

# Stream Behavior and Response to Disturbance

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US Army Corps of Engineers  
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# Structure, Function and Services

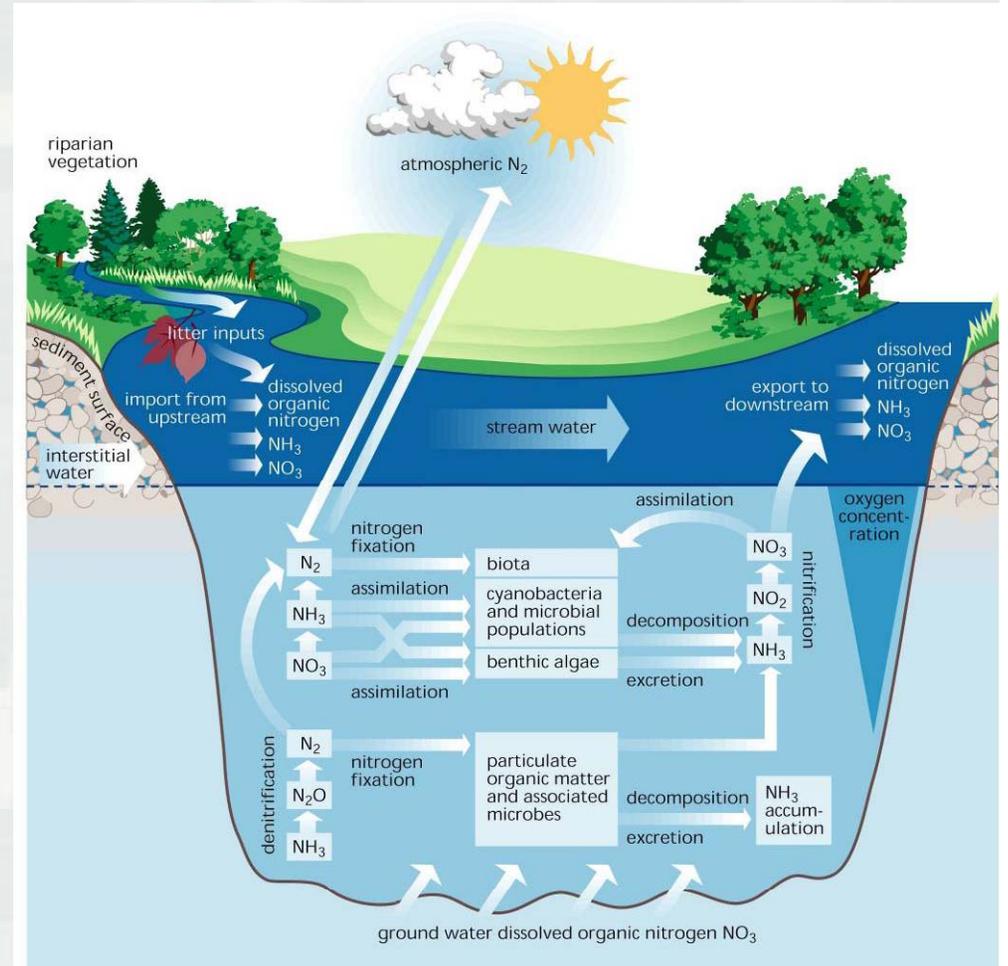
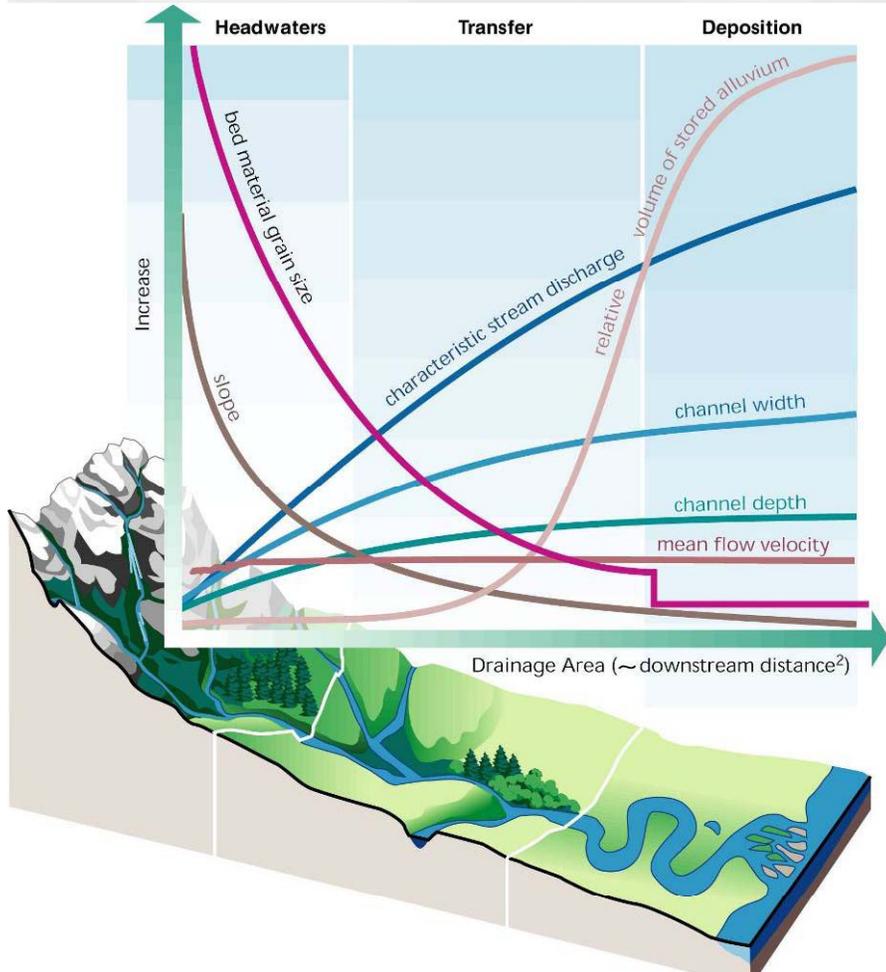
**Structure:** The characteristic structure of an ecosystem is defined by the physical organization of the abiotic and biotic components of that particular system.

**Function:** The characteristic exchanges of material, energy and nutrients within an ecosystem are called ecosystem functions.

**Services:** The specific ecosystem functions that are apparently beneficial to human civilization are called ecosystem services.



# Structure and Function



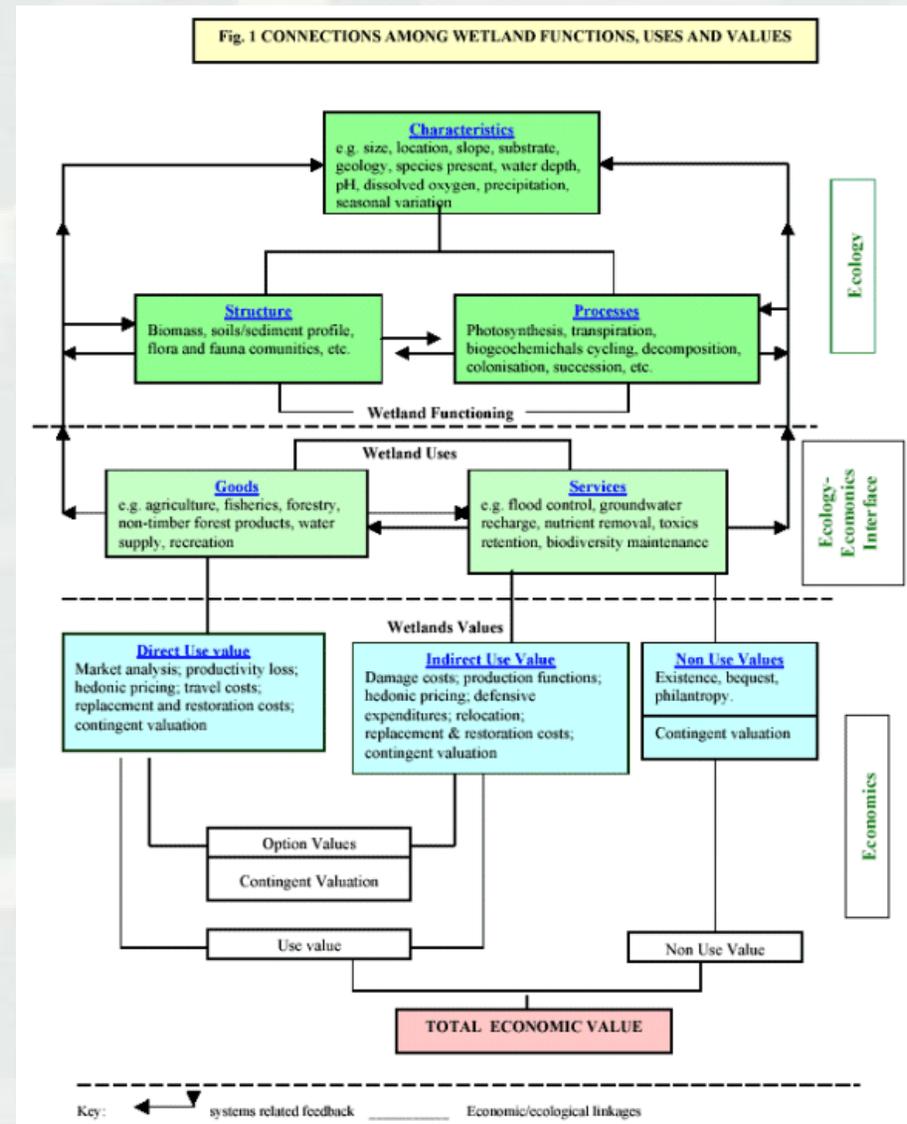
# Example Functions

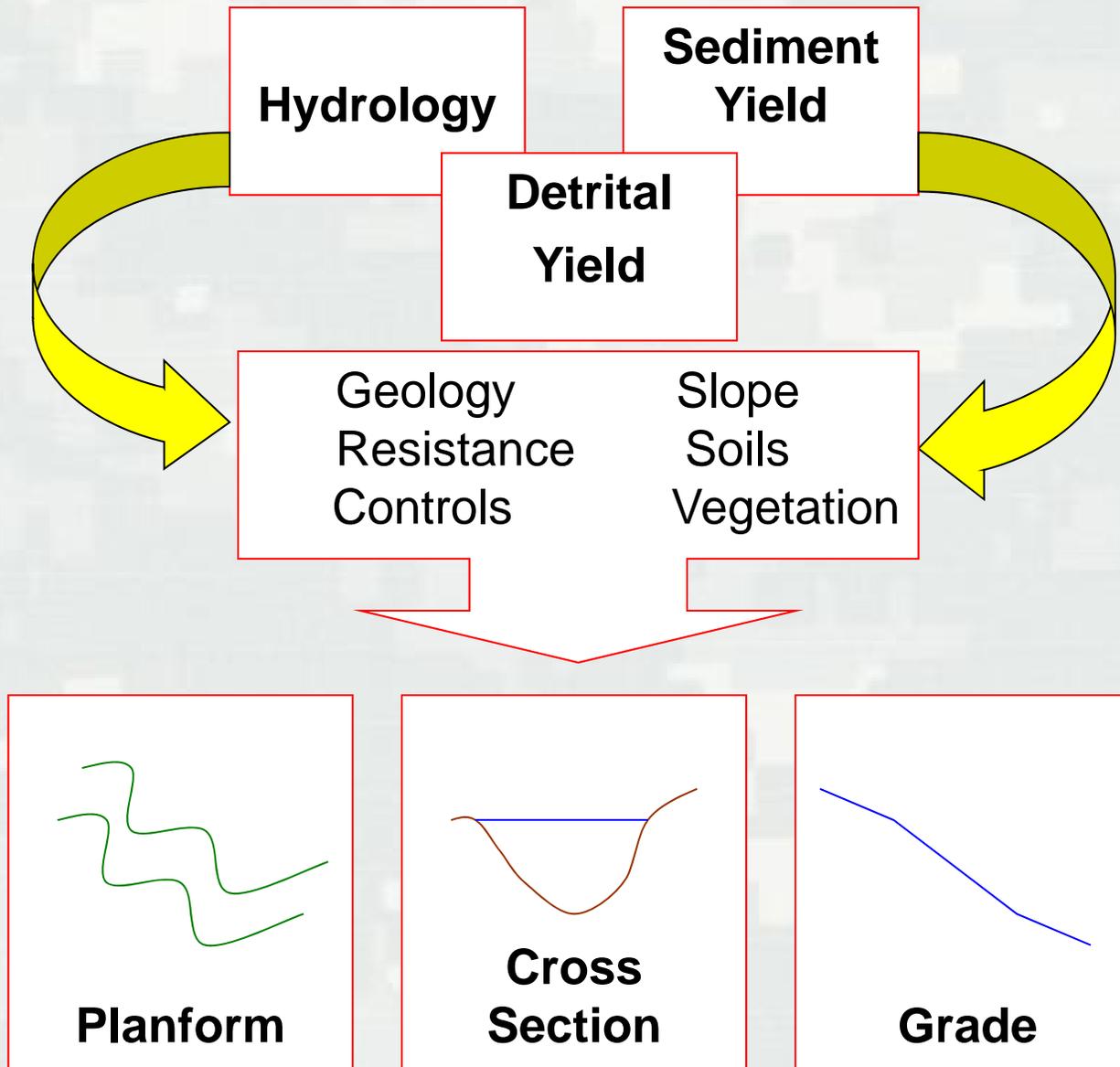
System Dynamics	Hydrologic Balance	Sediment Processes and Character	Biological Support	Chemical Processes and Pathways
Stream Evolution Processes	Surface Water Storage Processes	Sediment Continuity	Biological Communities and Processes	Water and Soil Quality
Energy Management	Surface / Subsurface Water Exchange	Substrate and Structural Processes	Necessary Habitats for all Life Cycles	Chemical Processes and Nutrient Cycles
Riparian Succession	Hydrodynamic Character	Quality and Quantity of Sediments	Trophic Structures and Processes	Landscape Pathways



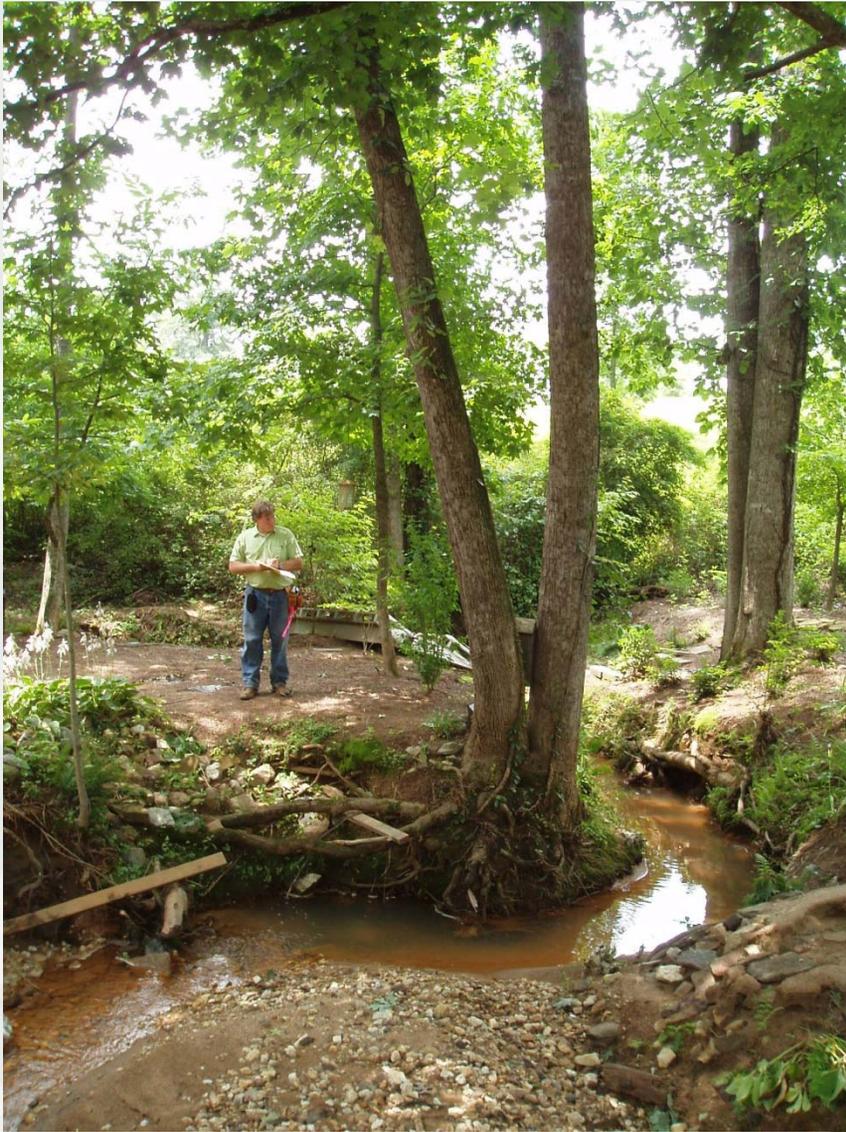
# Ecosystem Services

- Water Supply and Regulation
- Erosion Regulation/ Sediment Management
- Water Purification and Waste Treatment
- Natural Hazard Regulation
- Biodiversity Maintenance
- Recreational Opportunities
- Food
- Fiber, Fuel, and other Raw Materials
- Climate Regulation
- Clean Air
- Science and Education
- Maintain Cultural Diversity
- Spiritual and Inspirational
- Aesthetics

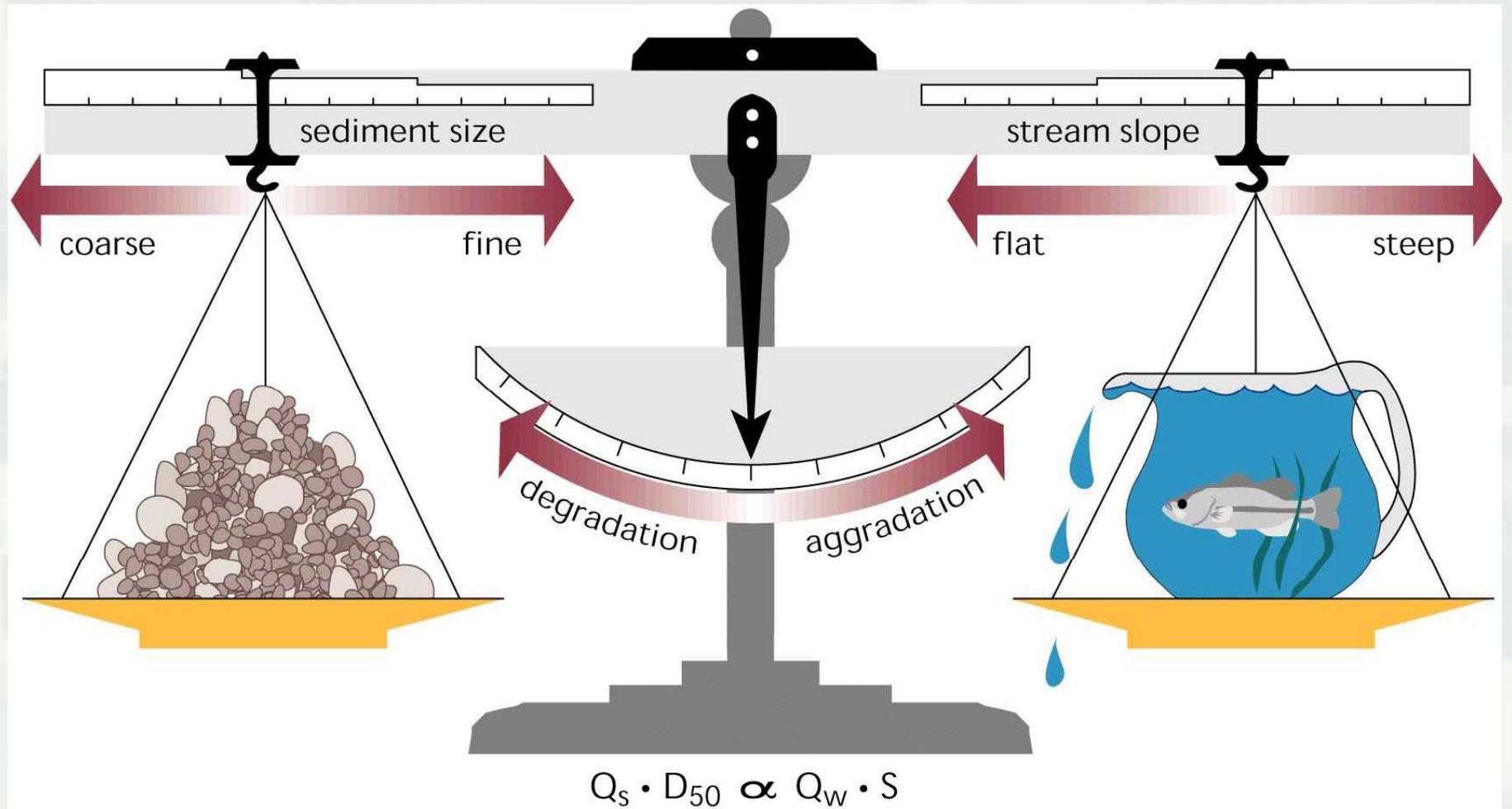




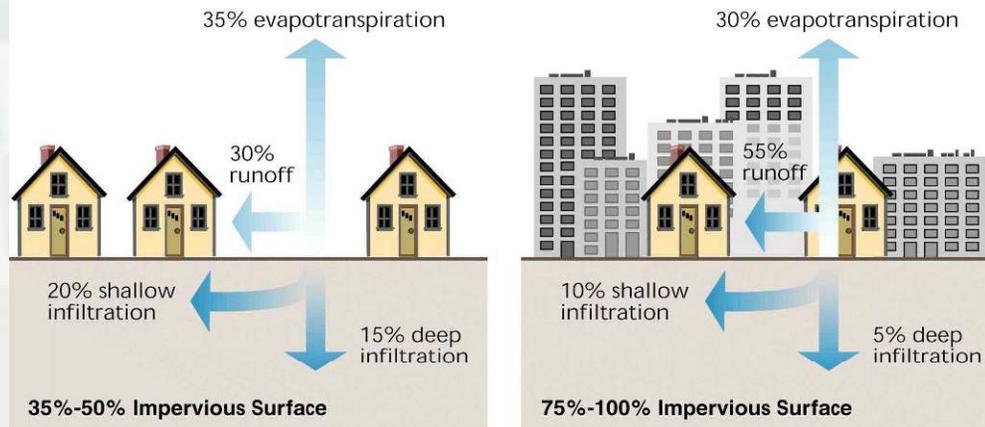
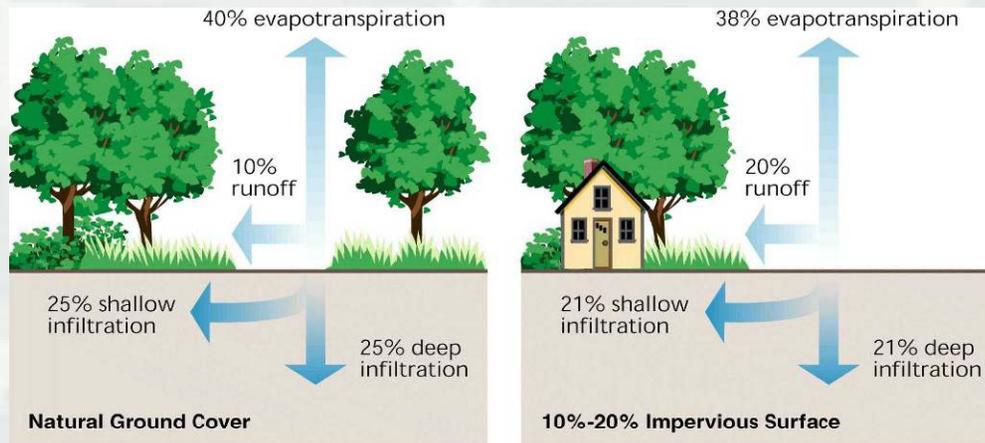




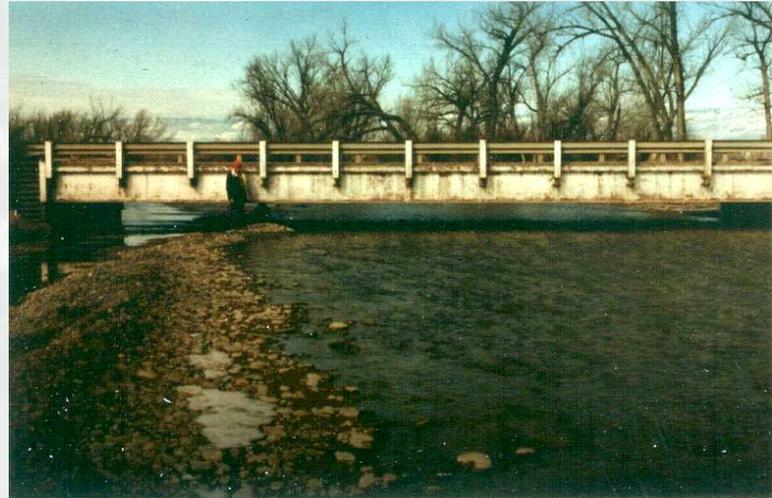
# Lane's Relation



# Excess Water



# Excess Sediments

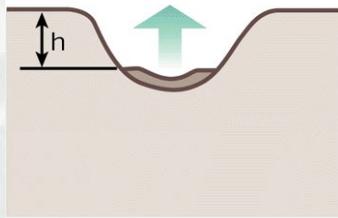


# Slope Adjustments



# Channel Evolution Model

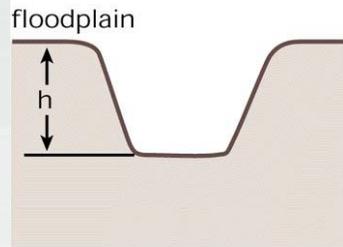
**Class I. Sinuous, Premodified**  
 $h < h_c$



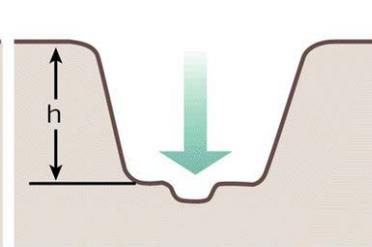
$h_c$  = critical bank height

→ = direction of bank or bed movement

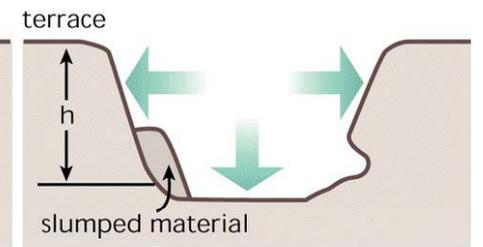
**Class II. Channelized**  
 $h < h_c$



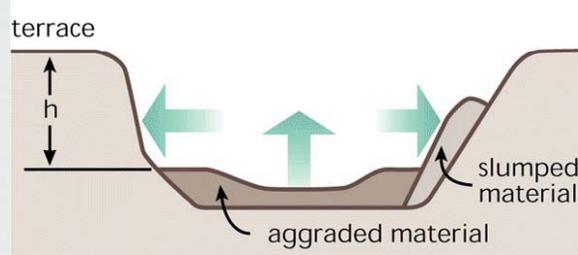
**Class III. Degradation**  
 $h < h_c$



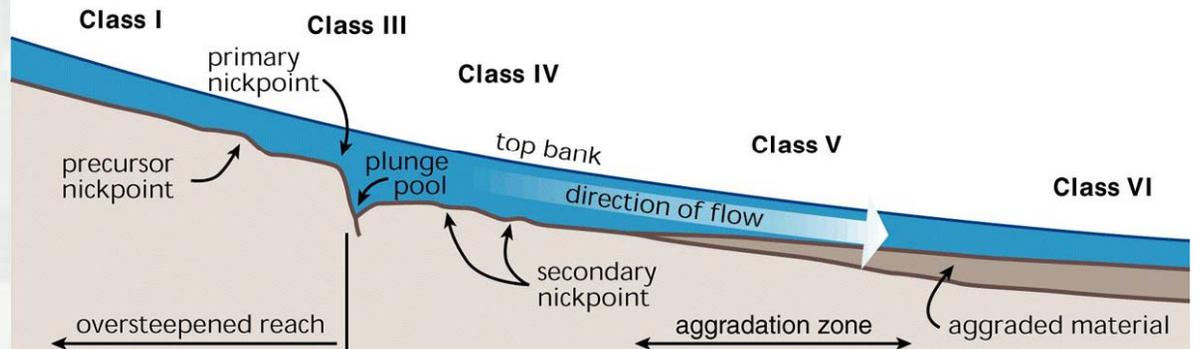
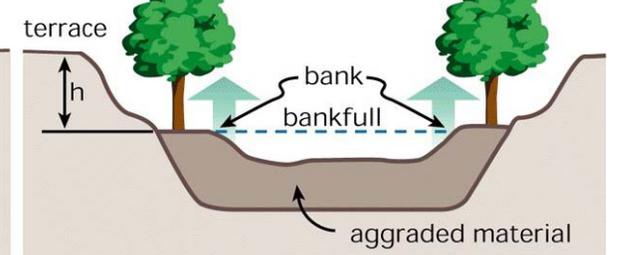
**Class IV. Degradation and Widening**  
 $h > h_c$



**Class V. Aggradation and Widening**  
 $h > h_c$

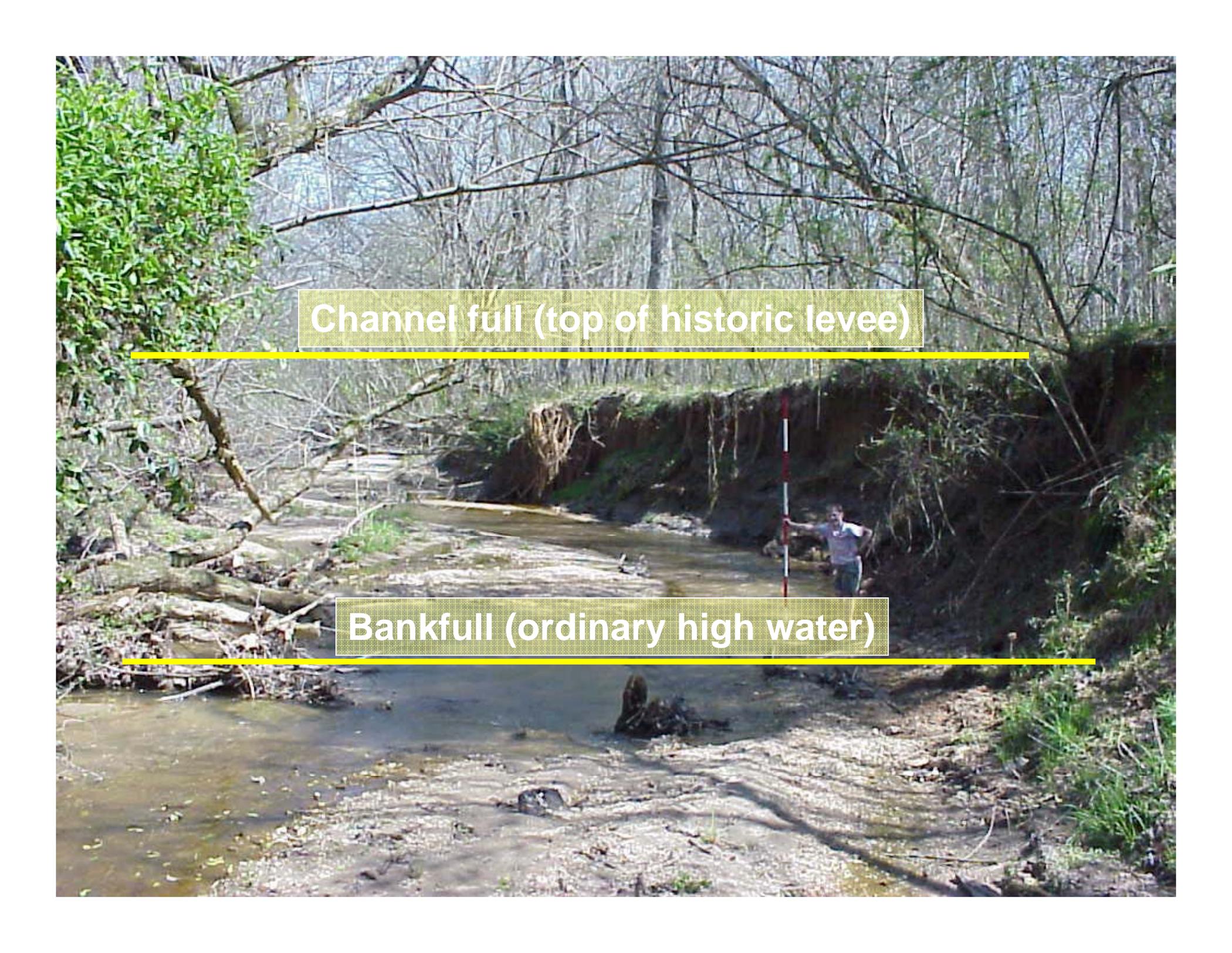


**Class VI. Quasi Equilibrium**  
 $h < h_c$



# CEM Stages





Channel full (top of historic levee)

Bankfull (ordinary high water)

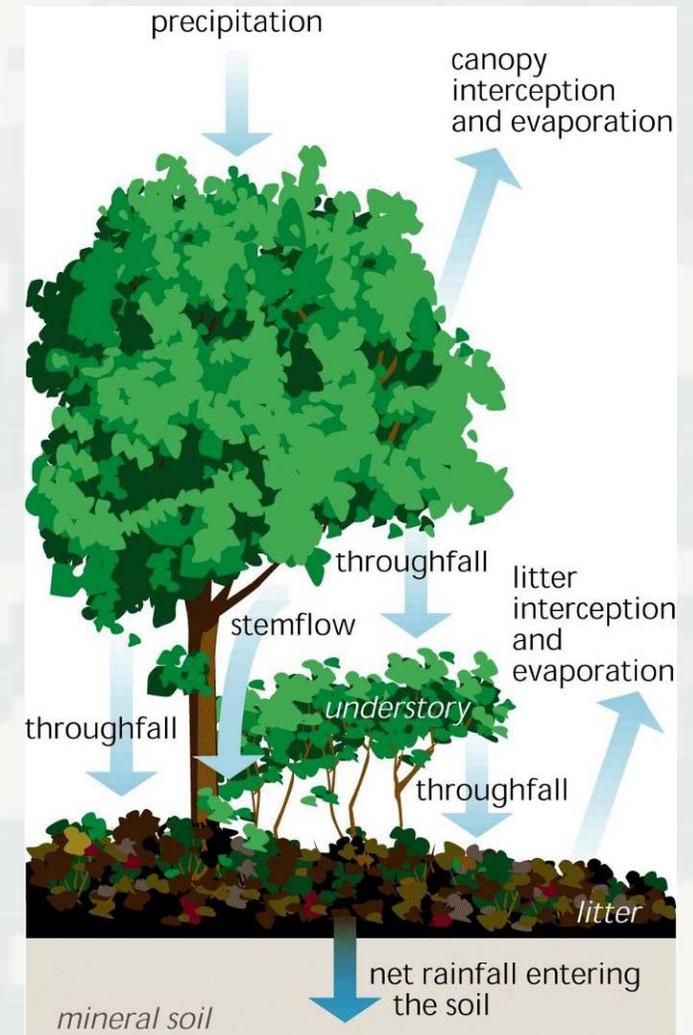
# Landscape Changes

- Vegetation clearing/alteration
- Topsoil removal/homogenization
- Changed contours



# Vegetation Effects

- Interception
  - Rain is prevented from getting to the land surface
- Transpiration
  - Diffusion of water vapor from plant leaves to the atmosphere
- Evapotranspiration
  - Combination of evaporation and transpiration
- Resistance
- Stability
- Shading
- Air movement effects
- Bank strength
- Debris trapping and supply
- Nutrient sourcing
- Hydraulic friction
- Velocity refugia



# Hydrologic Alteration

- Magnitude
- Timing
- Duration
- Rate of Change



Photo - EarthJustice

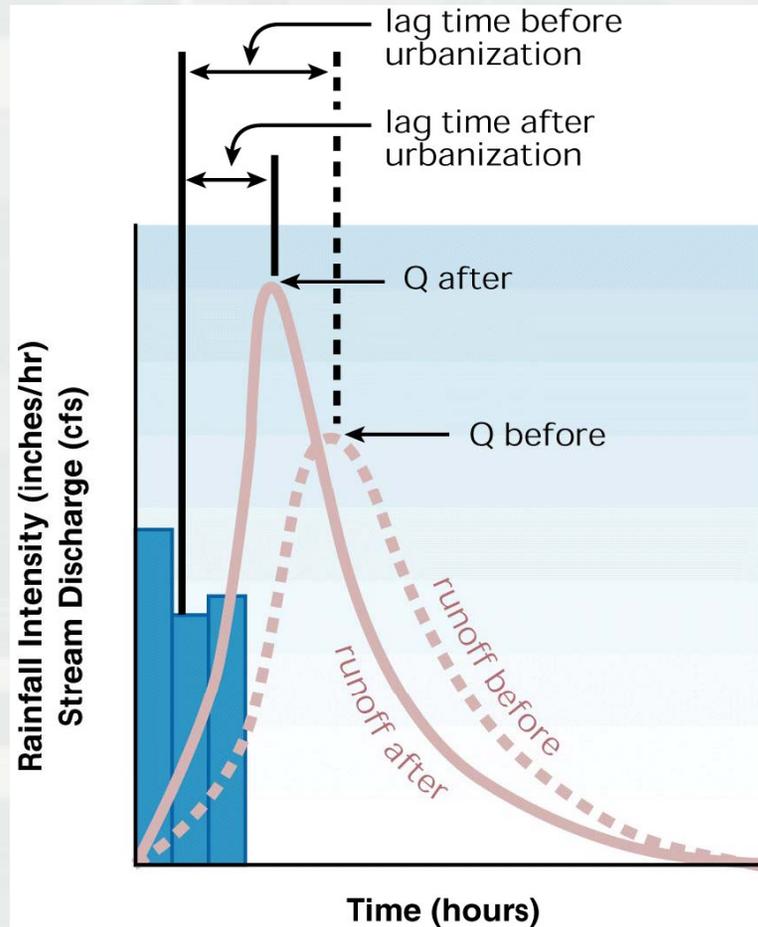
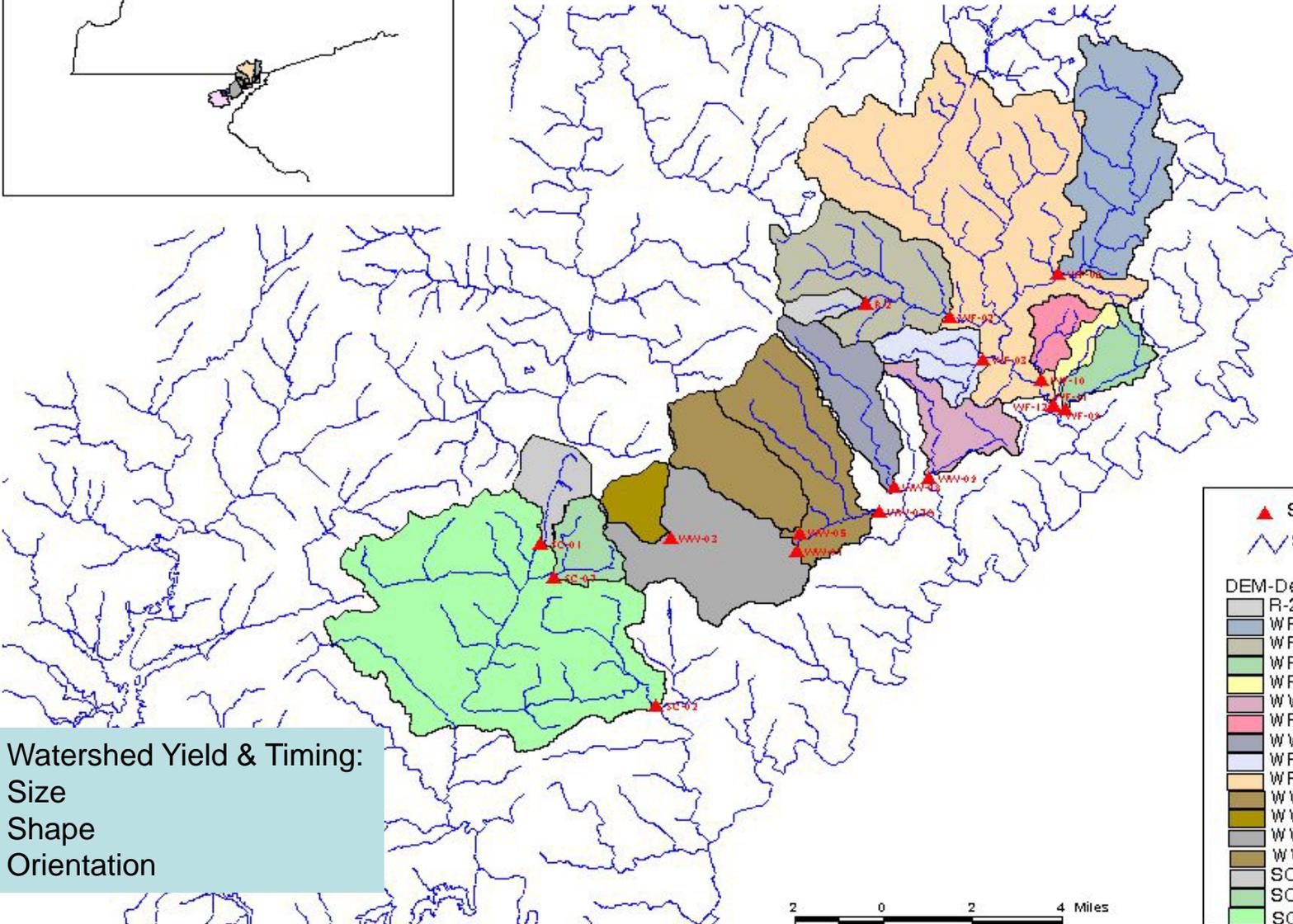
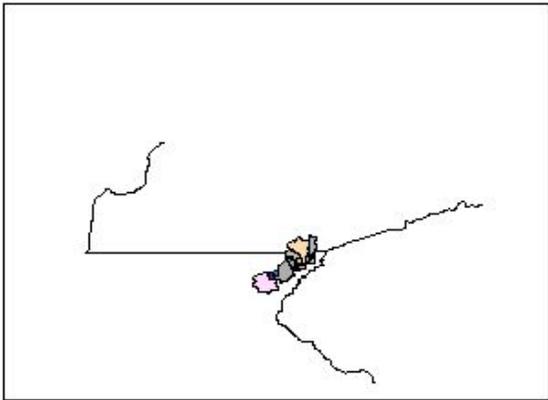


Fig. 1.15 -- A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams. In Stream Corridor Restoration: Principles, Processes, and Practices (10/98). Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

# CHATTOOGA RIVER WATERSHED SEDIMENT YIELD STATIONS



Watershed Yield & Timing:  
Size  
Shape  
Orientation

▲ STATIONS  
~ STREAMS

DEM-Derived Watersheds

- R-2
- WF-08
- WF-02
- WF-09
- WF-11
- WW-09
- WF-10
- WW-08
- WF-03
- WF-12
- WW-05
- WW-03
- WW-01
- WW-02A
- SC-01
- SC-07
- SC-02

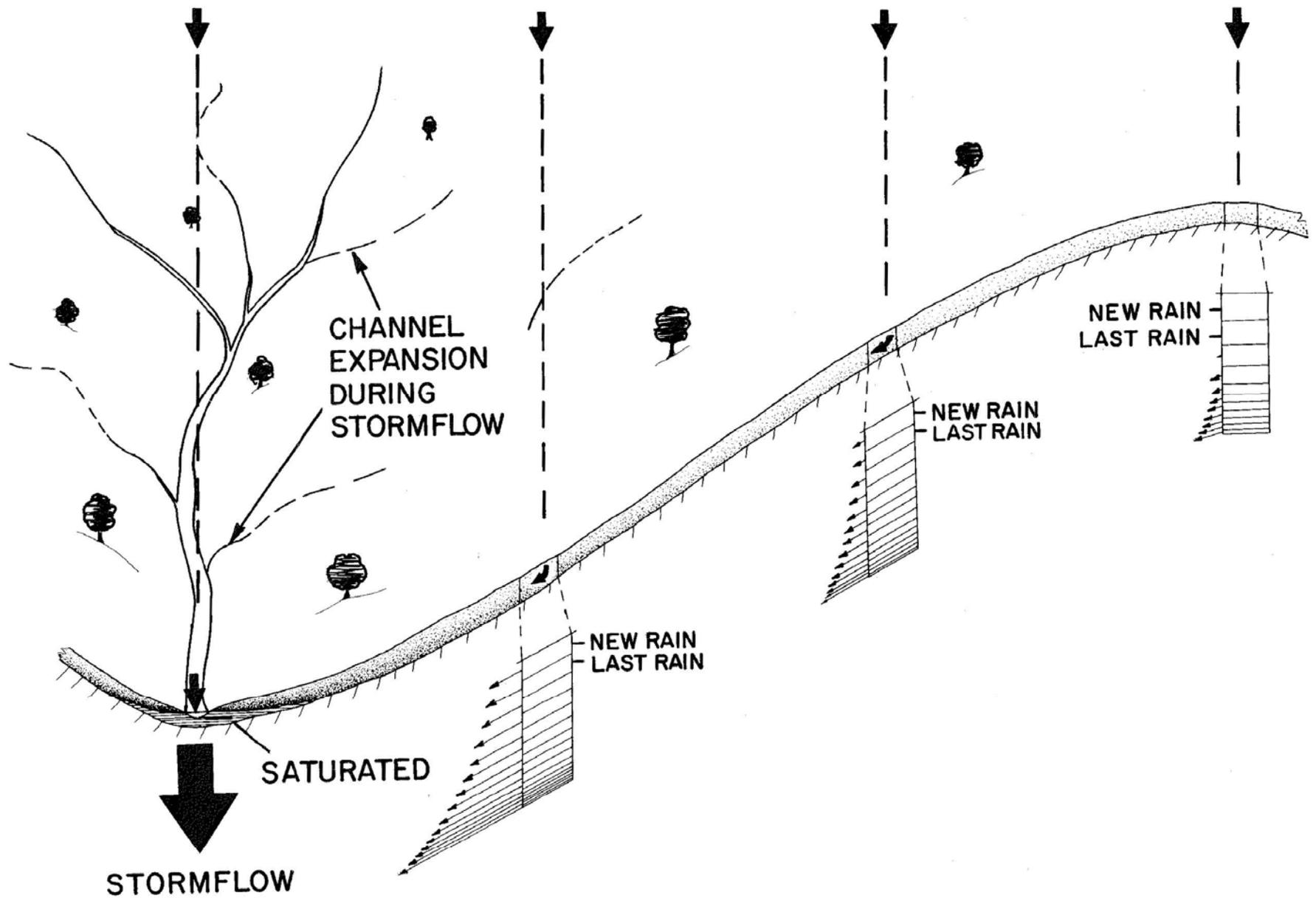
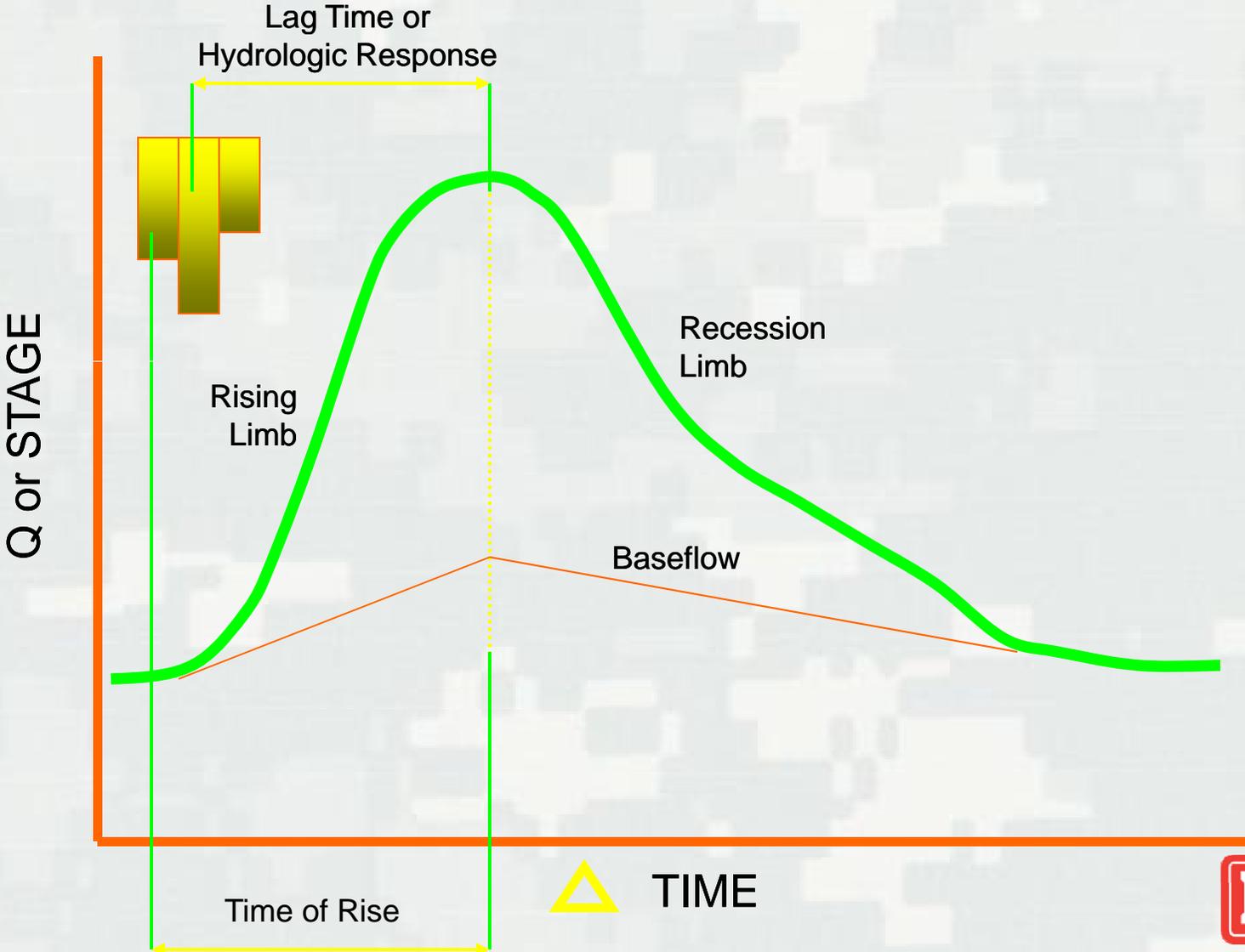
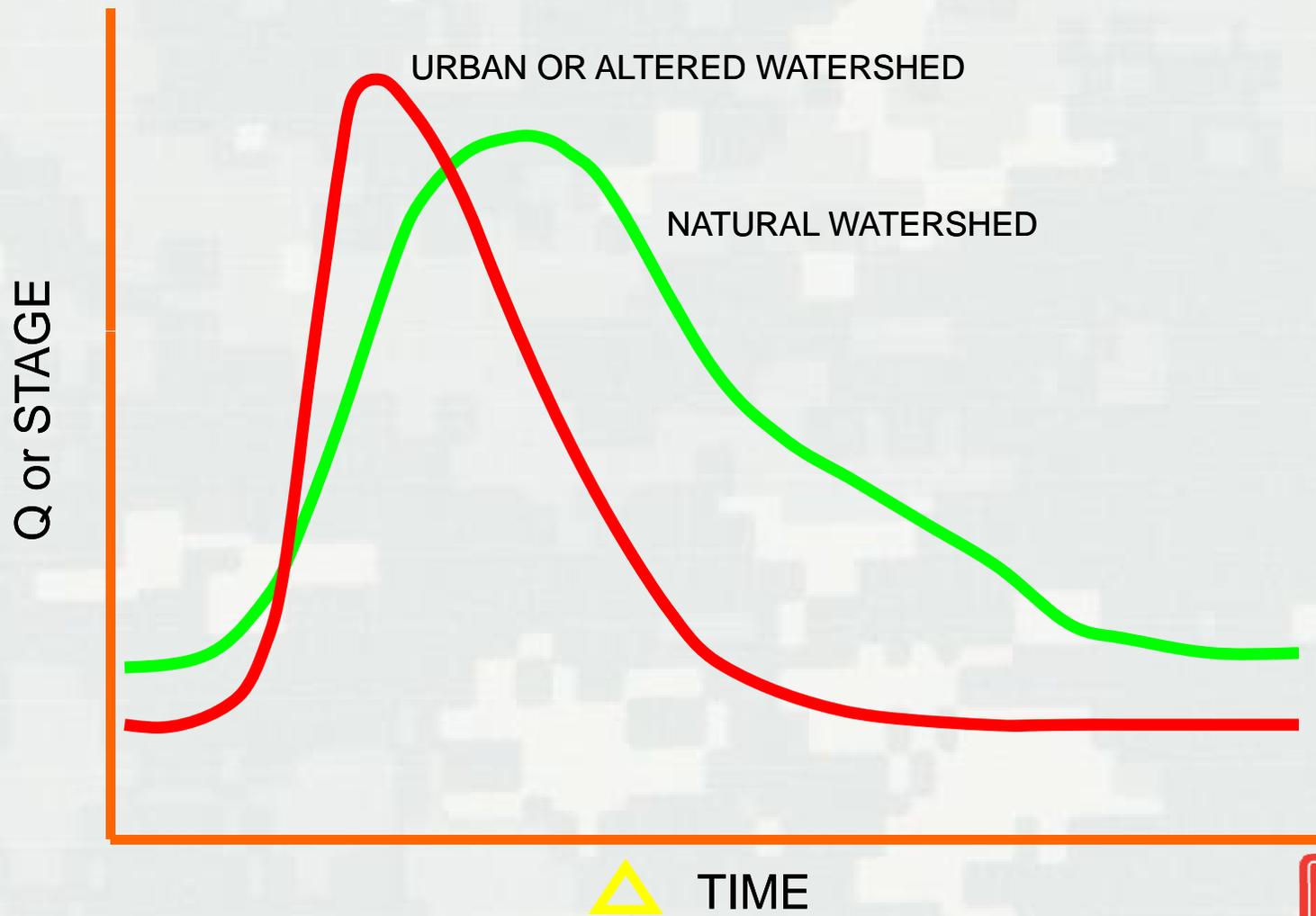


Fig 7-13. An idealized section through an upland forest basin, showing the varying source area for stormflow (direct runoff) and the source of delayed baseflow (from Hewlett and Hibbert 1967).

# STORM HYDROGRAPH



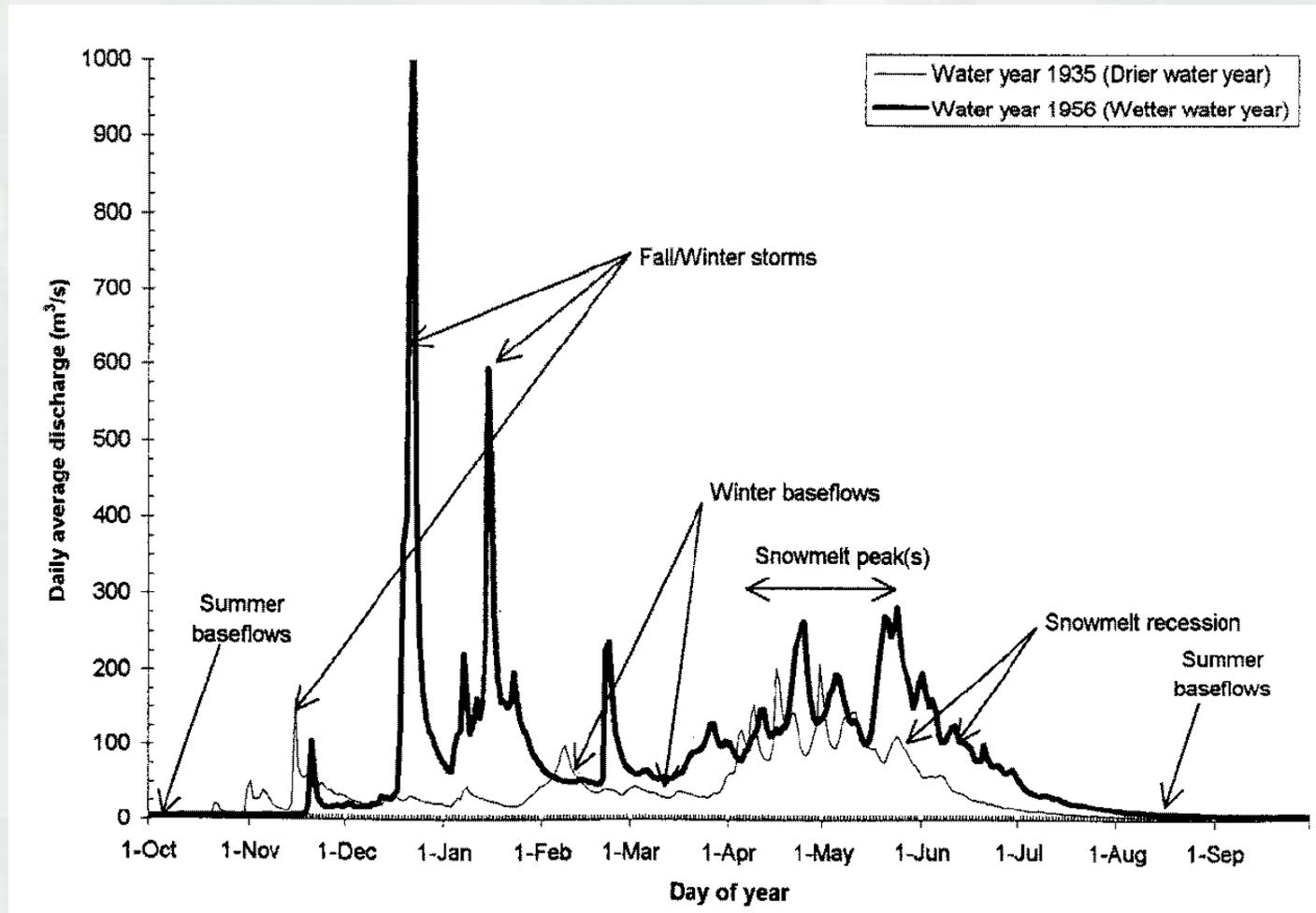
# HYPOTHETICAL WATERSHED RESPONSE, STORM HYDROGRAPHS



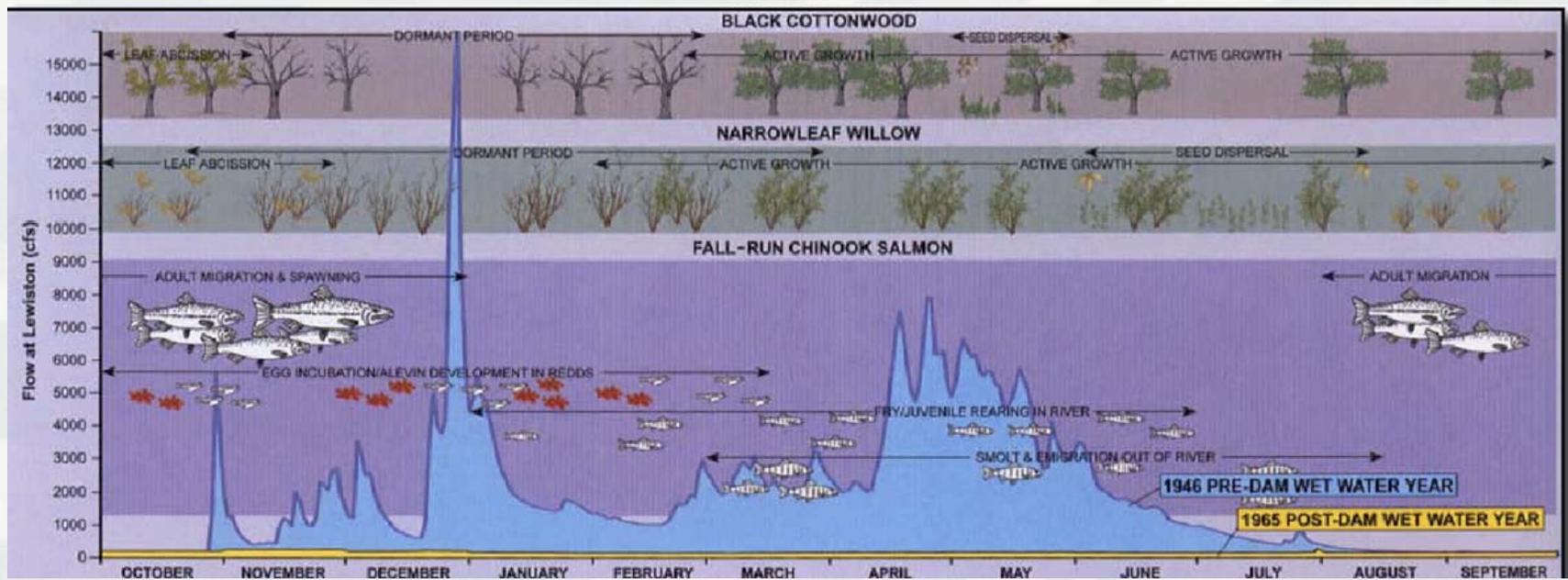
△ TIME



# Hydrograph Keys



# Hydrograph Keys



# Hydrologic Characteristics

Rivers need natural flow magnitude, frequency, timing, duration, rate of change

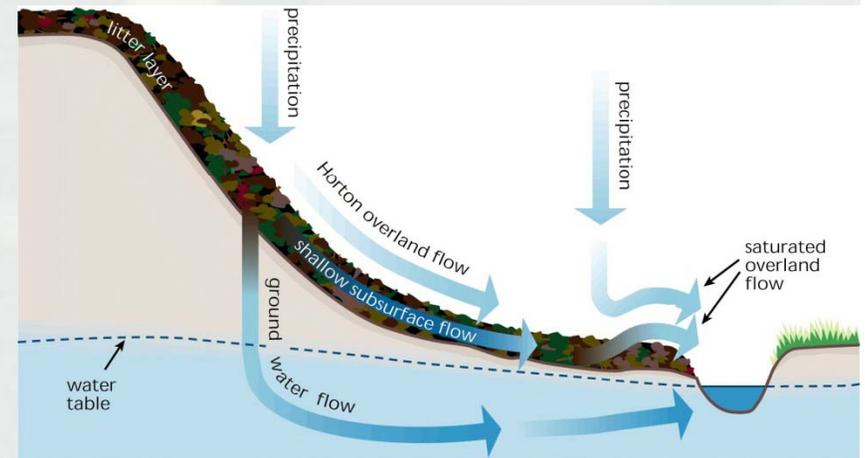
## Natural Flow Regime

<u>Component</u>	<u>Specific Alteration</u>	<u>Ecological Response</u>
magnitude and frequency	increased variation	loss of sensitive species
magnitude and frequency	flow stabilization	invasion of exotic spp.
timing	loss of seasonal peaks	disrupt cues for fish
duration	prolonged low flow	increased temp; conc. of organisms
duration	prolonged inundation	change in vegetation; tree mortality
rate of change	rapid stage change	wash-out of aquatic spp., stranding

Poff et al. 1997

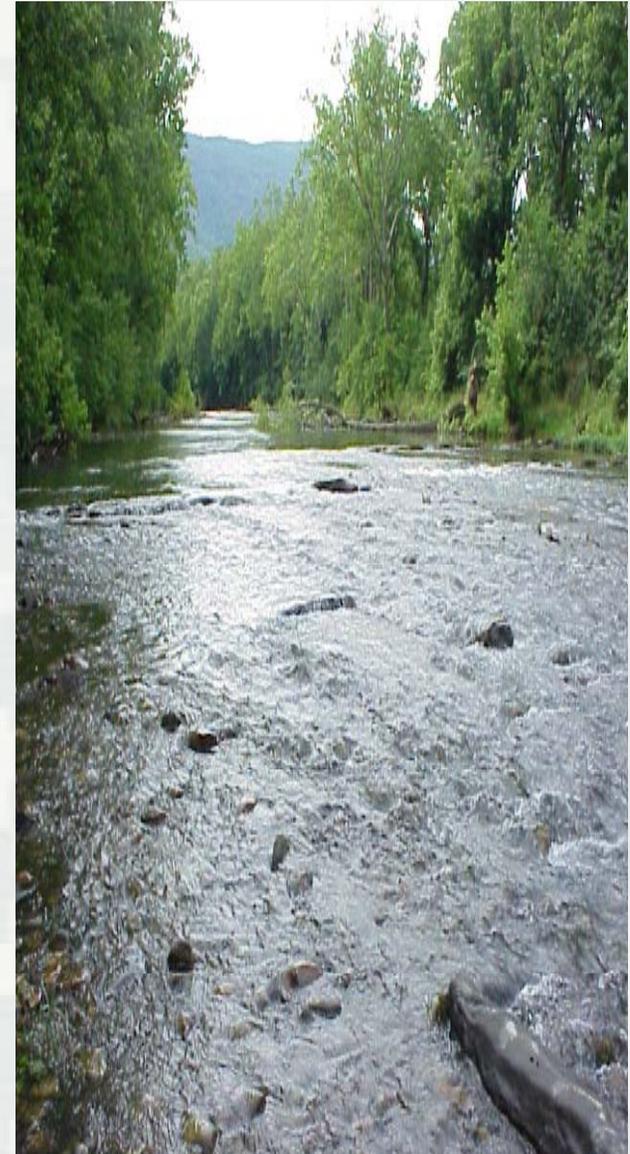
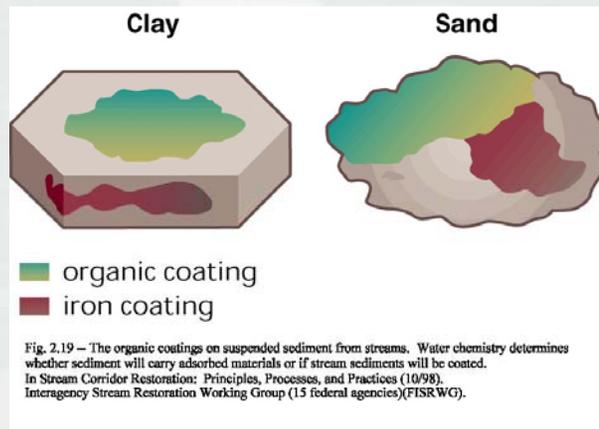
# Surface/Groundwater

- Altered soils
- Changed topography
- Settling ponds
- Vegetation community



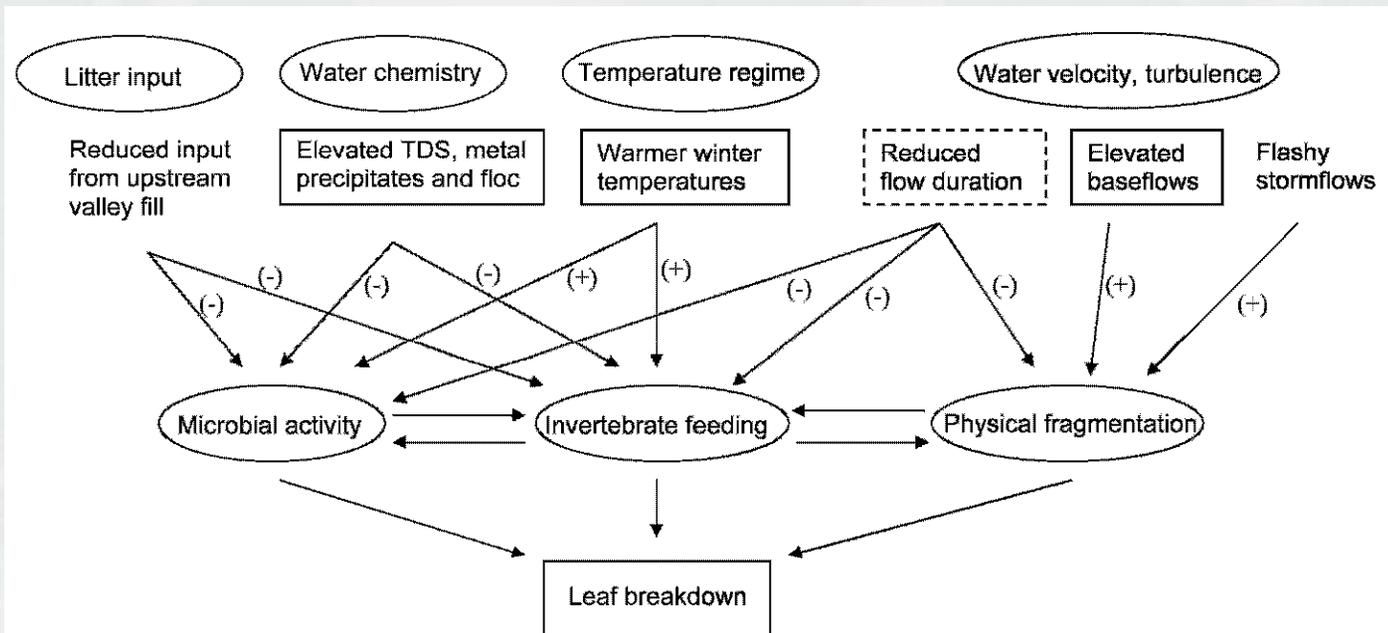
# Sediment Processes

- Increased yield
- Changed PSD
- Embeddedness
- Associated contaminants



# Energy Processes

- Primary productivity
- Organic matter input
- Transformation
- Downstream transport
- Respiration
- Nutrient uptake



# Water Quality

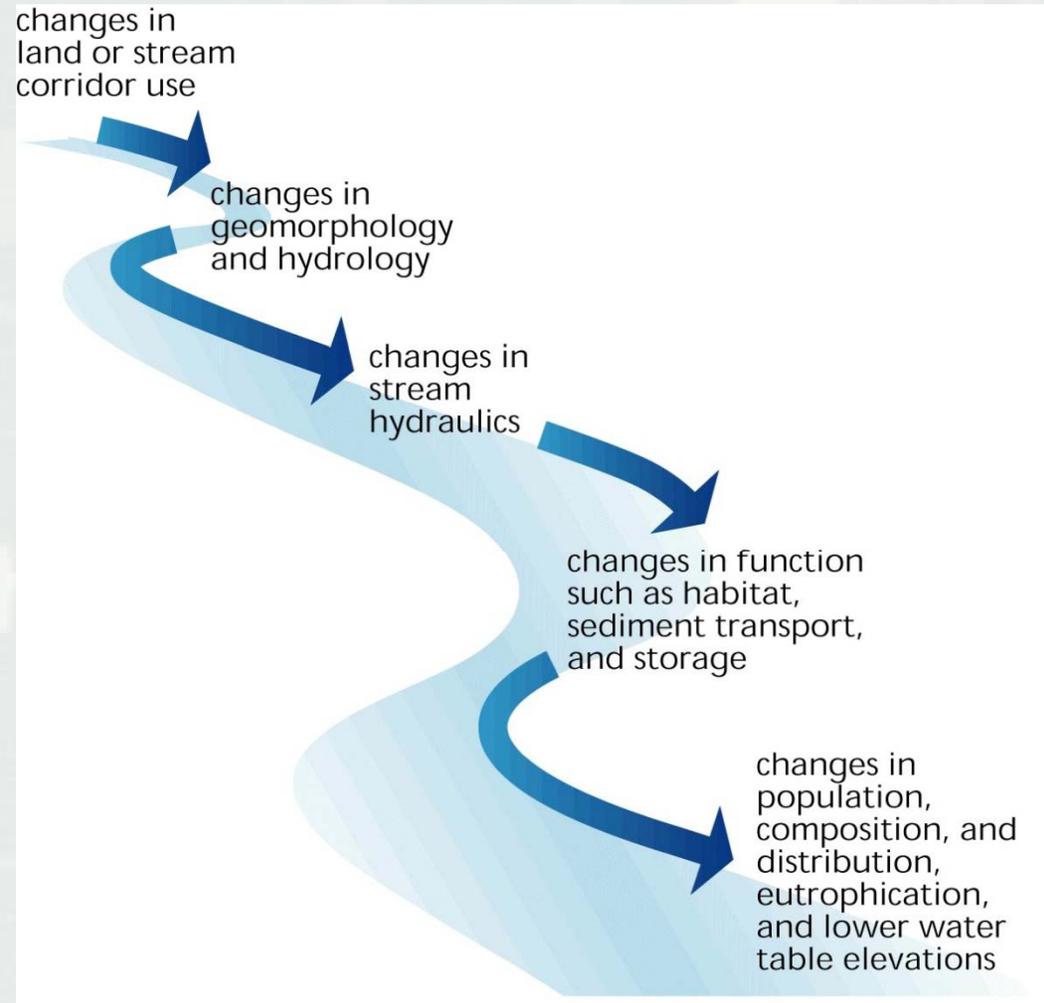
- Specific conductivity
- pH
- Temperature
- TSS
- Nutrients
- Organic matter
- Dissolved solids
- Precipitates



Photo from Appalachian Voice



# Cascading Effects



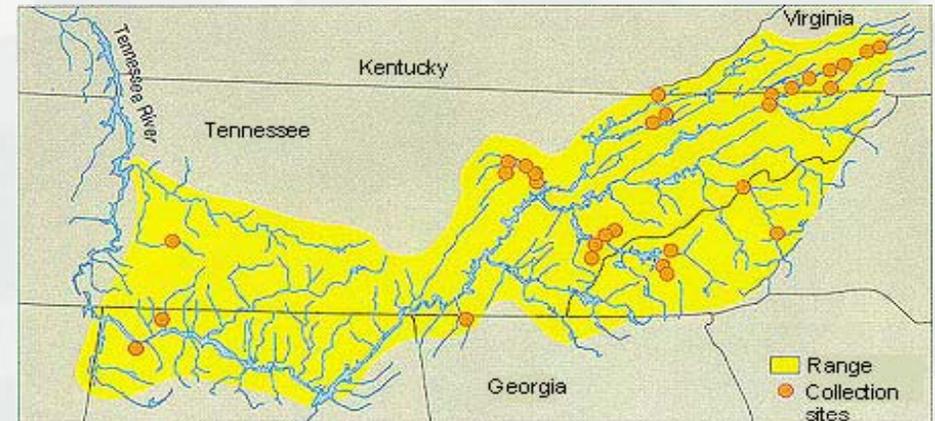
# Cumulative Effects on Aquatic Organisms



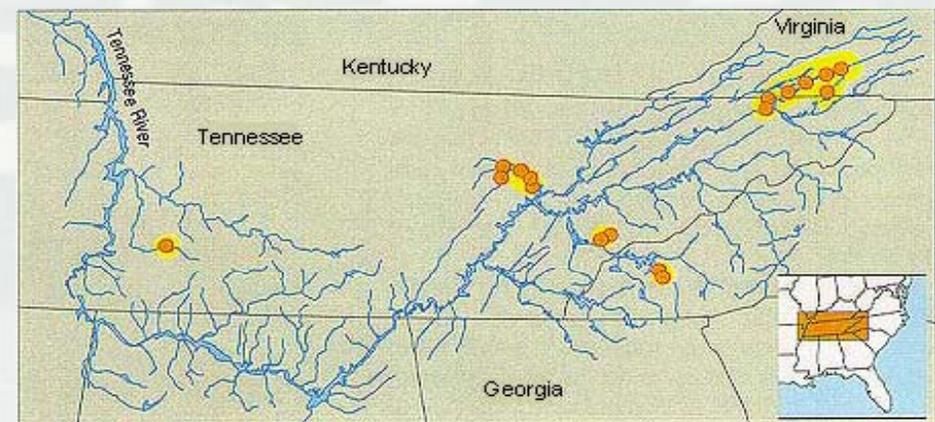
Pre-1930's

## Fishes:

- loss/alteration of habitat  
    spawning, feeding, refugia
- fragmentation of habitat
- scour of gills, eggs, YOY
- clogging of gills
- impairs respiration
- increased stress
- decreased growth
- disruption of spawning cues
- community shift
- reduced diversity



Present



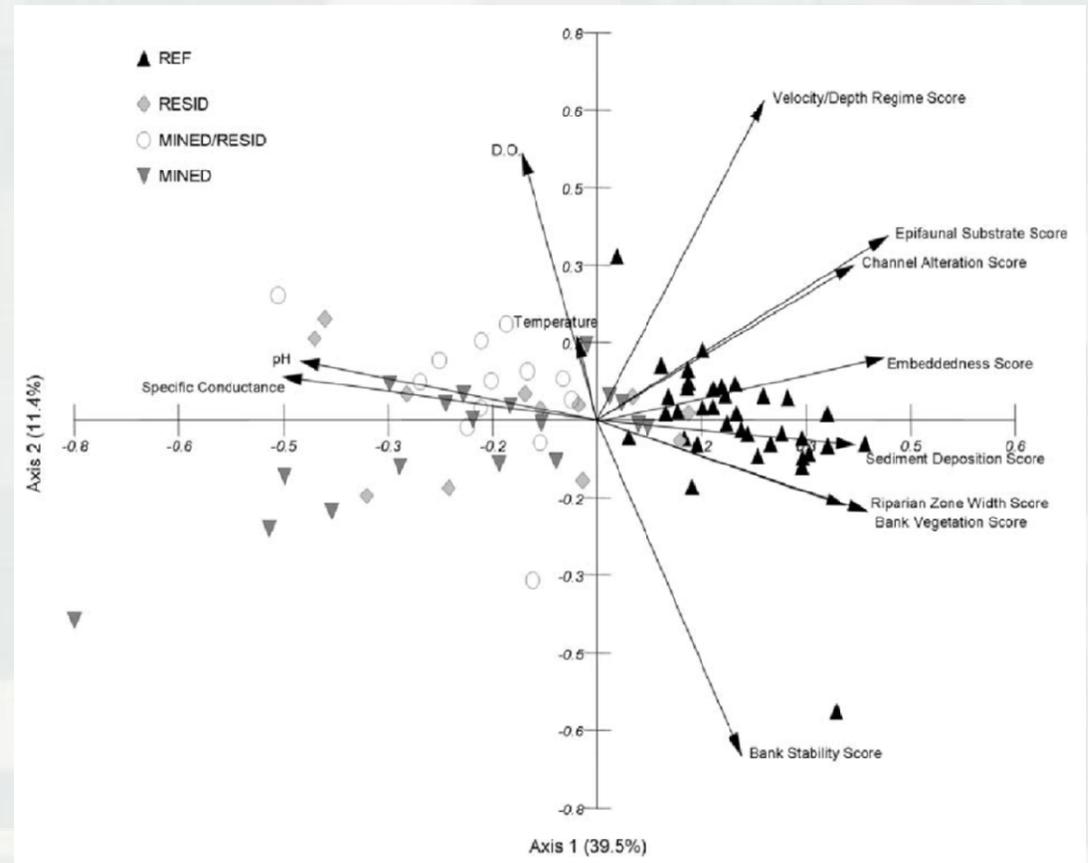
# Invertebrates/Autotrophs

## Invertebrates:

- loss of habitat: embeddedness
- increases drift
- clogging, and scouring of gills
- community shift

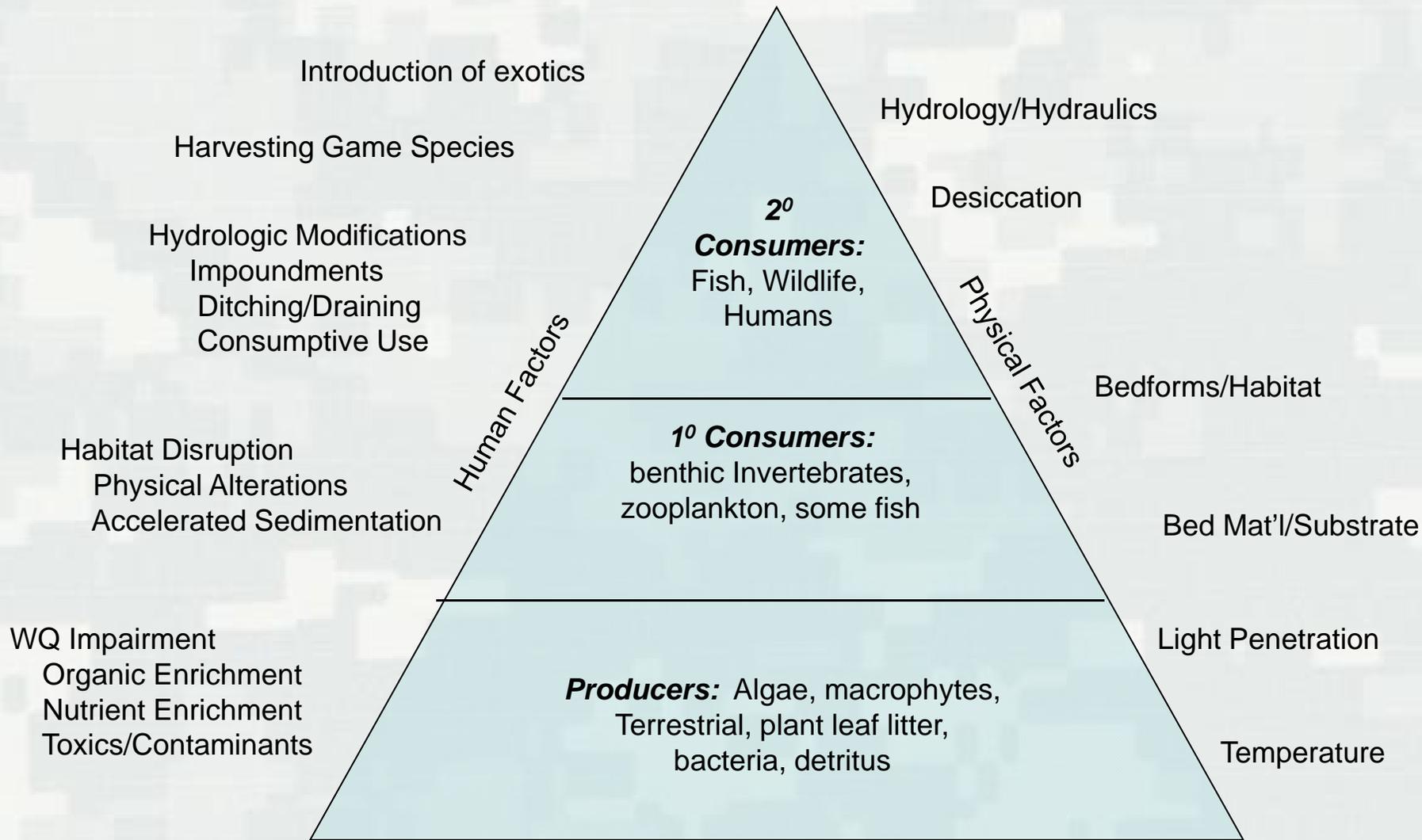
## Autotrophs:

- increased sunlight/photosynthesis
- surface scour...affects periphyton
- reduced water clarity/photosynthesis
- deposition: buries algae



Pond 2010





Pruitt 2010

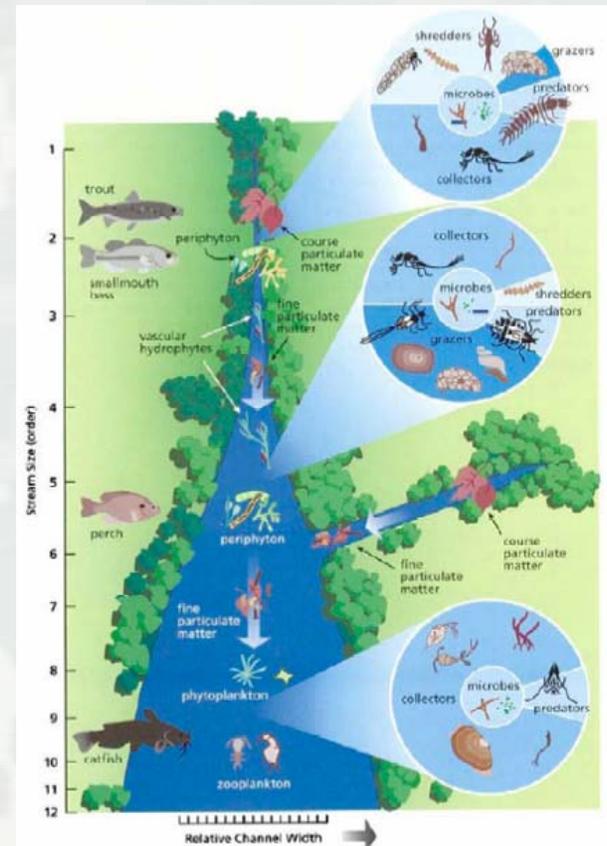


Factors affecting aquatic ecosystems depicted at trophic levels

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# River Continuum Concept

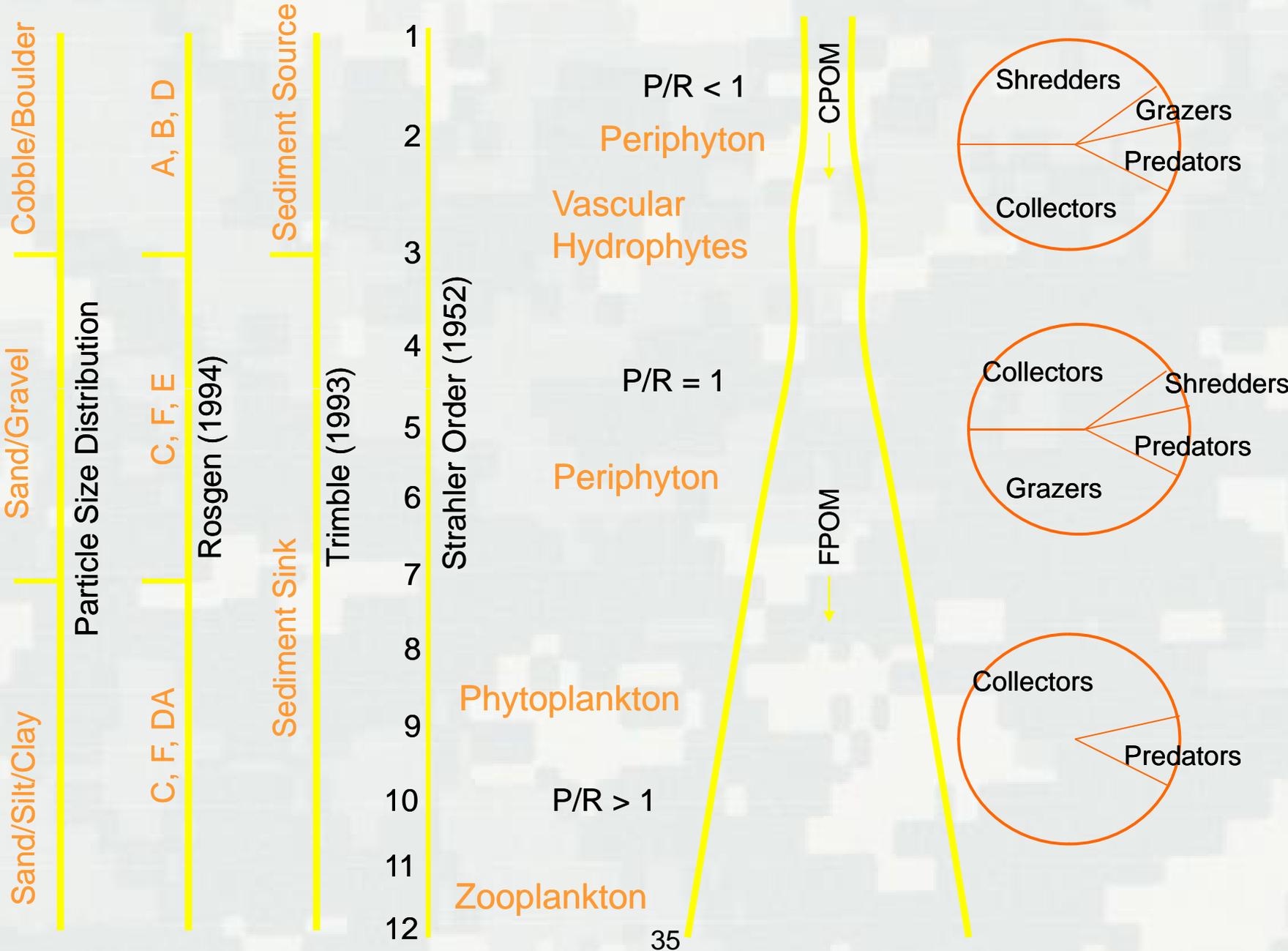
A river's biological and chemical processes correspond to its physical attributes. The nature of biological communities changes in a downstream direction in relation to the changing, but predictable physical structure. This means that the structure of the biological communities is also predictable and that the communities adapt to the particular conditions of a stretch of stream.



(Vannote et. al. 1980)

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# River Continuum Concept (Vannote 1980)



# Temporal Response/Recovery



# Attributes of Restored Systems:

- Characteristic assemblage of species, including indigenous species to extent practicable
- All functional groups present for continued development along appropriate trajectory
- Physical environment capable of sustaining reproducing populations of species necessary for community maintenance
- Normal function for stage of ecological development, recognizing that character and functions may/should change with time
- Suitably integrated into the landscape
- Potential threats from surrounding landscape removed
- Sufficiently resilient to endure normal periodic stress
- Self-sustaining





**Questions?**



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