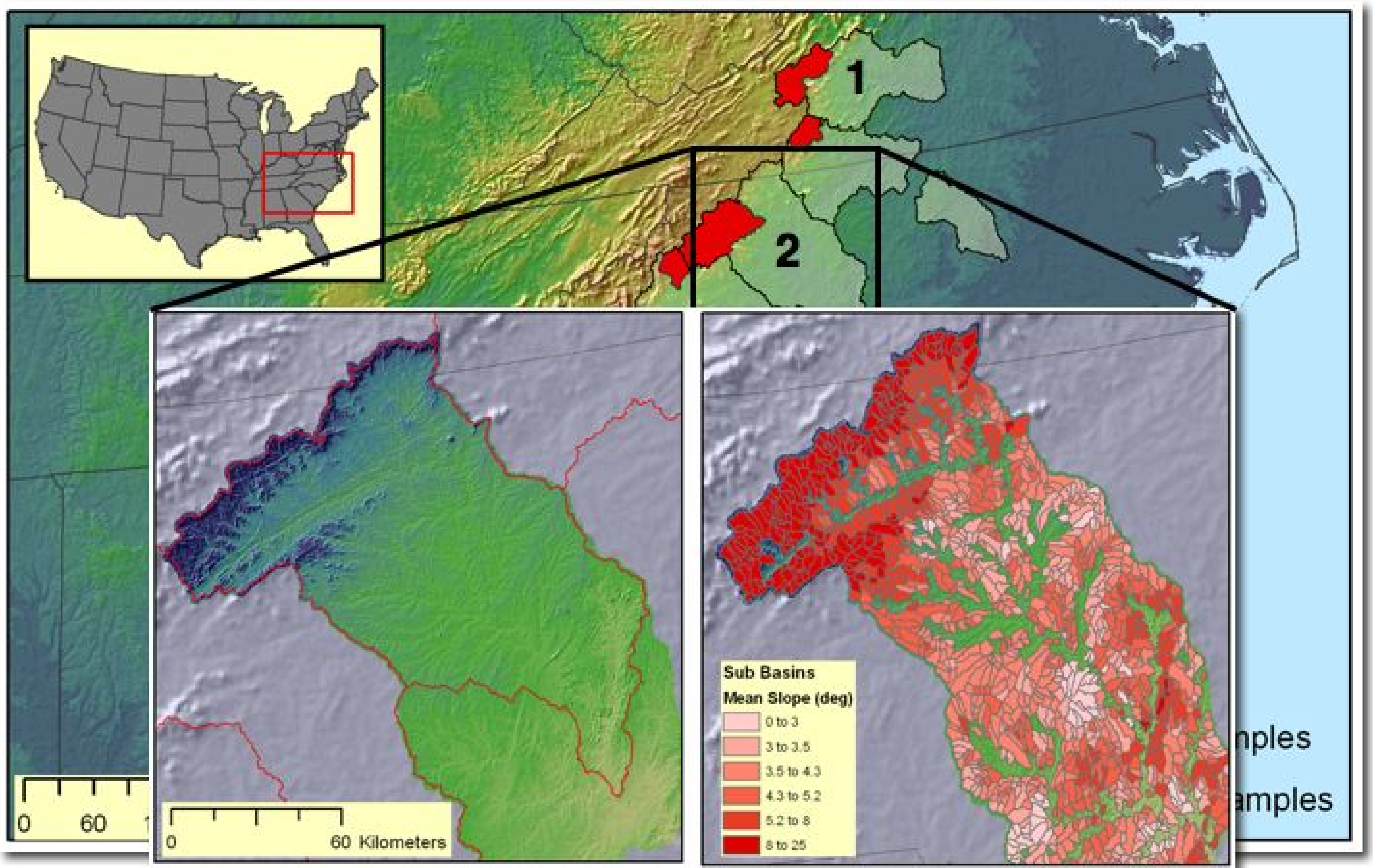
Any Landscape is divided into hydrologic Units - drainage basins:



- Lithologic resistance
- Tectonic environment
- Climatic regime
- Landuse patterns

And history

We can consider fluvial processes
At a number of spatial and temporal scales:

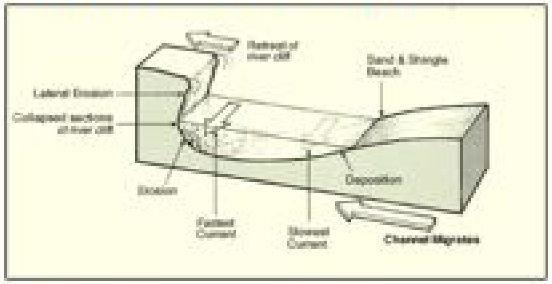


The Drainage System:

•Hillslopes

•River channels

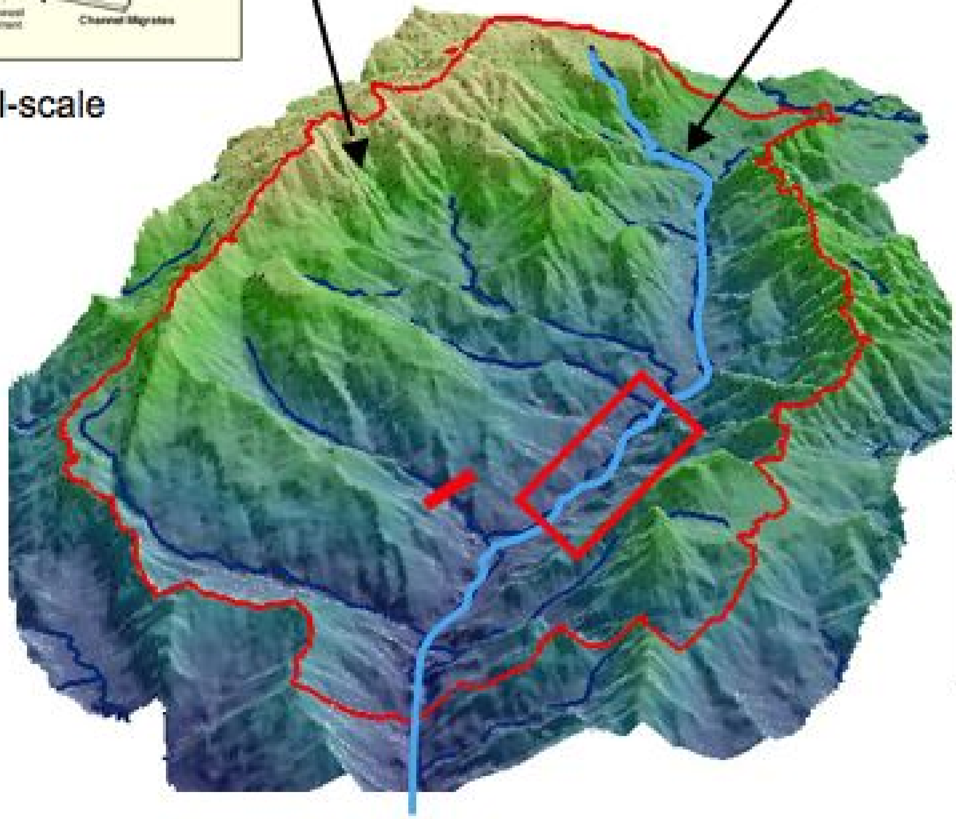
1. Rivers in x-section:



•Relatively small-scale

2. Rivers in plan-view:

•Intermediate-scale



3. Rivers in Long-Profile:

•Relatively large-scale

4 ways we're going to consider river channels

4. Channel and Drainage System Change Through Time:

- **X-section:** bank erosion and deposition - channel migration:

- **X-section:** channel bed incision vs. aggradation:

- **Plan-view:** changes in drainage pattern through time:

- **Long-Profiles:** changes through glacial-interglacial and geologic Time. **Fluvial Terraces** - our keys to the past…

- **Human-Landscape Interactions:** effects of land-use change on Fluvial systems:

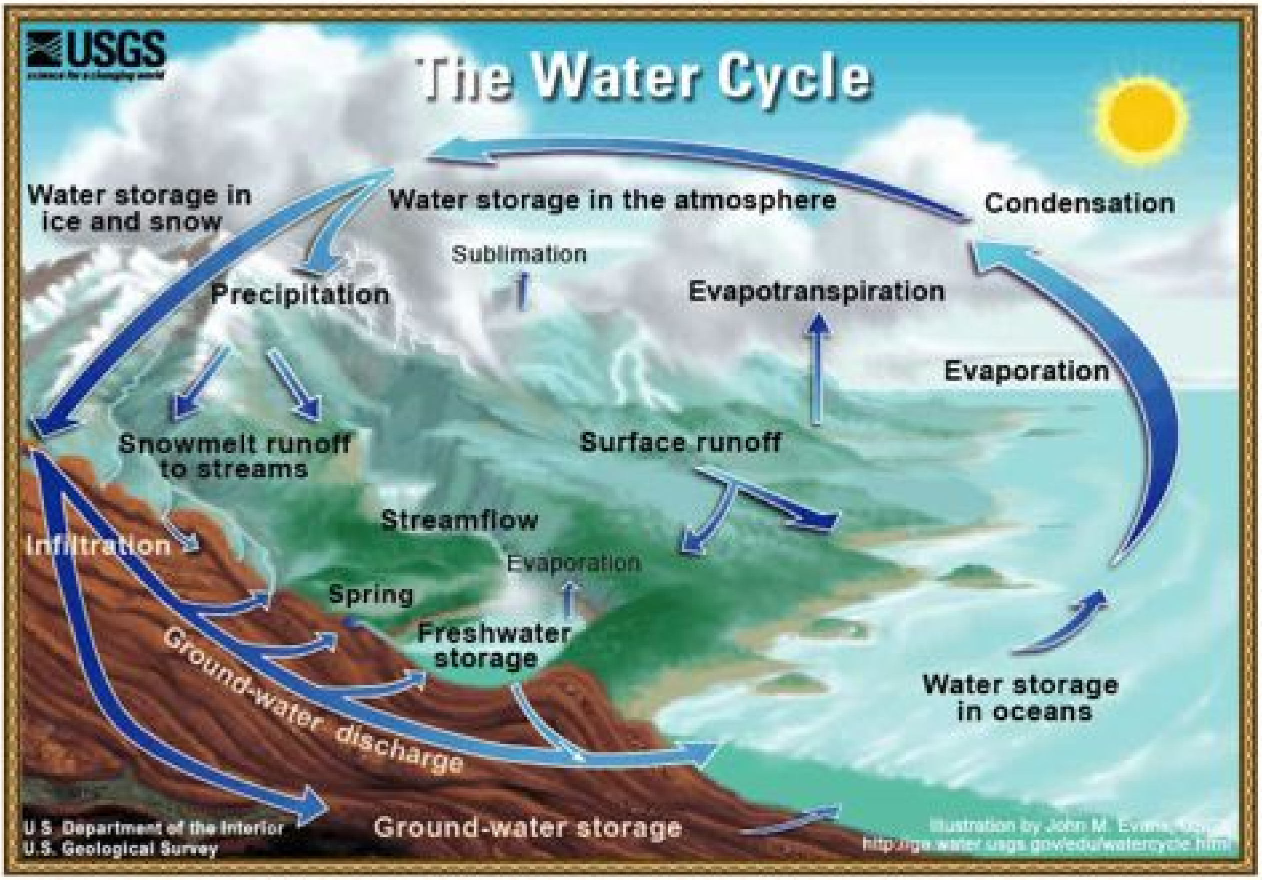
- **Effects of Changing Climate** on hillslope and fluvial processes.

Where to Start?

1 - Water

2- Energy

The Water:

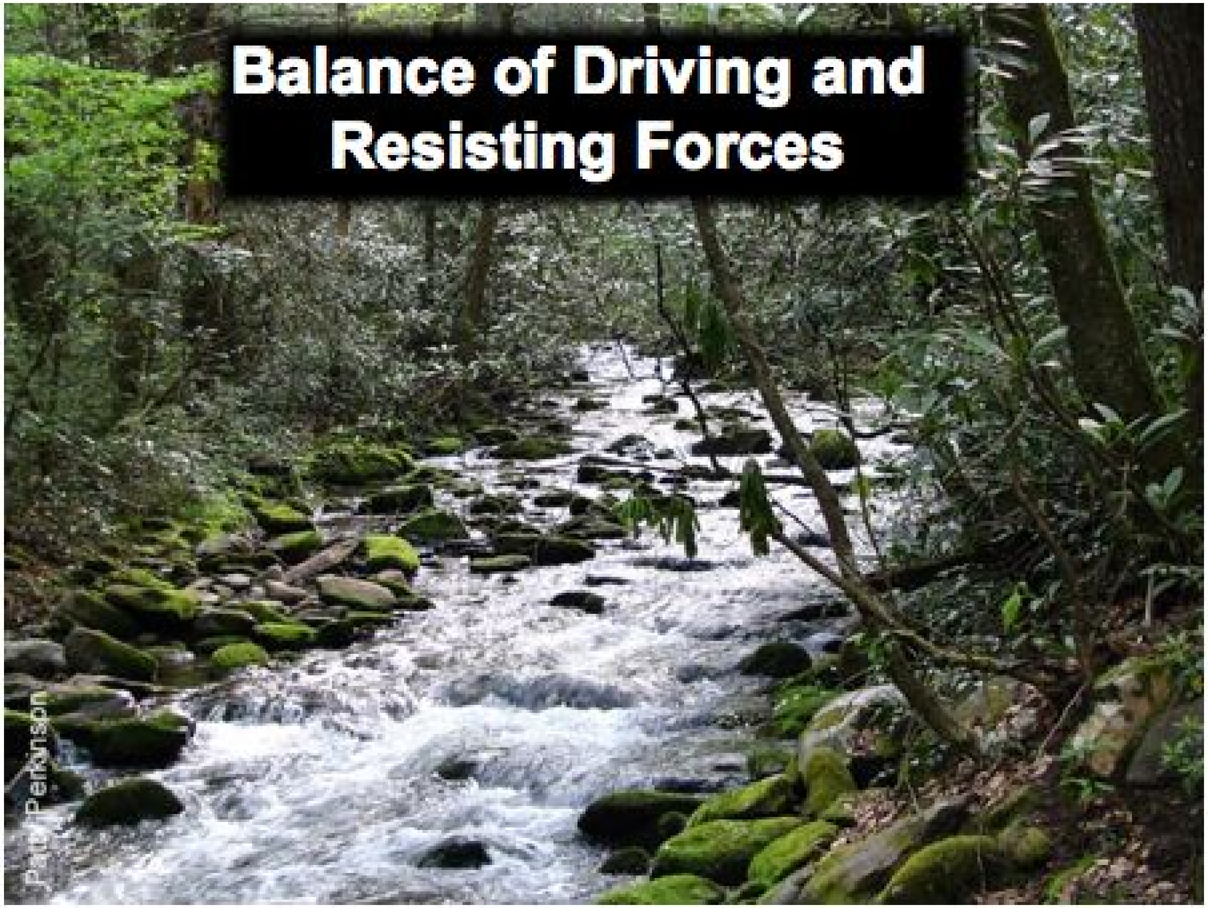


- Solar Forcing drives the hydrologic cycle.
- Provided Precipitation and water to hillslopes and River channels.

The Energy:

Driving Force: PE = mgh ~Δ h

•Gravity responsible for the movement of water down Gradient
•Tectonics maintains gradient and height.



Resisting Forces:

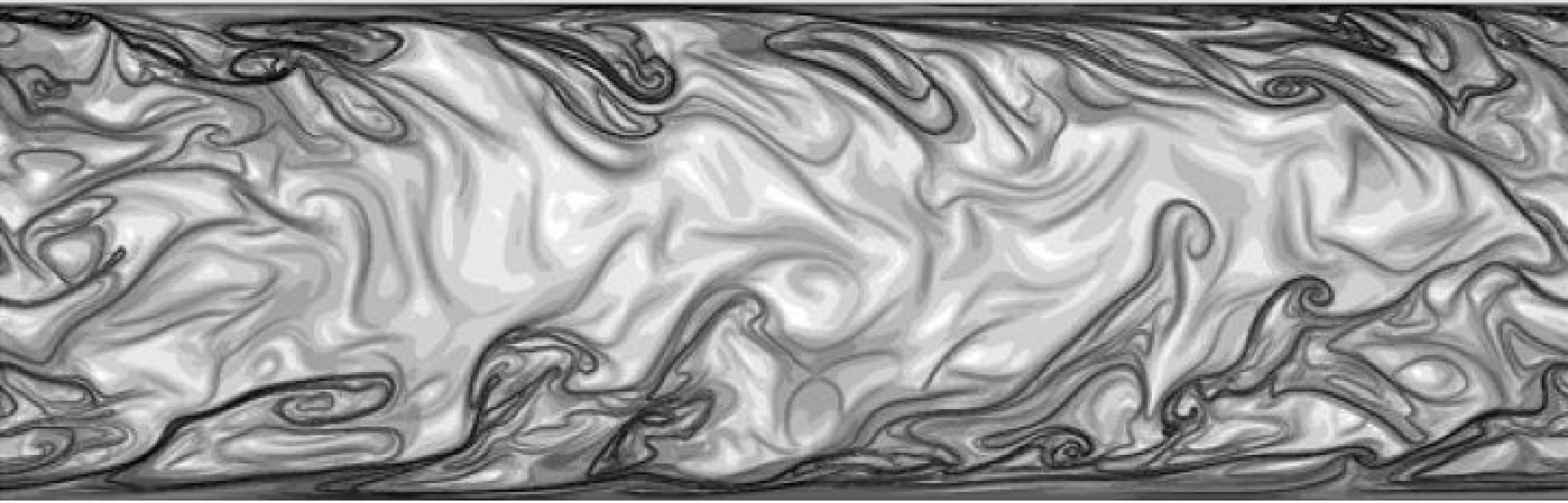
•Channel Properties:
Width-depth relationships
Lithology

•Bank and Bed roughness

•Vegetation

•Erosion and transportation
Of sedment.

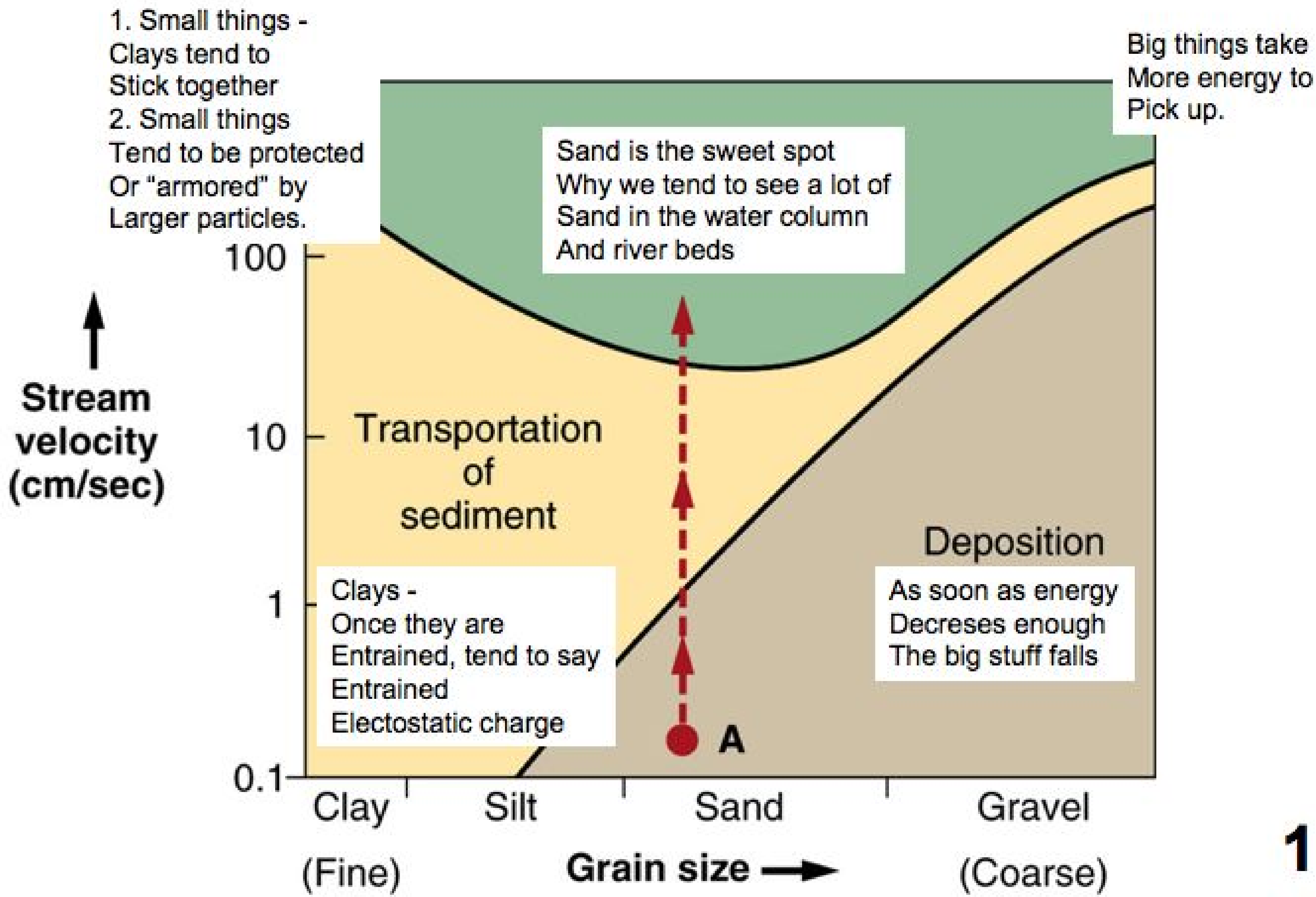
Turbulent Flow:



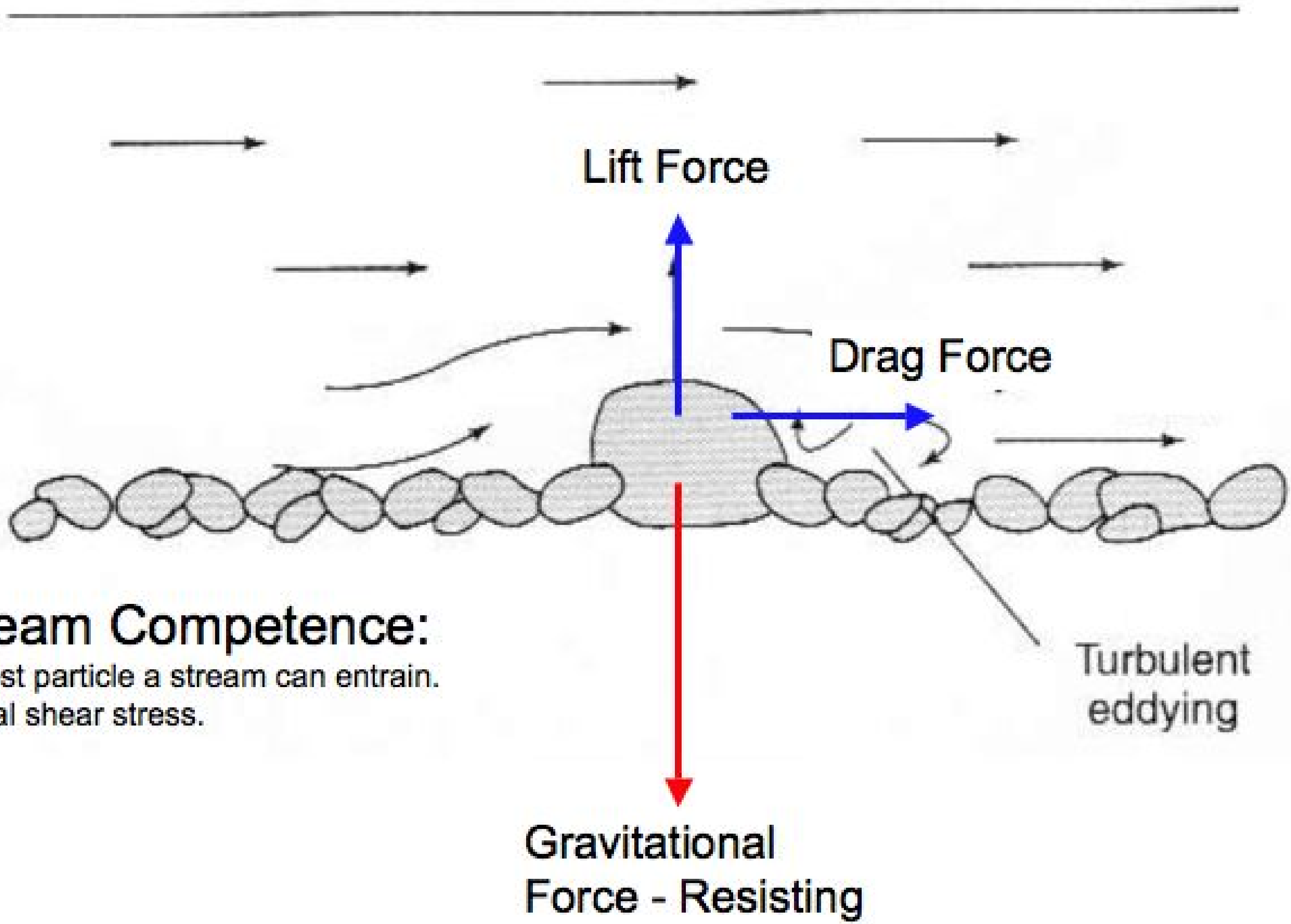
- Majority of Energy in the system is dissipated through turbulence caused by Channel irregularities.

- Remaining energy goes into the **Erosion and Transportation** of Sediment.

Hujlstrom Diagram:



Particle Entrainment:

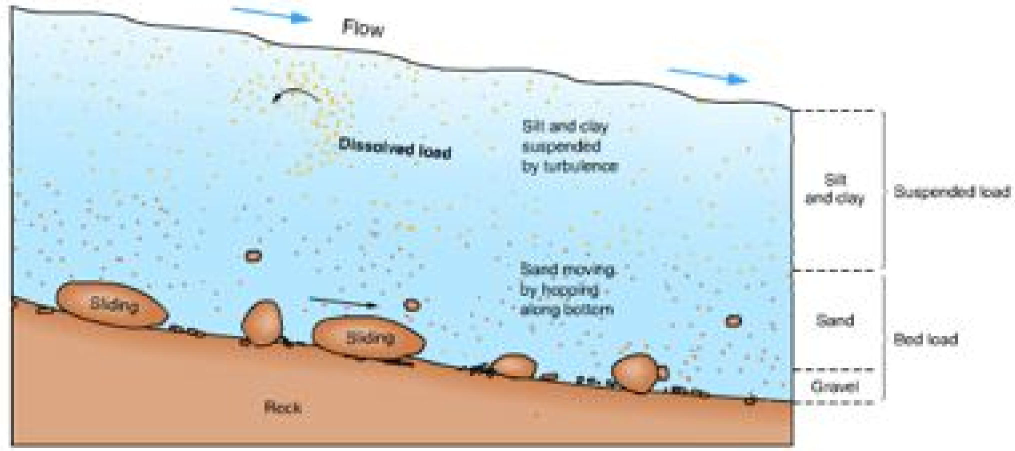


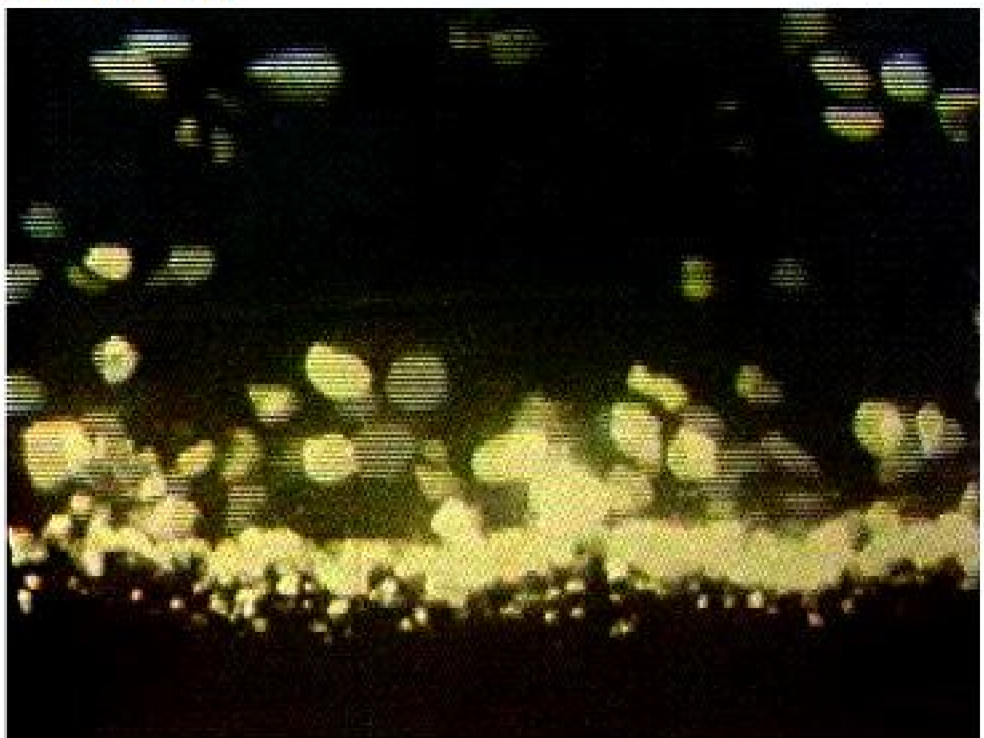
Stream Competence:

Largest particle a stream can entrain.
Critical shear stress.

Modes of Sediment Transport

- Suspended Load
- Bed Load
  - Sliding
  - Rolling
  - Saltating
- Dissolved Load





Note Bedload bashing

Essentially, we're talking about thresholds:

•Minimum amount of energy required to make something move, or to cause erosion in **Alluvial Channels**.

Bedrock Channels And Thresholds:

$$e = KA^mS^n$$

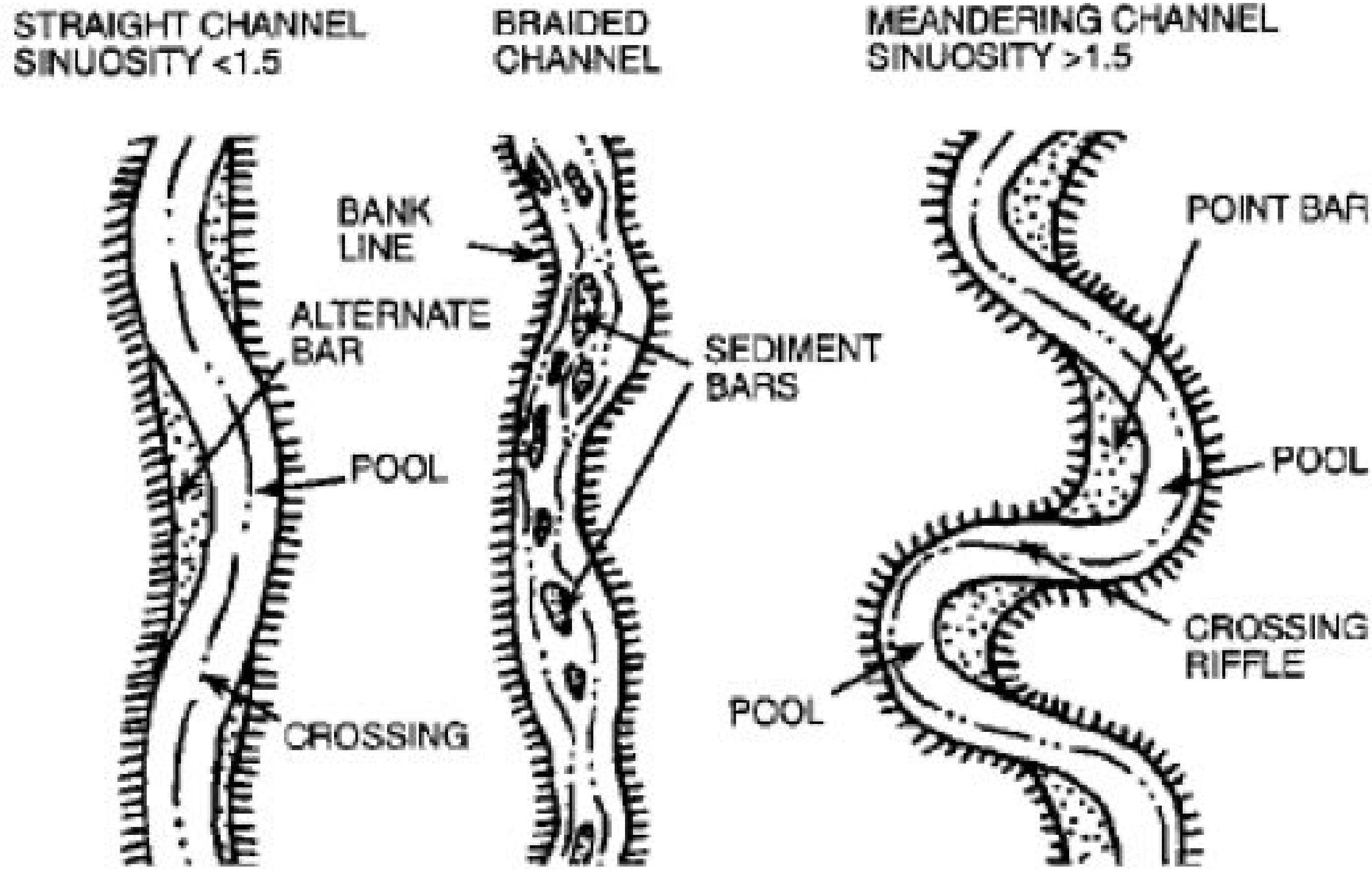
•Very different Erosional processes
(entrainment vs. detachment and abrasion)

•Big changes only happen In low-frequency High-magnitude events
(Huge Floods)

Zoom out a little bit.

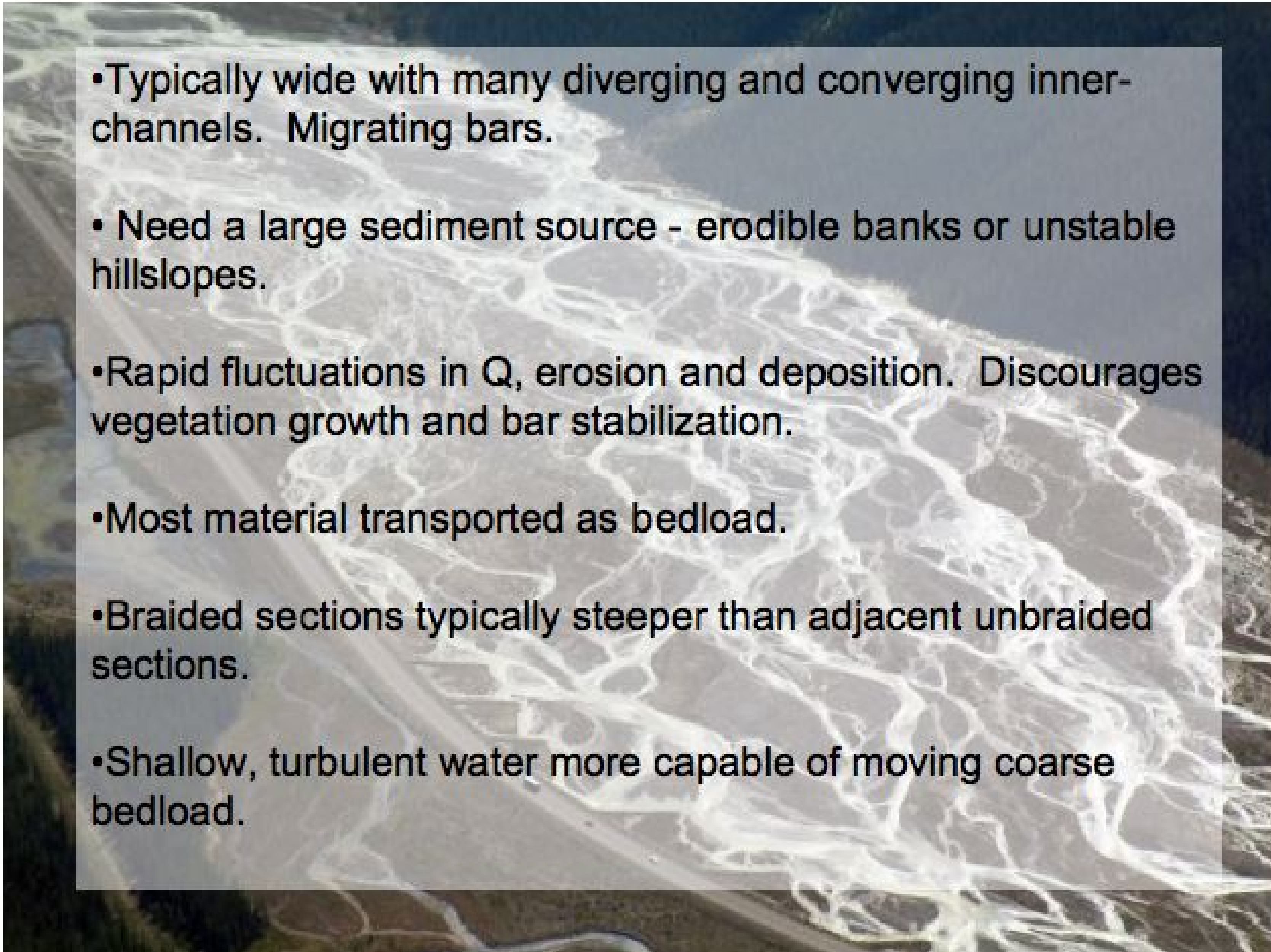
River channel and flow patterns

Basic Taxonomy:



In actuality, divisions are not that distinct, and channel form can vary greatly over different spatial scales.

Braided Channels - Multi strand:



- Typically wide with many diverging and converging inner-channels. Migrating bars.

- Need a large sediment source - erodible banks or unstable hillslopes.

- Rapid fluctuations in Q, erosion and deposition. Discourages vegetation growth and bar stabilization.

- Most material transported as bedload.

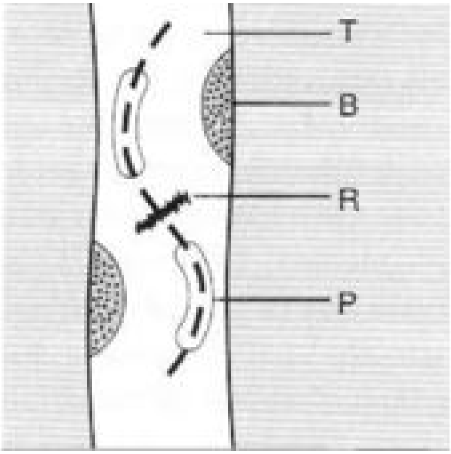
- Braided sections typically steeper than adjacent unbraided sections.

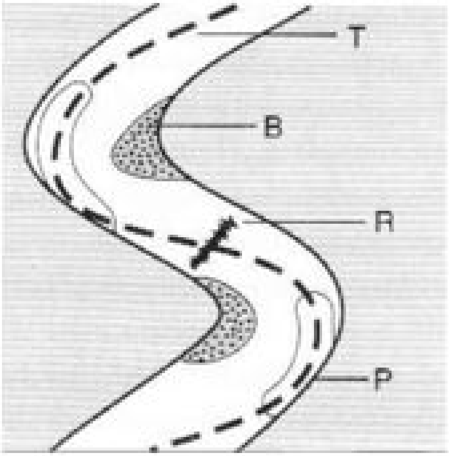
- Shallow, turbulent water more capable of moving coarse bedload.

Straight and Meandering Channels - Single strand

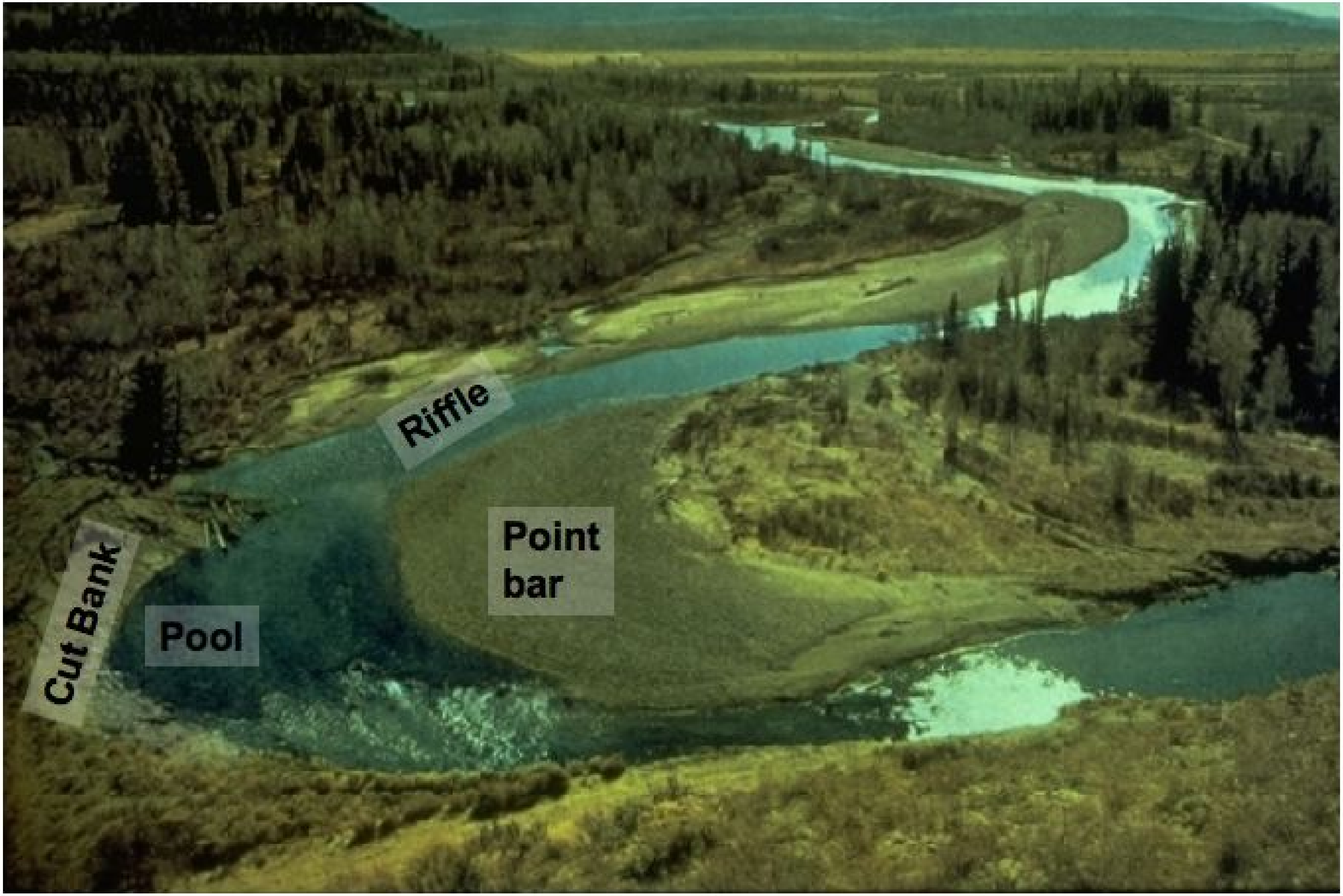
Rivers do not like to be straight

Given time, they wander

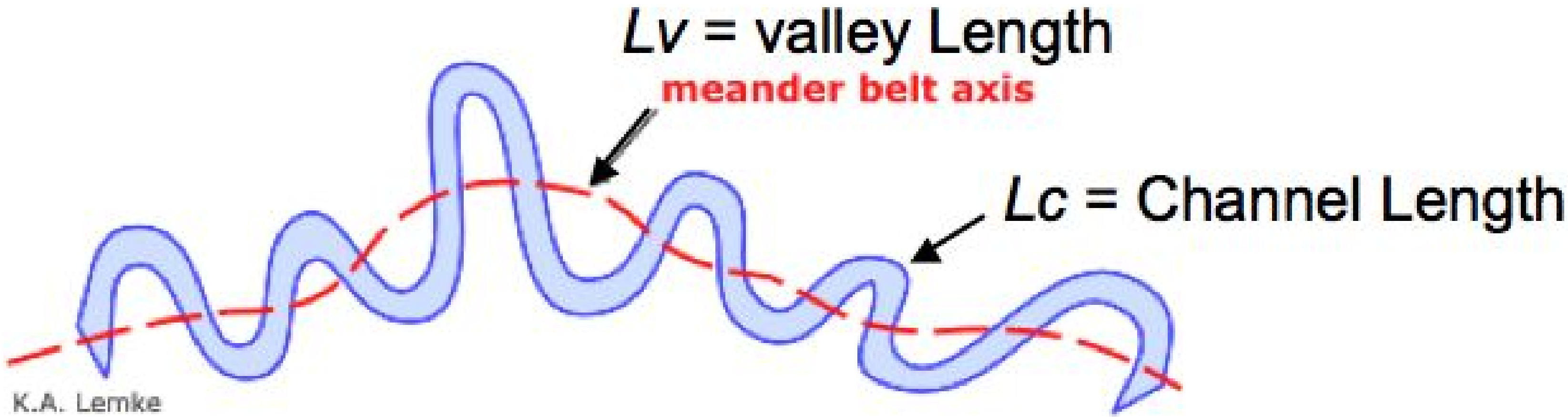




Meandering Channels - Anatomy



River Sinuosity:

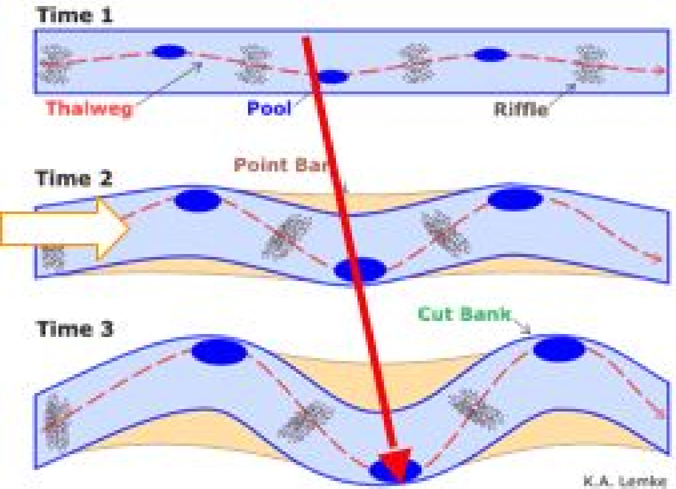


$$Sinuosity = \frac{L_c}{L_v}$$

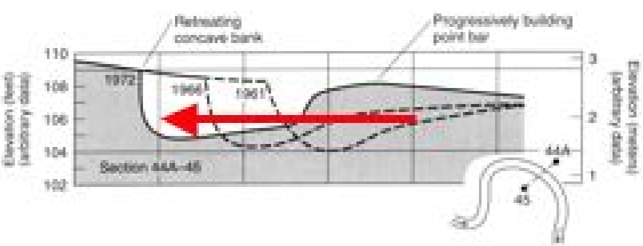
- Very Qualitative: Rivers with S > 1.5 are said to be sinuous
- Provides a means of comparison between rivers from different Locations, tectonic environments or climatic regions.

Meander Migration

Map View:

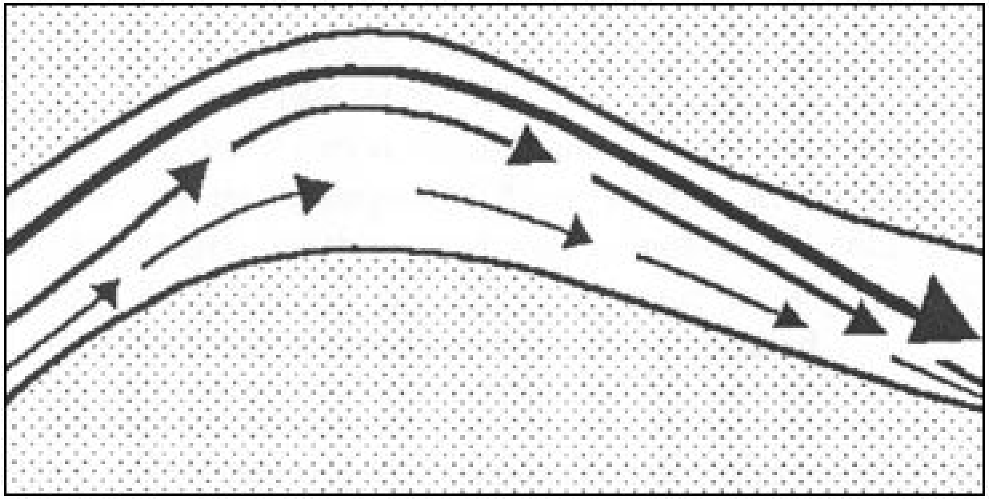


X-section:



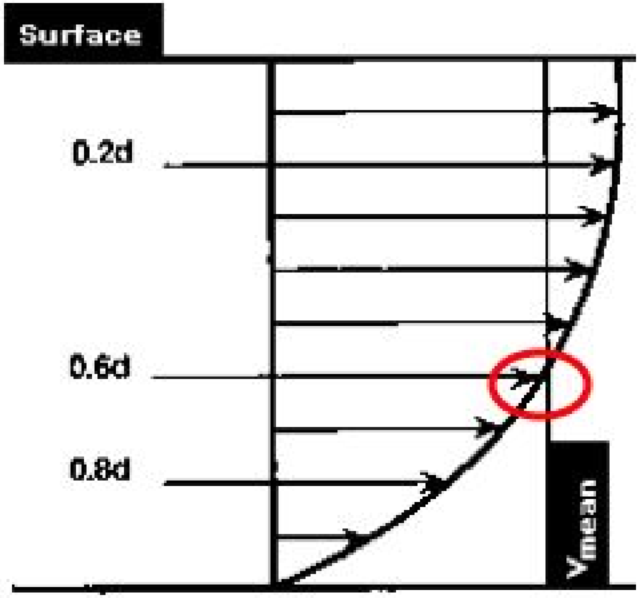
Why does this happen?

Need to consider flow in 3 dimensions:



Plan View:

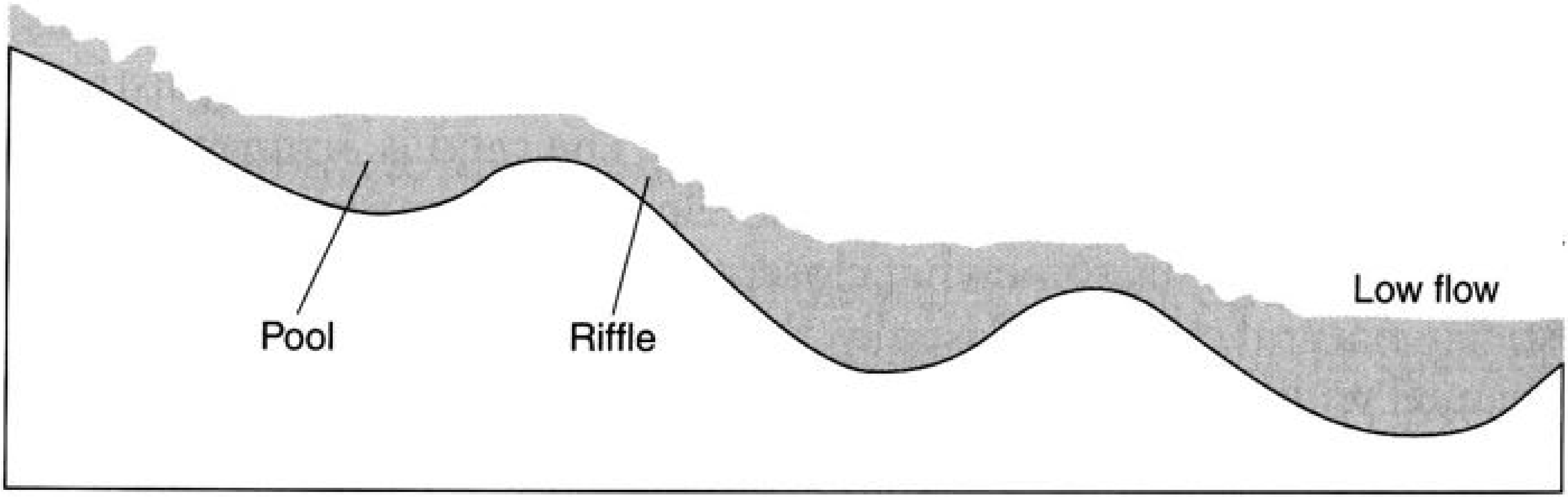
- Flow non-uniform across channel
- Fastest along outside bank (cut)
- Slowest along interior bank (point bar)



Cross-section:

- Flow fastest just below surface
- Slowest at the channel perimeter
- Average Velocity = **0.6 depth**
- Important for next weeks lab.

Need to consider flow in 3 dimensions:

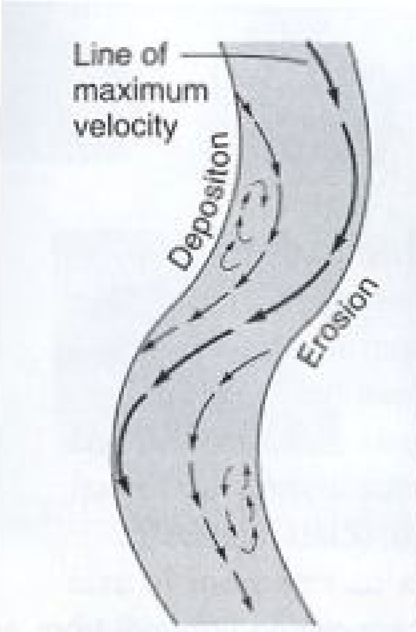


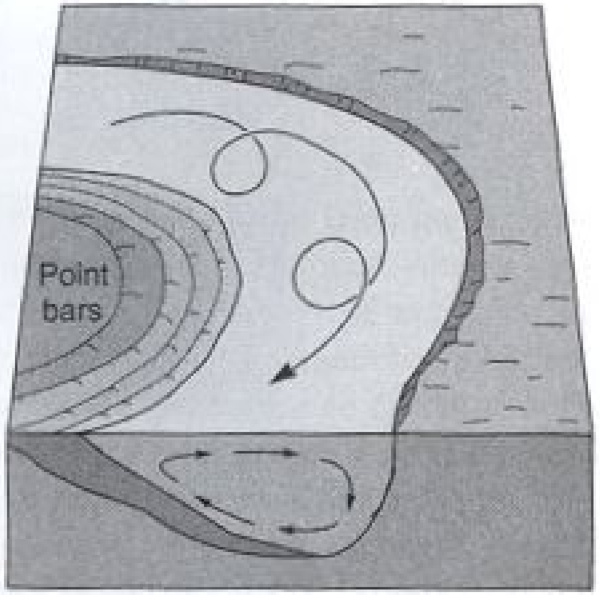
Profile View:

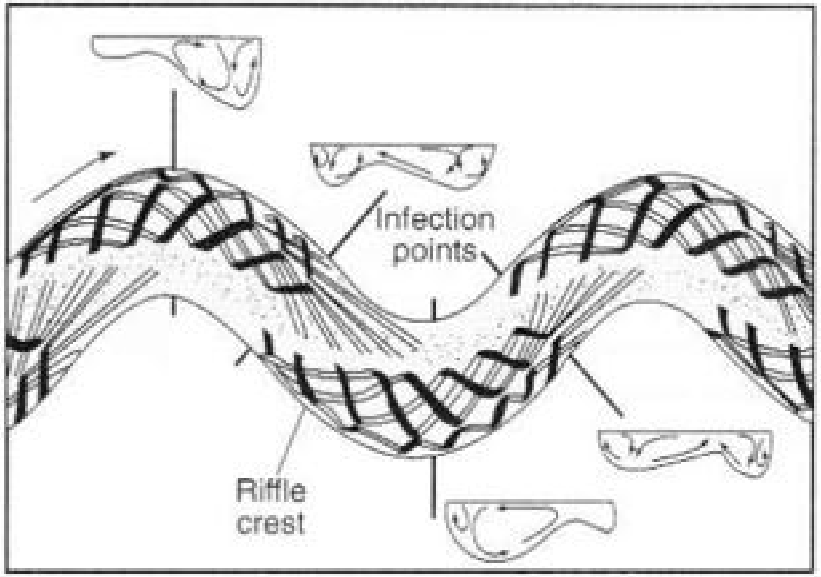
- At Low Flow: Pools (slow flowing water) separated by riffles (rapid flow).

- At High flow: Velocity reversal. Rapid water scours pools thus maintaining bed morphology.

Helical Flow:







Thalweg - deepest part of channel
Migrates back and forth across meander pools and riffles

Corkscrew Circulation - Erodes and undercuts banks
Resulting in the slow steady migration of meanders.

Net result - over time, meandering channels rework Entire floodplain.

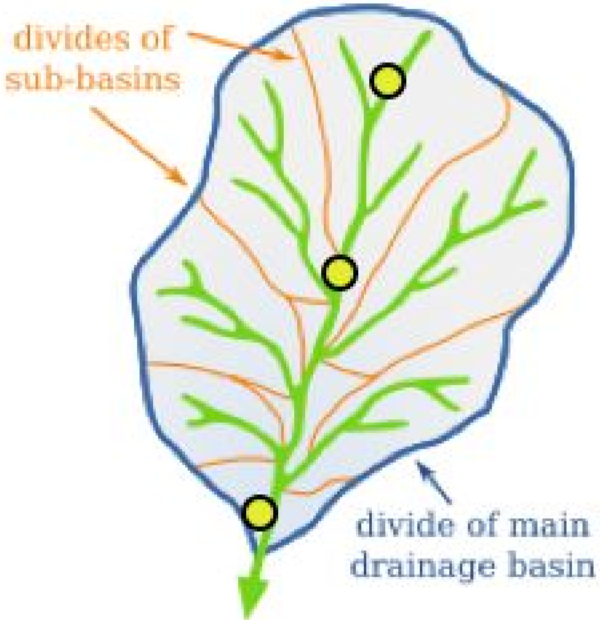
Stream Equilibrium Conditions:

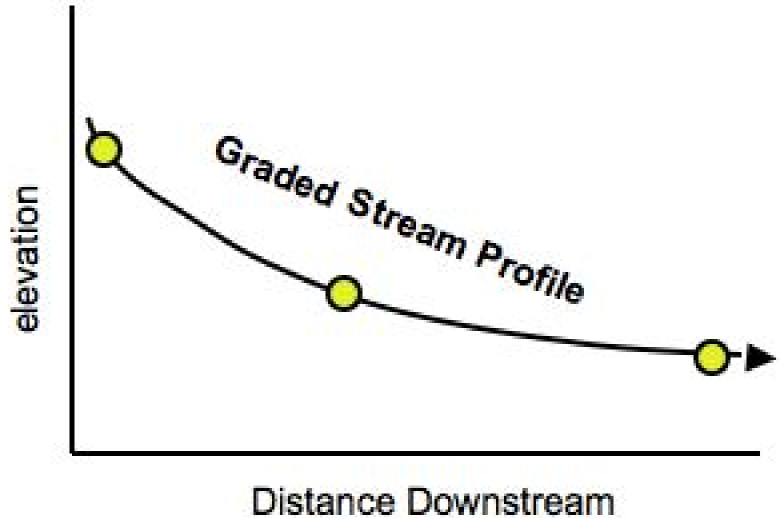
All rivers strive to maintain a balance between:
1 - Driving and Resisting Forces
2 - The amount and size of sediment supplies to them
3 - substrate they are trying to erode through

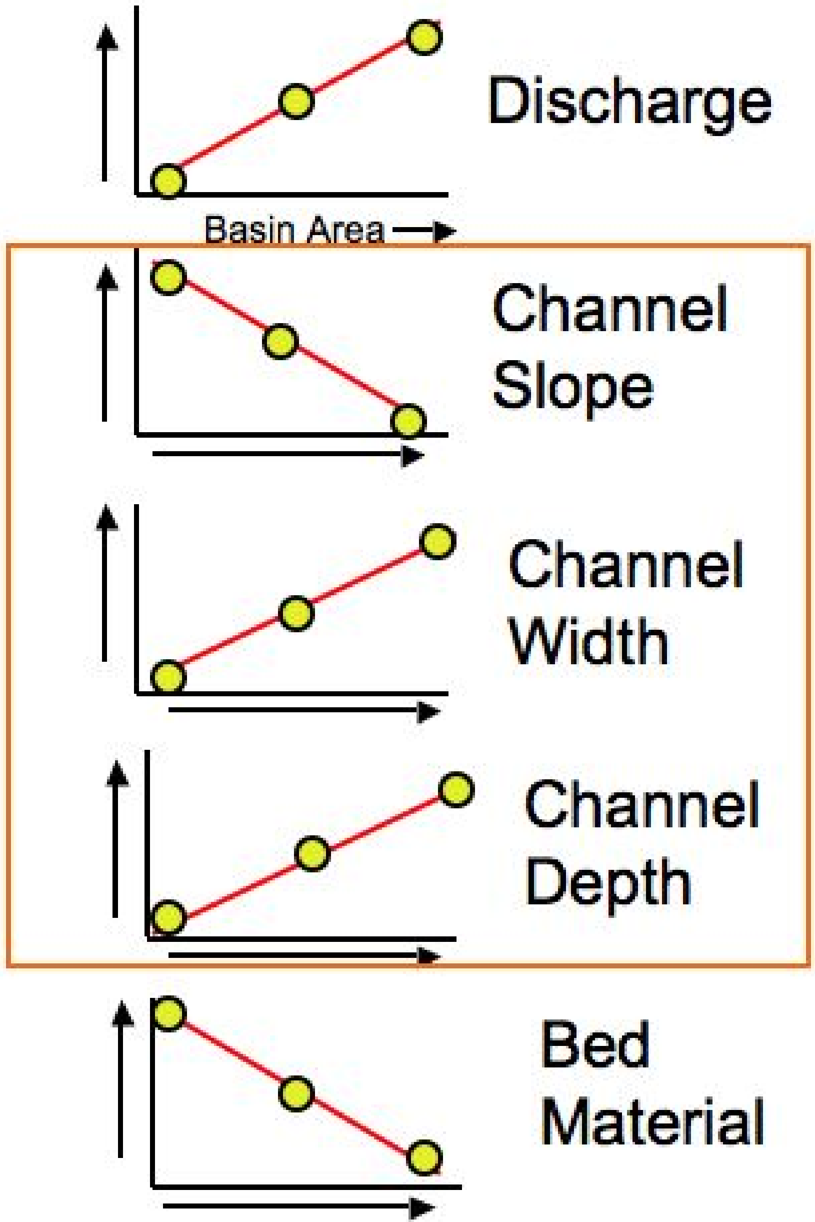
Very Scale Dependent Concept!

System Equilibrium - Ideal Conditions

Basin area relationships







Remember - Depends on scale.

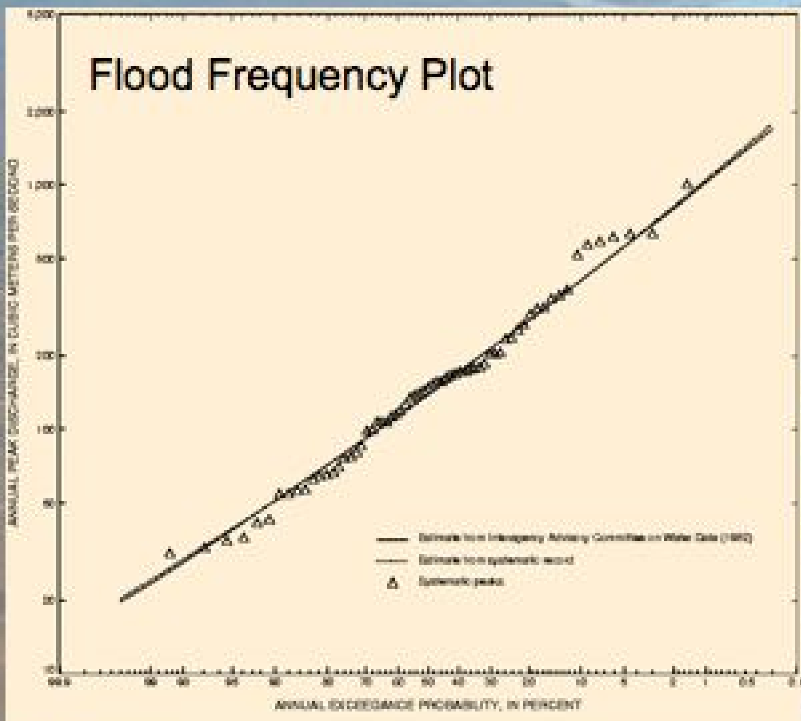


Figure 3. Flood-frequency curve for Virgin River at Littlefield, Ariz. (gaging station 09415000).

- Precipitation / Discharge essentially random For any given climate regiem

- Erosion and deposition at small scales

- Over longer time periods and larger spatial Scales, a system remains adjusted to:

    - Range of discharges
    - Range of sediment loads

- Does this by tweaking hydraulic variables

Quasi-Equilirum Conditions

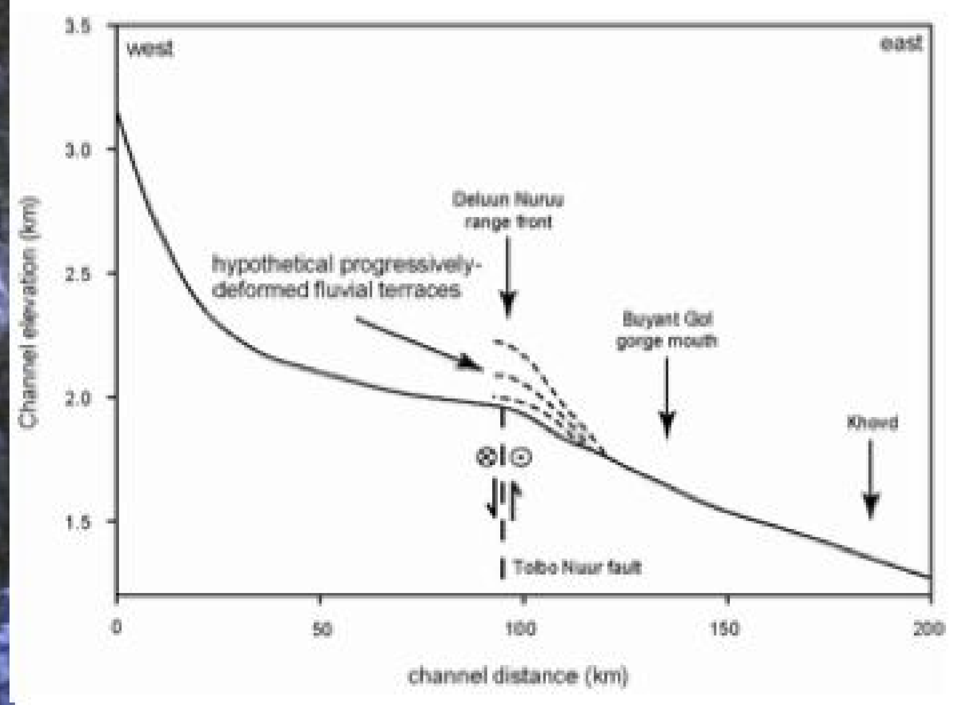
What happens when something big changes?

Cross a Threshold:

Rapidly Uplifting Terrain or Faulting along river

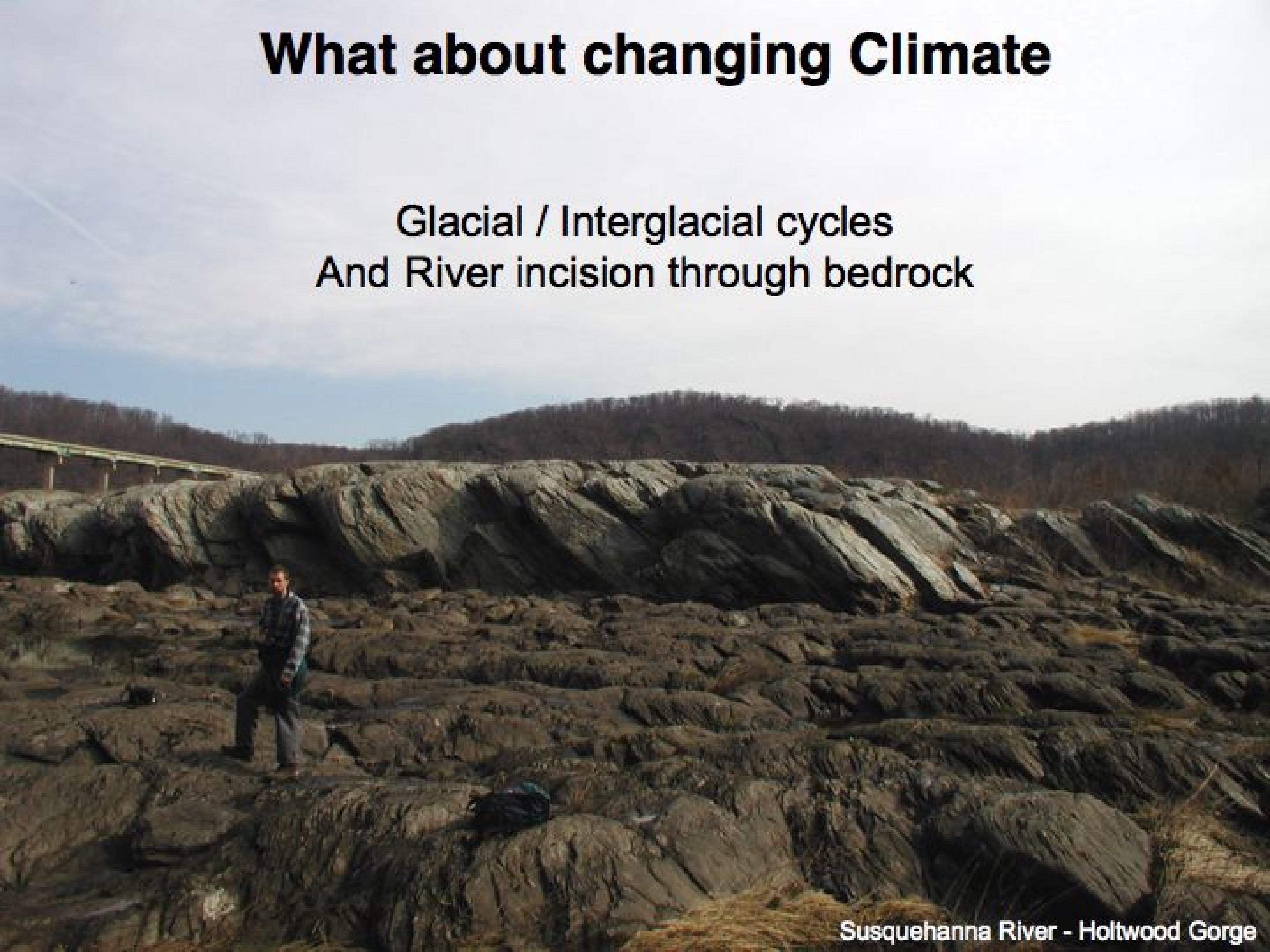
- Narrow Gorges reflect disequilibrium And river's inability to keep up with Uplift

- Seen as knickzones in Long-profile

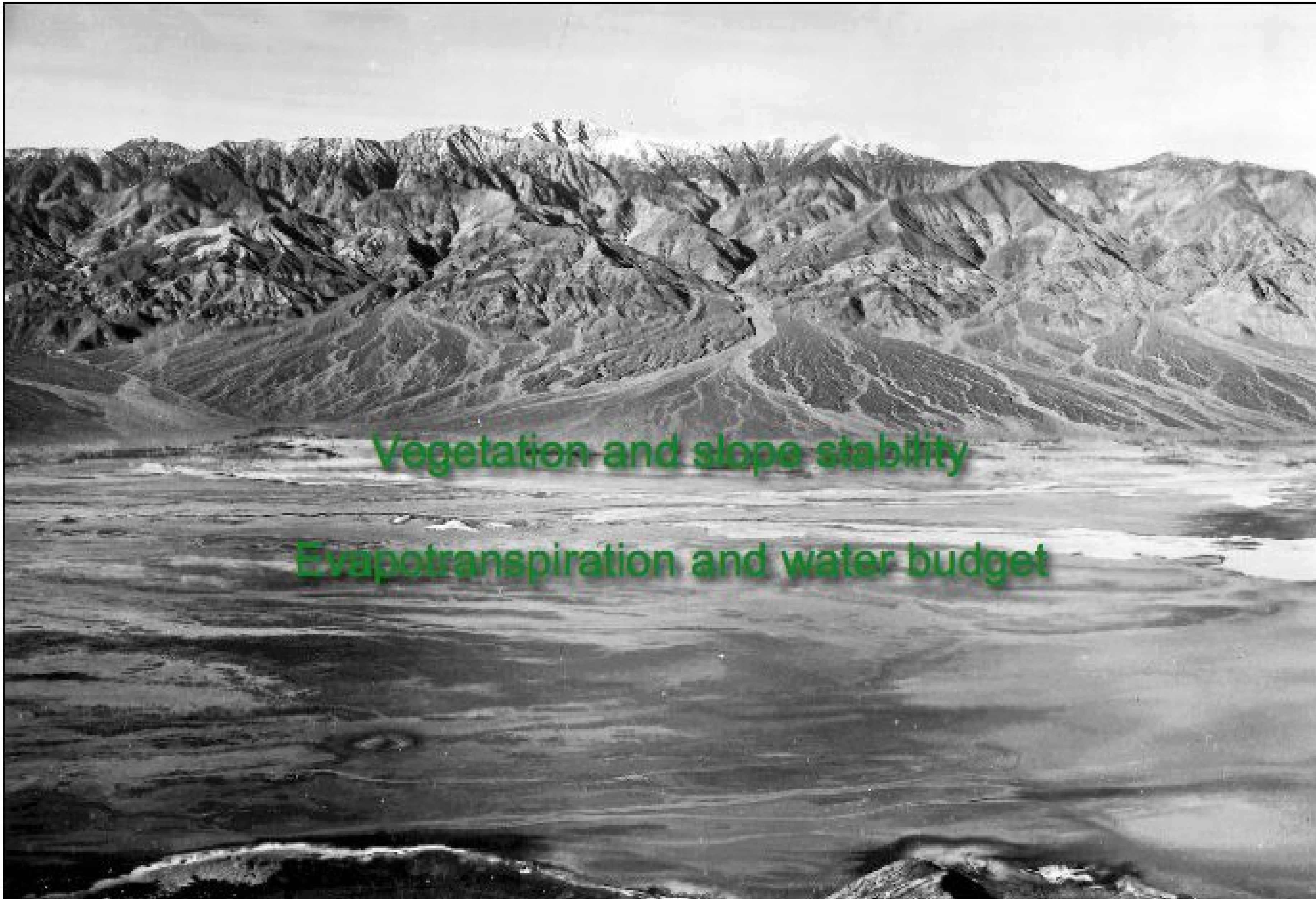


What about changing Climate

Glacial / Interglacial cycles
And River incision through bedrock



What about changing Climate



Human Landuse / Cover Conditions:

Human Landuse / Cover Conditions:

On Wednesday:
Canoe trip down the Winooski

Where to meet:

- Here - quick GPS introduction.

To Bring:

- Weather looks good, but bring rain gear just incase.
- Water shoes
- Pencil
- Sunscreen and funny hat
- Digital camera if you have one.

Laminar Flow:

Particles of water travel parallel to one another and never cross paths.

Doesn't actual exist!

Yet most most flow equations
Are based on the principles of
Laminar flow.