WATERSHED HEALTH THROUGH UNDERSTANDING

An Overview of Physical Processes and Interconnectivity within Drainage Basins

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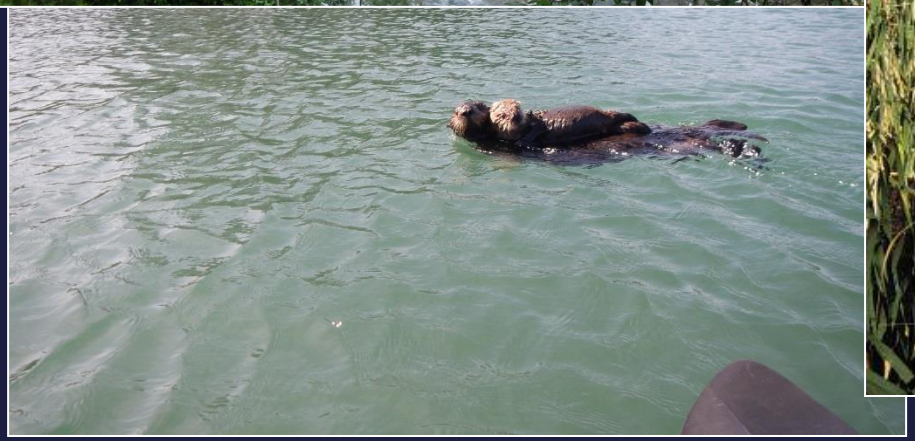
a presentation for
Snohomish County Community Rights
August 13, 2021

Image couresy of lip rippers fishing adventures

Rivers as Integrators

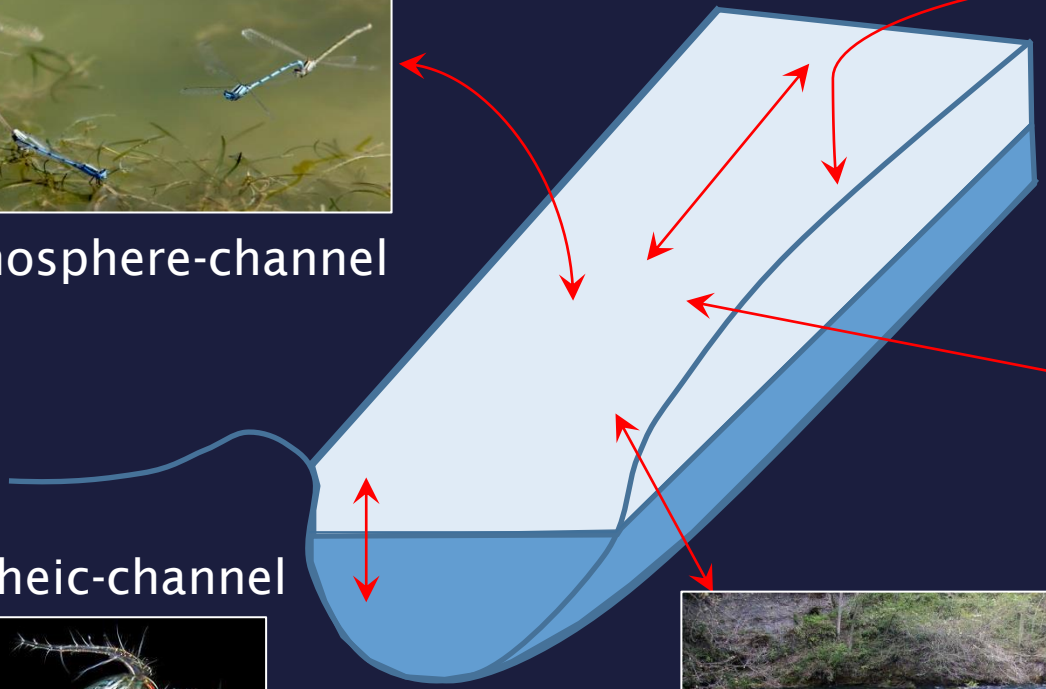


Six Degrees of Connection

Upstream-downstream

Hillslope-channel

Atmosphere-channel



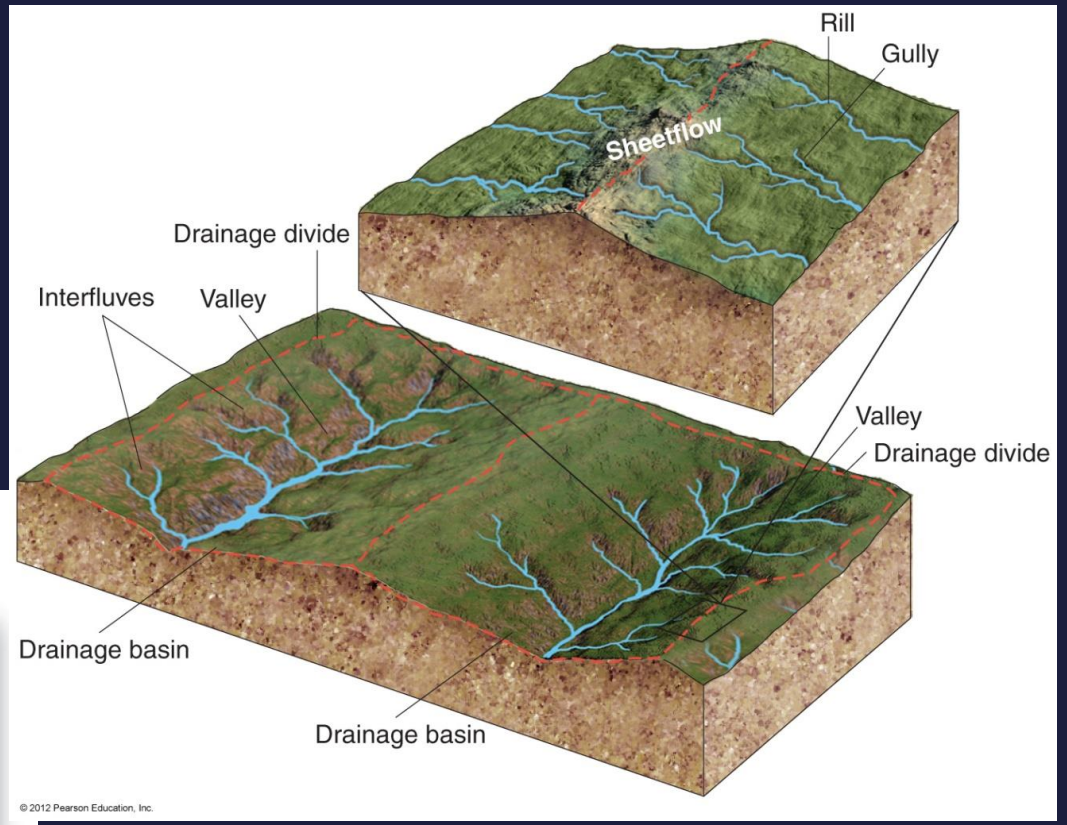
Floodplain-channel

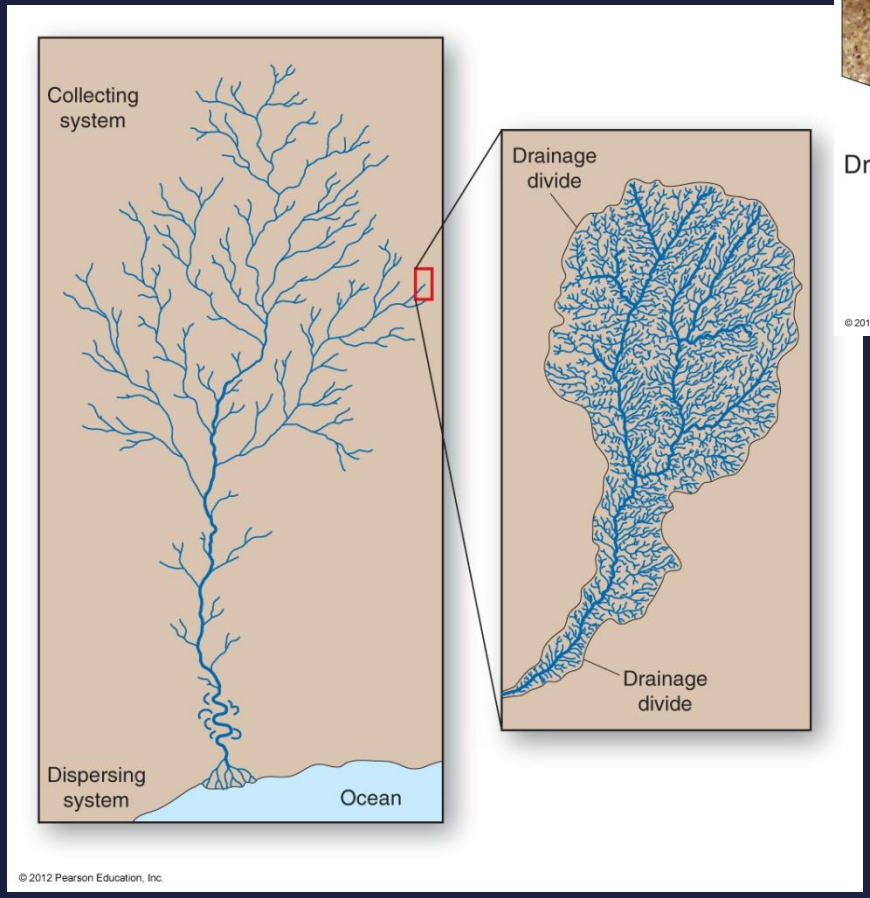
Hyporheic-channel

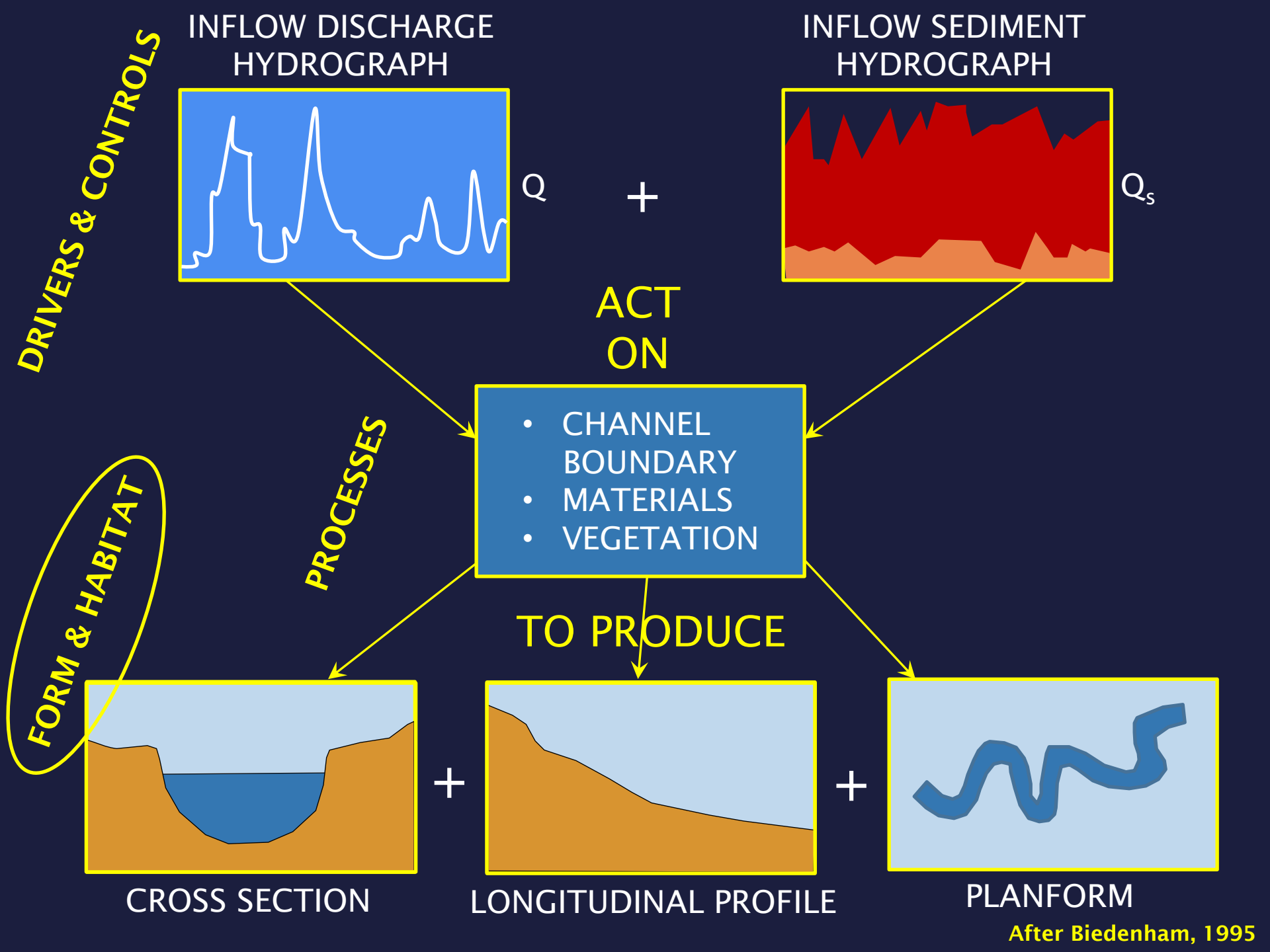
Groundwater-channel

Photo sources: thephotoforum.com, blackrivercleanup.wix.com, aquatech.com

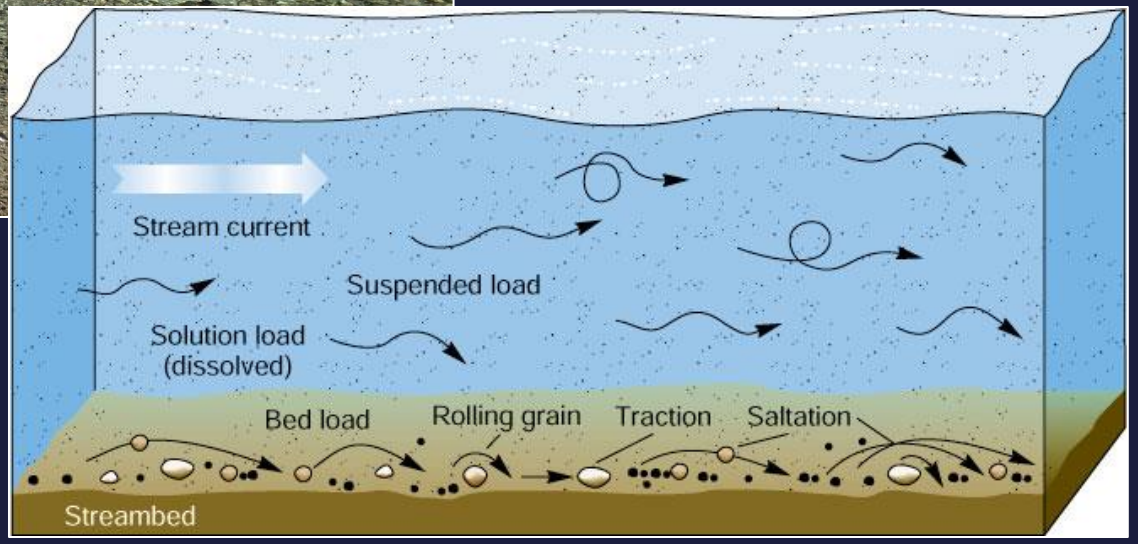
Drainage Basins/ Watersheds



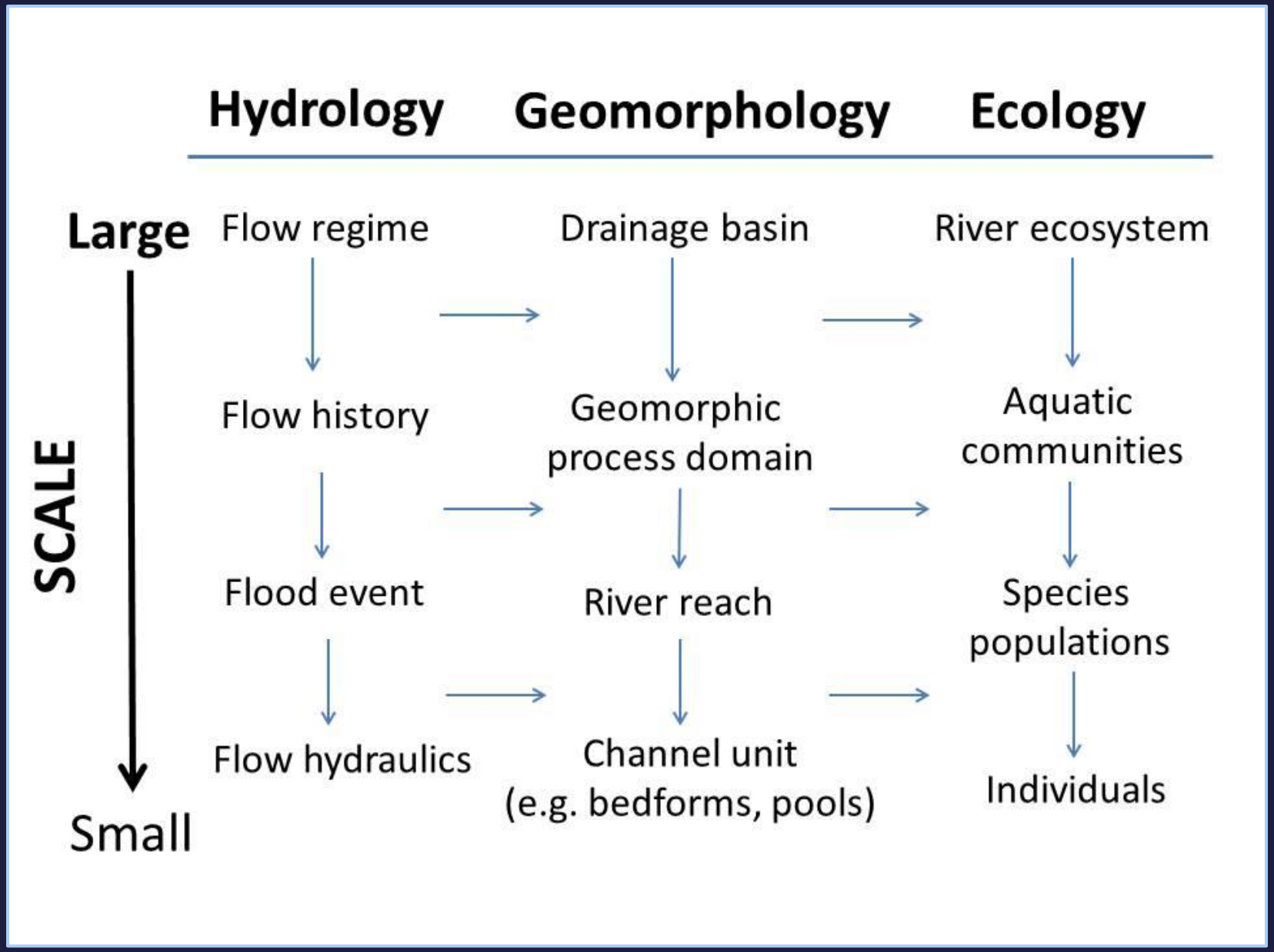



DRIVERS & CONTROLS
INFLOW DISCHARGE HYDROGRAPH
Q
+
INFLOW SEDIMENT HYDROGRAPH
Q_s
ACT ON
• CHANNEL BOUNDARY
• MATERIALS
• VEGETATION
PROCESSES
FORM & HABITAT
TO PRODUCE
CROSS SECTION
+
LONGITUDINAL PROFILE
+
PLANFORM
After Biedenham, 1995

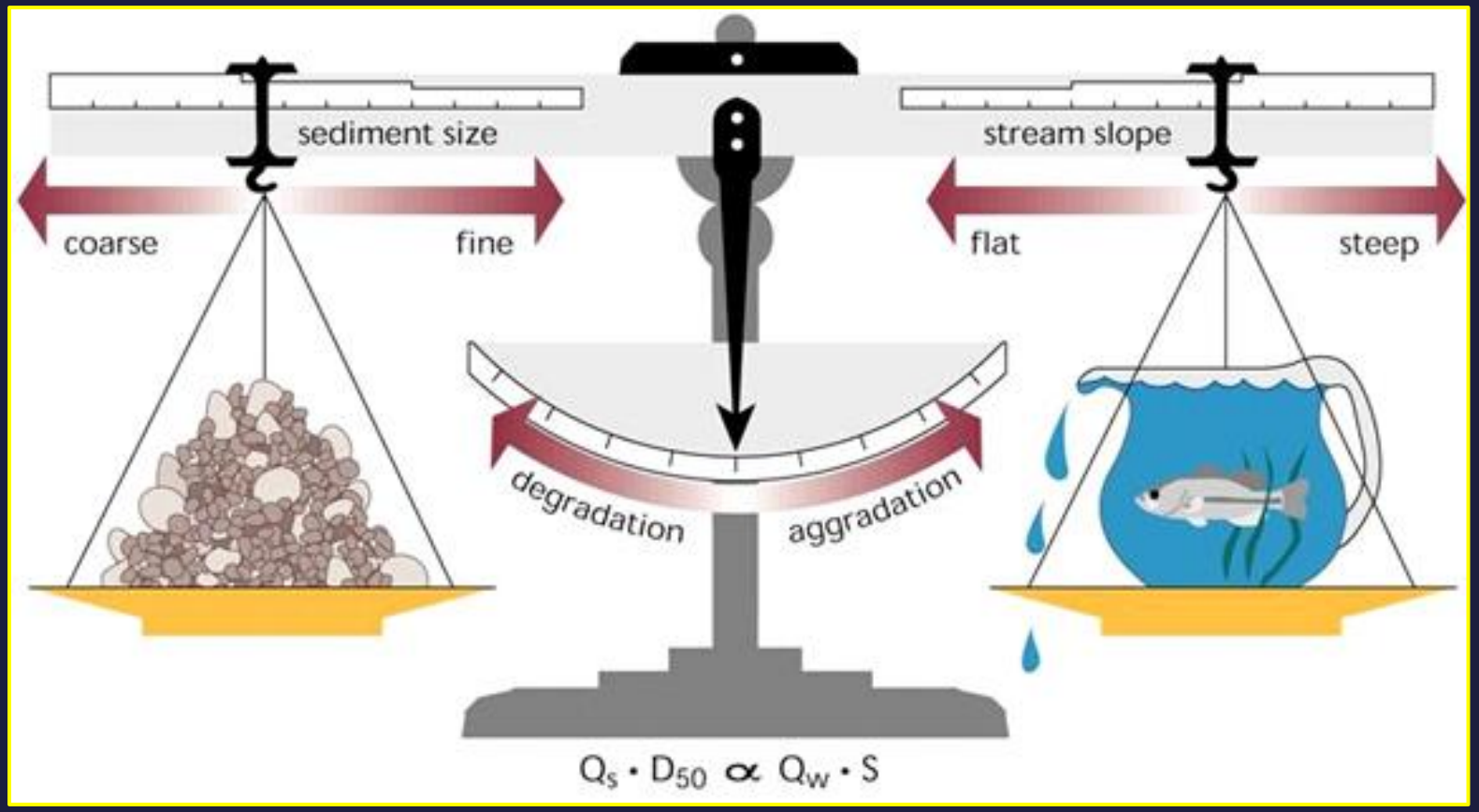
Scale: Space and Time



Spatial scale relationships



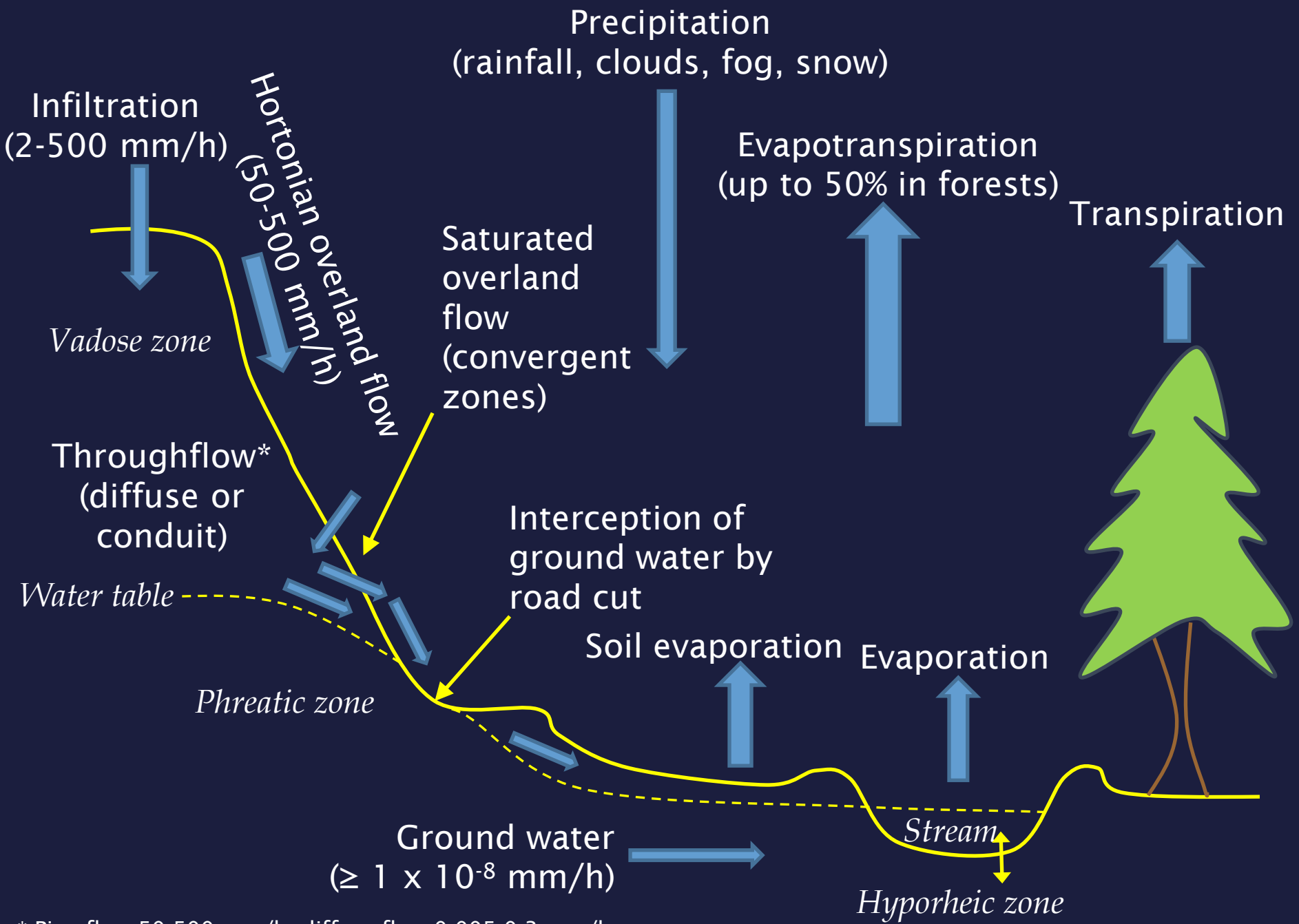
Dynamic Equilibrium



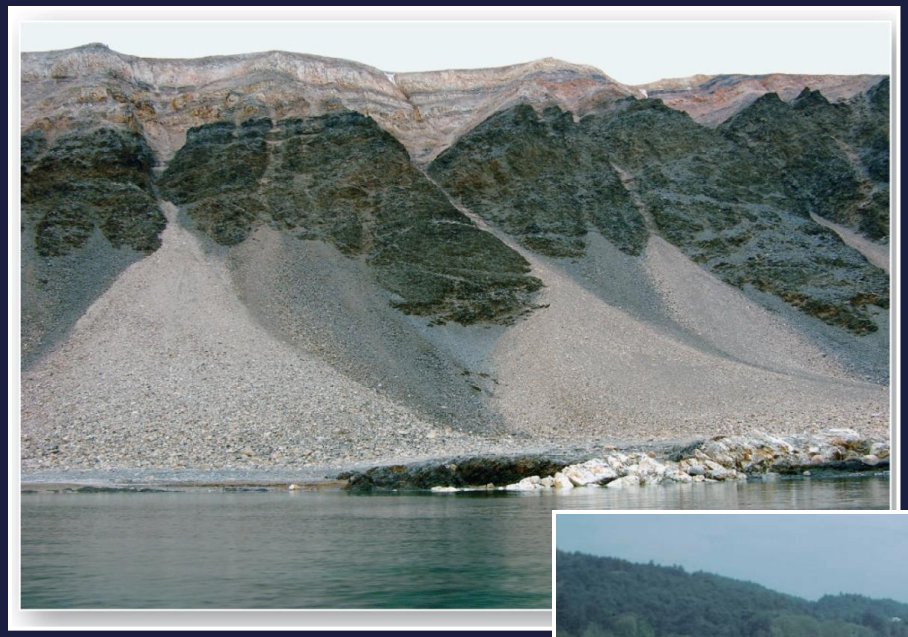
Lane's Balance

WATERSHED CONTROLS

- Streamflow Processes
- Sediment Regime
- Vegetation
- Land Use


Precipitation
(rainfall, clouds, fog, snow)
Infiltration
(2-500 mm/h)
Hortonian overland flow
(50-500 mm/h)
Evapotranspiration
(up to 50% in forests)
Transpiration
Saturated
overland
flow
(convergent
zones)
Vadose zone
Throughflow*
(diffuse or
conduit)
Interception of
ground water by
road cut
Water table
Soil evaporation
Evaporation
Phreatic zone
Stream
Ground water
(≥ 1 x 10-8 mm/h)
Hyporheic zone
* Pipe flow 50-500 mm/h; diffuse flow 0.005-0.3 mm/h

Sediment Sources and Delivery

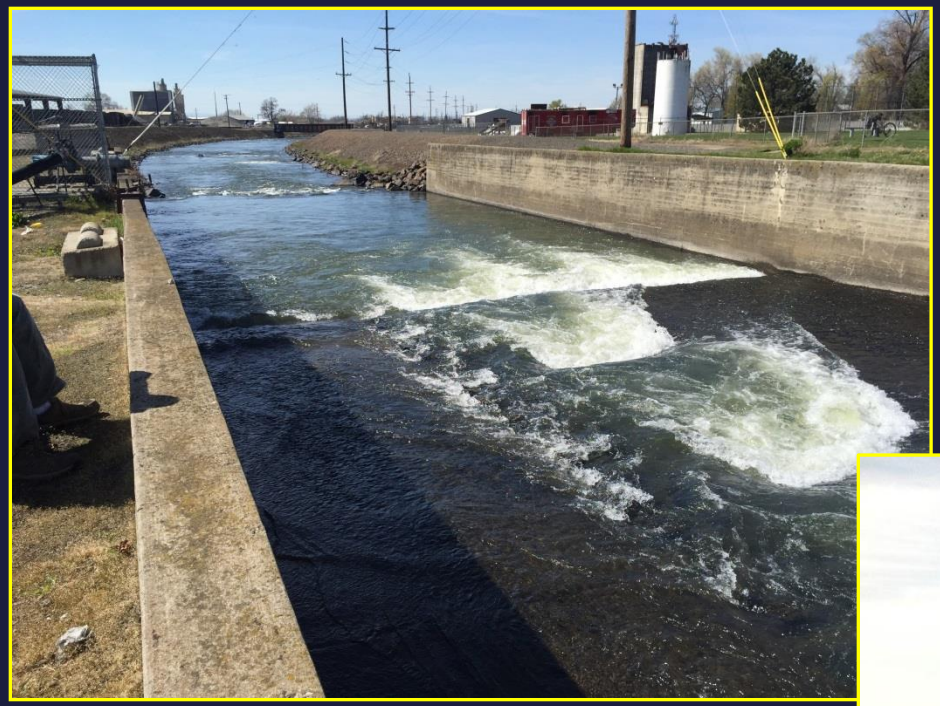


Mass wasting

Surface erosion

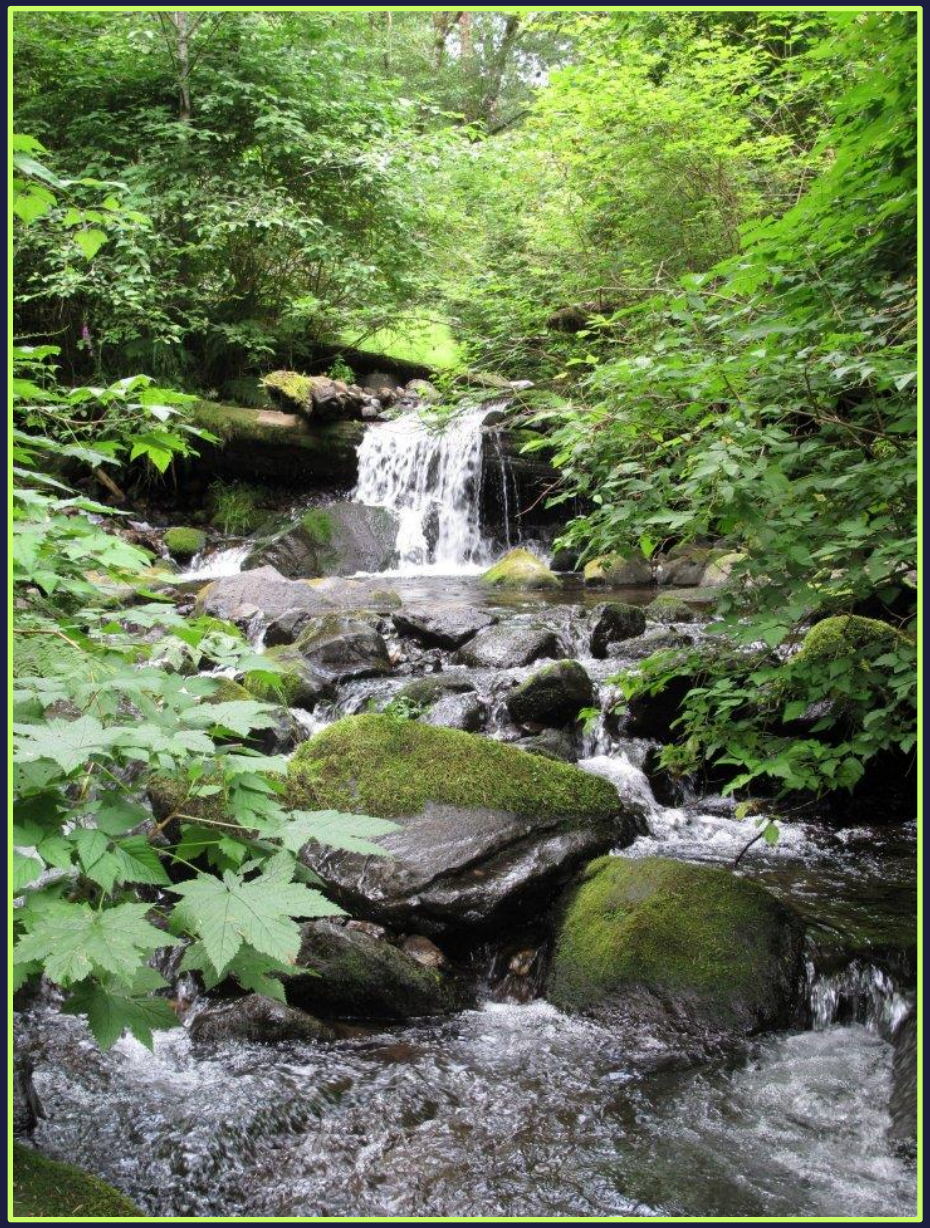
Bank erosion

Land Use



Vegetation

Instream Wood



- Creates channel complexity
  - Moderates stream power
  - Sediment deposits
  - Knickpoints
- Creates aquatic habitat
  - Pools
  - Spawning grounds
  - Shade
  - Protection
- Nutrient storage

WATERSHED PROCESSES

Discharge

- Amount of stream discharge (Q) depends on:
  - Recent weather
  - Drainage basin variables
    - Size
    - Relief
    - Climate
    - Vegetation
    - Rock type
    - Land-use
- Q = Volume of water in a given cross section per unit of time

Discharge

- Q = wdv
  - w = width
  - d = channel depth
  - v = stream velocity
- Q = A*v
  - A = cross-sectional area
  - v = stream velocity

Common Discharges

- Snohomish R. at mouth
  - 9,500 cfs
- Queets R. nr Clearwater
  - 4,347 cfs
- Skagit R. nr Mount Vernon
  - 16,800 cfs
- Columbia R. at mouth
  - 264,900 cfs

10 cfs
=
4,488 gallons
per minute

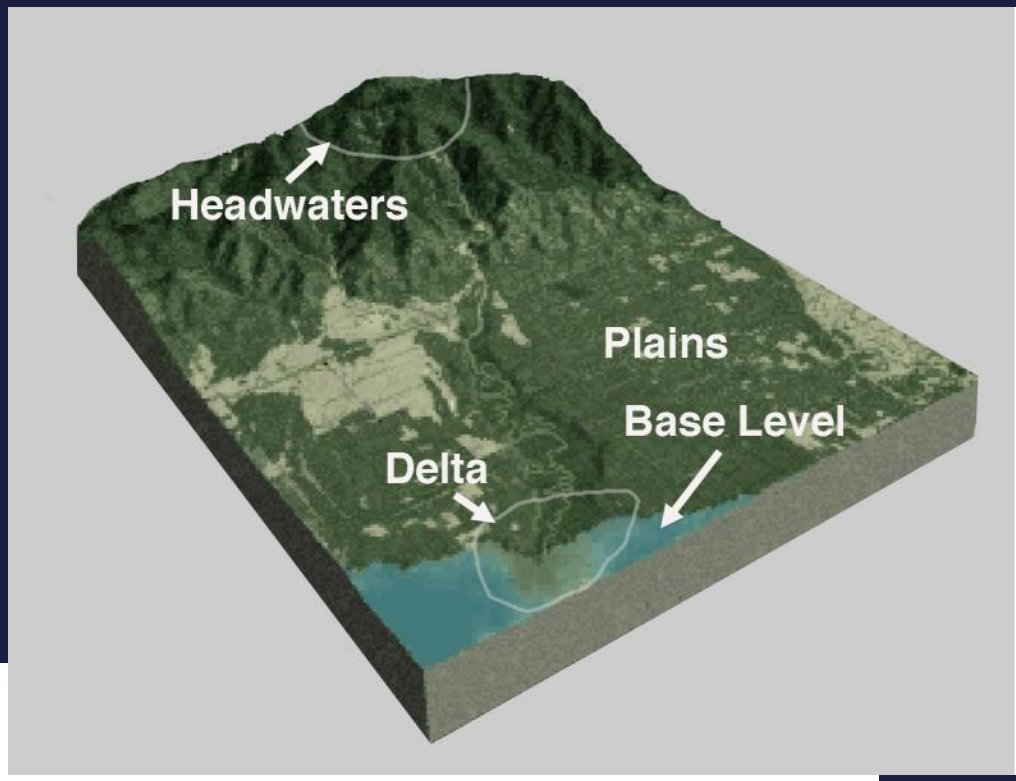
RIVER GRADIENT

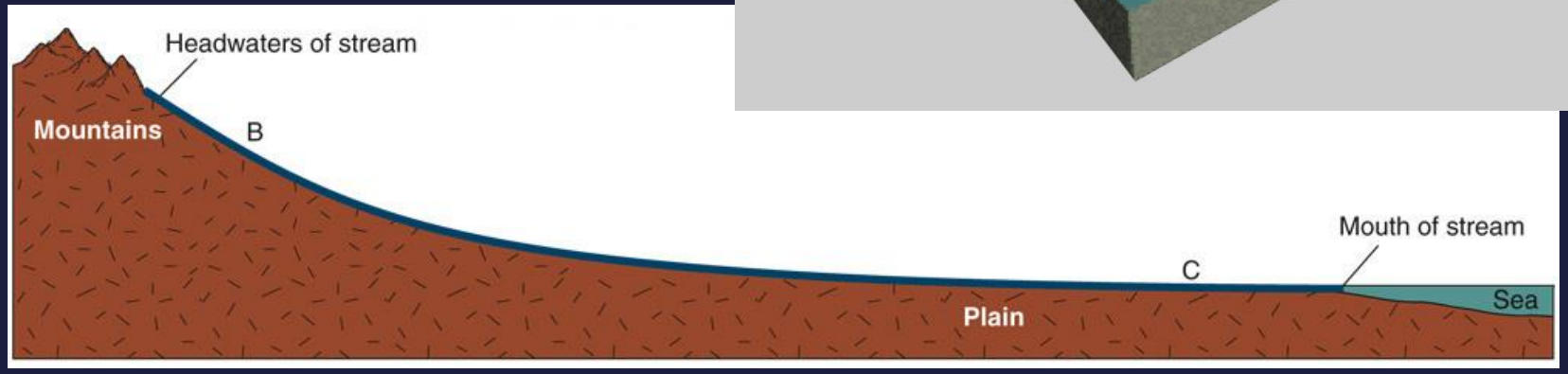
Slope as an Adjustable Variable

- Slope is important in fluvial systems!
  - $V = (1/n)R^{0.67}S^{0.5}$
  - V is a controlling variable in Fr, Re, shear stress
    Stream power: $\omega = \gamma Q S$
  - Steep streams look very different from flat streams

Idealized River Profile

- Divides a stream into upper (A), middle (B), & lower (C) reaches
- Gradient diminishes downstream





Snohomish Watershed Profile

Form: Channel morphology

Straight | Meandering | Island Braided | Braided

Increasing lateral migration rate

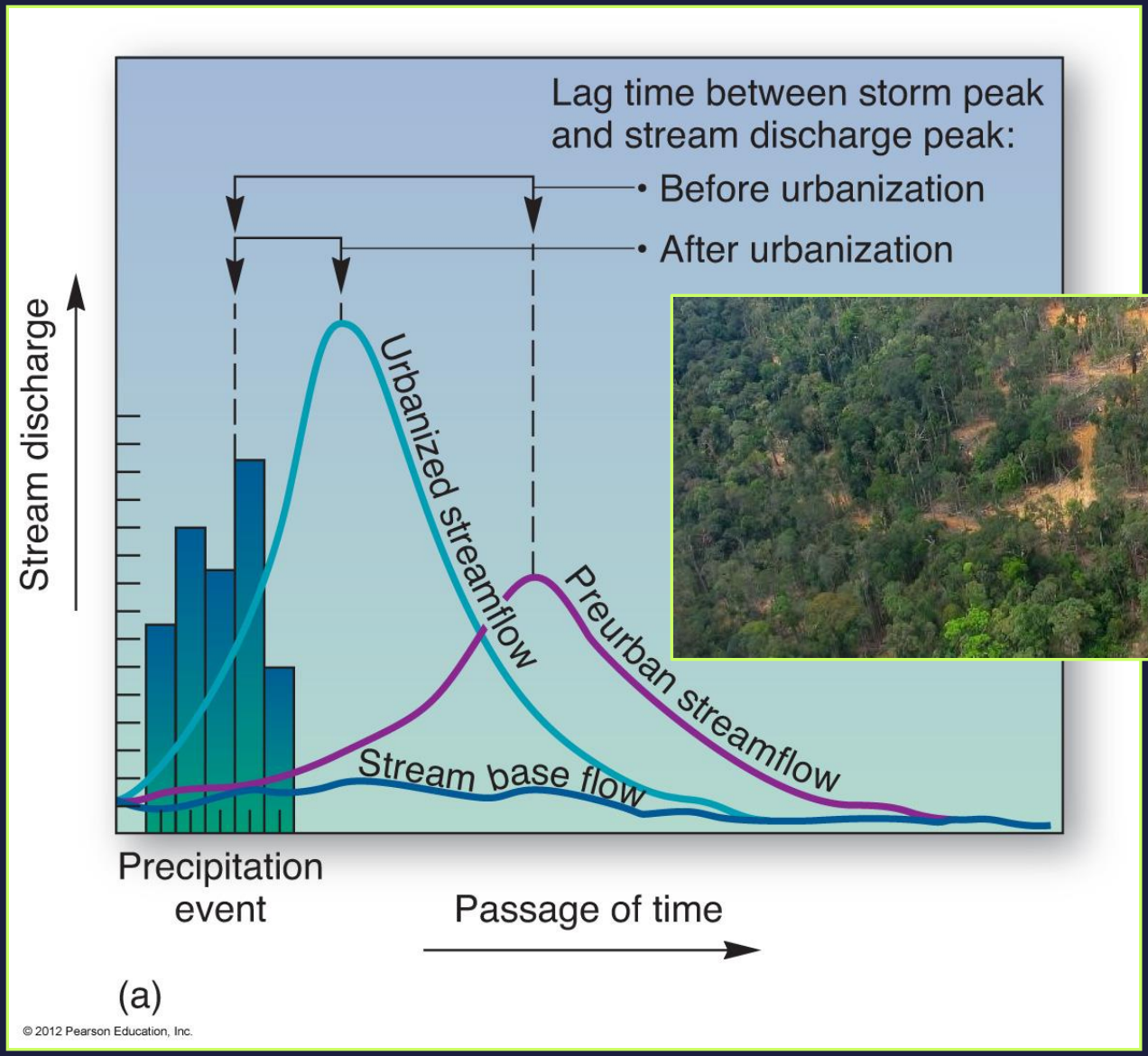
Slide Courtesy of: Tim Beechie

DISTURBANCE FORMS AND PROCESSES

Natural Disturbance Regimes

- Wildfire
- Floods
- Landslides
- Tree infestations by insects
- Other

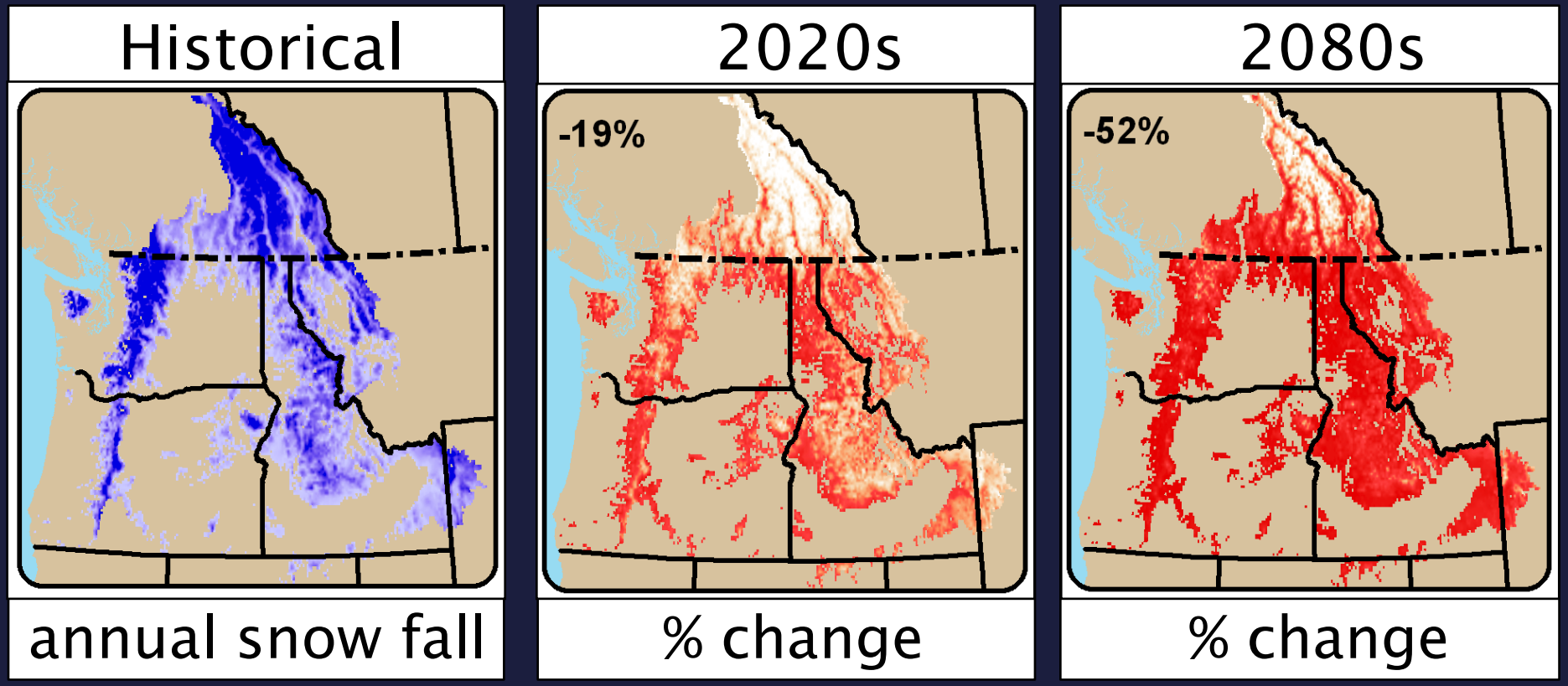
Human Alterations Impacts



Climate Change

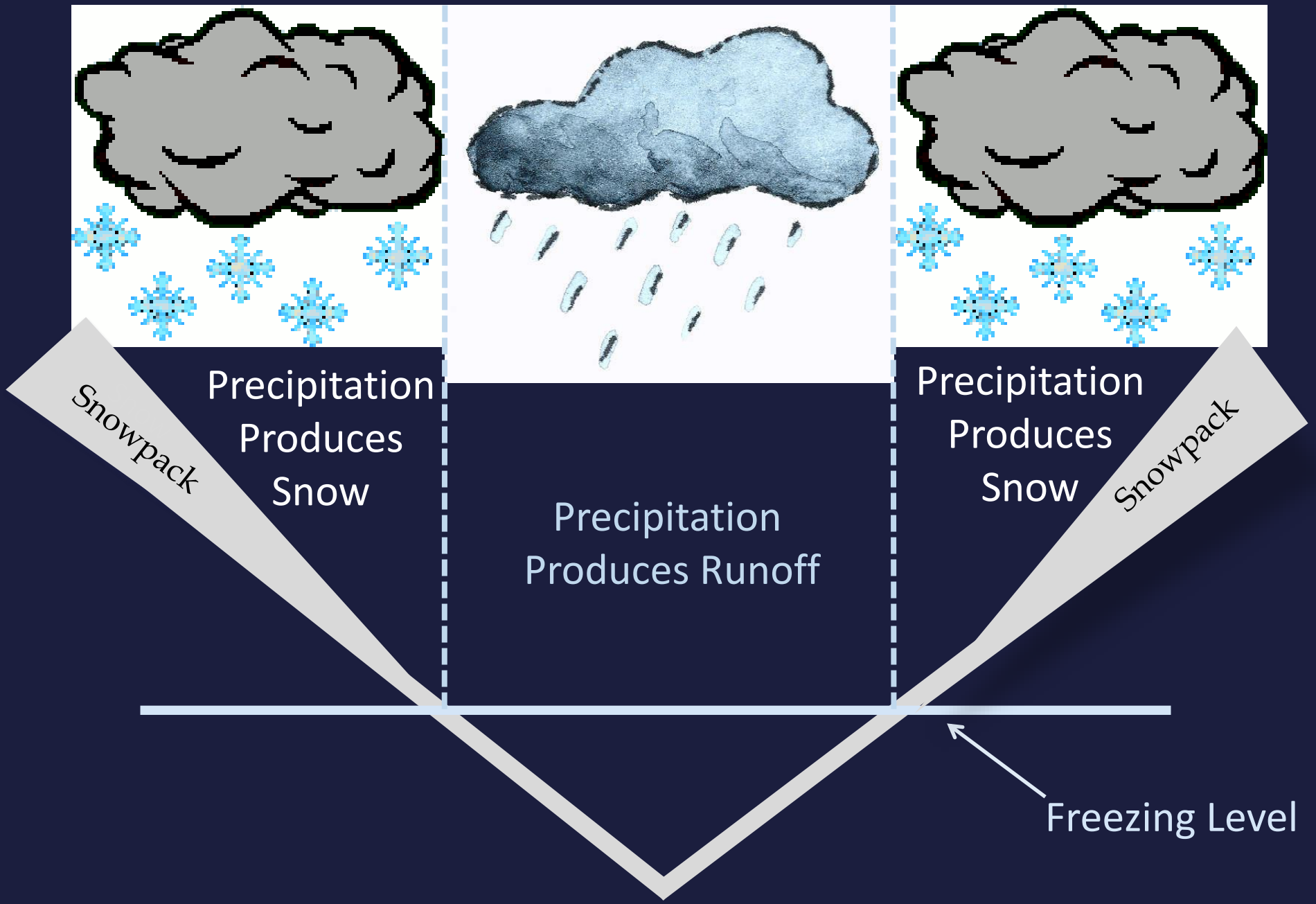
- Future changes in climate will cause future changes in stream morphology

Key Regional Response: Less Snow and More Rain

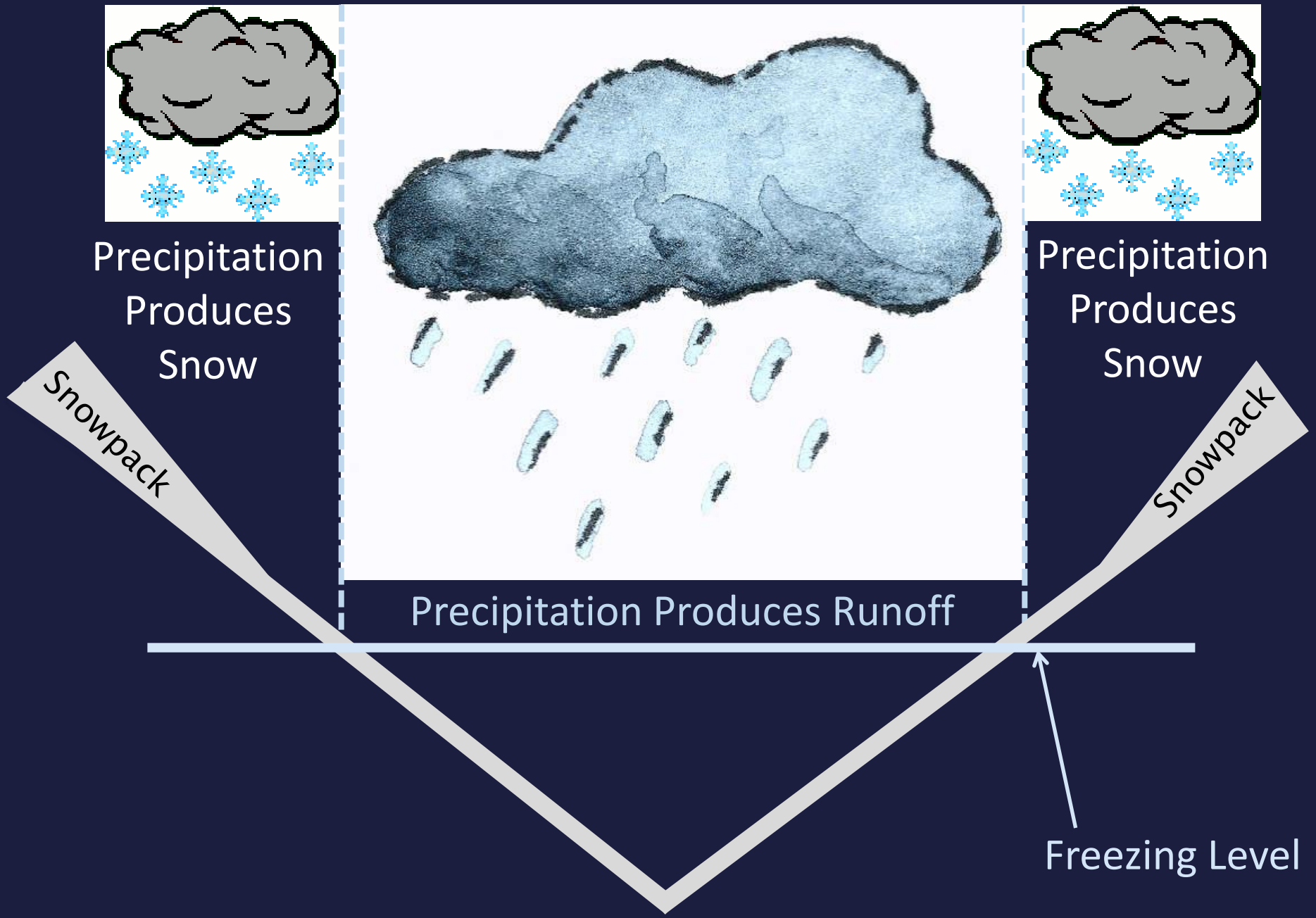


- Same precipitation but as rain
- Higher peak flows

Schematic of a Cool Climate Flood



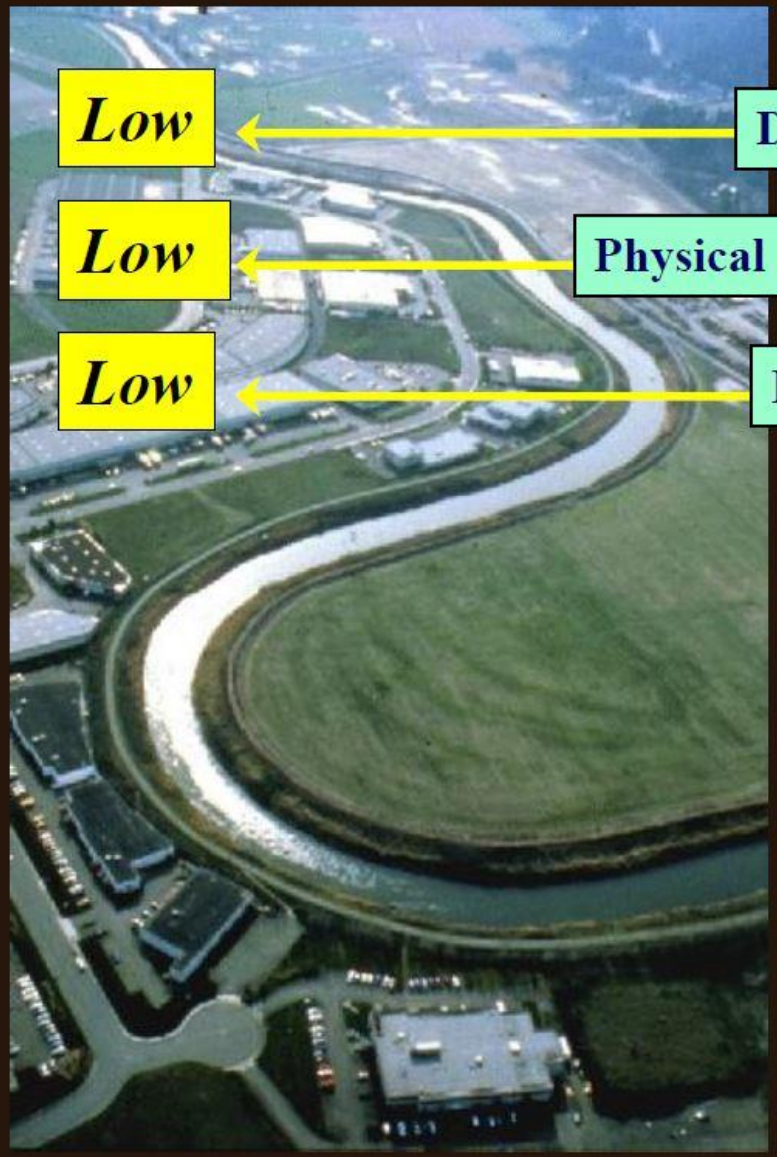
Schematic of a Warm Climate Flood



Projected Changes in Rain-dominant Basins

- Projected shifts in seasonality
  - more intense rain events in winter
  - drier in summer

Habitat: Structure and Complexity



Low ← Deformability → High

Low ← Physical complexity of channel → High

Low ← Habitat value → High

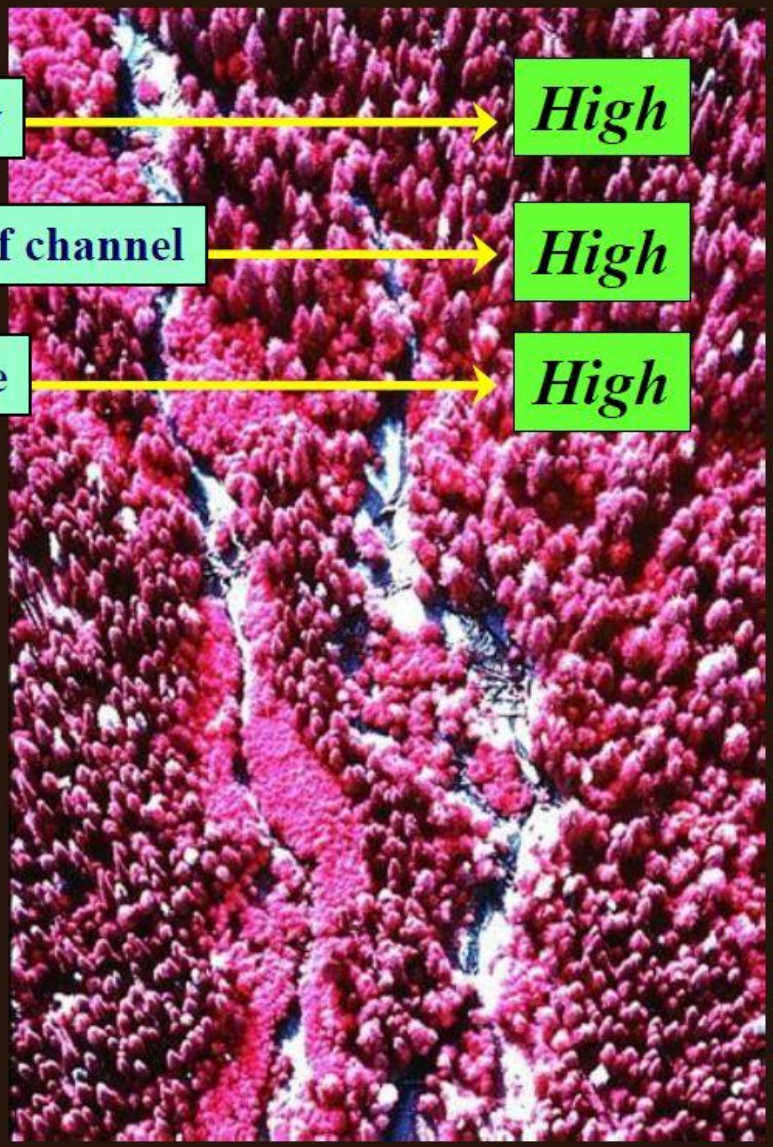


Photo by: David Montgomery

Photo by: Tim Abbe

Slide Courtesy of: Tim Beechie

Conclusions

It's all connected.
It's complex.
Scale is important.
Slope's a big deal.
Rivers are awesome.