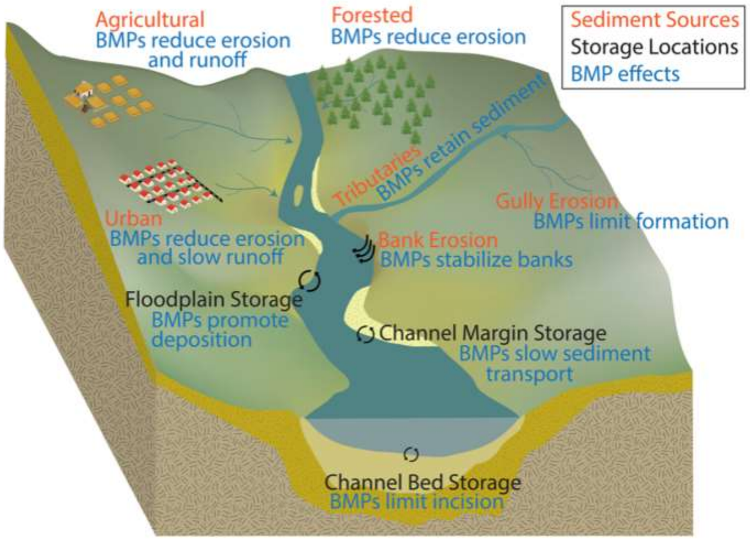
SESSION 1

Historical changes of to Chesapeake landscapes and identify the evolution of stream restoration goals, regulations, practices, and practice implementation (after the 1972 Clean Water Act)

OBJECTIVES

1. How has **management** or mismanagement resulted in impairment of streams (watershed and stream management)?
2. What is our understanding of how **stressors** influence streams and our ability to appropriately identify and address stressors?
3. What are the **drivers** for stream restoration?
4. In the past, what **management** was taken to restore streams?



From: Noe et. al. (2020). Sediment dynamics and implications for management: State of the science from long-term research in the Chesapeake Bay watershed, USA

SYNTHESIS OF SESSION #1

Watershed Legacies and Their Implications (Wohl)

Watershed History, Stream Degradation Patterns and Stressors (Panel 1)

Outcomes from Past Stream Restoration Efforts (Panel 2)

(pre-2010 period of Chesapeake Bay Agreement)

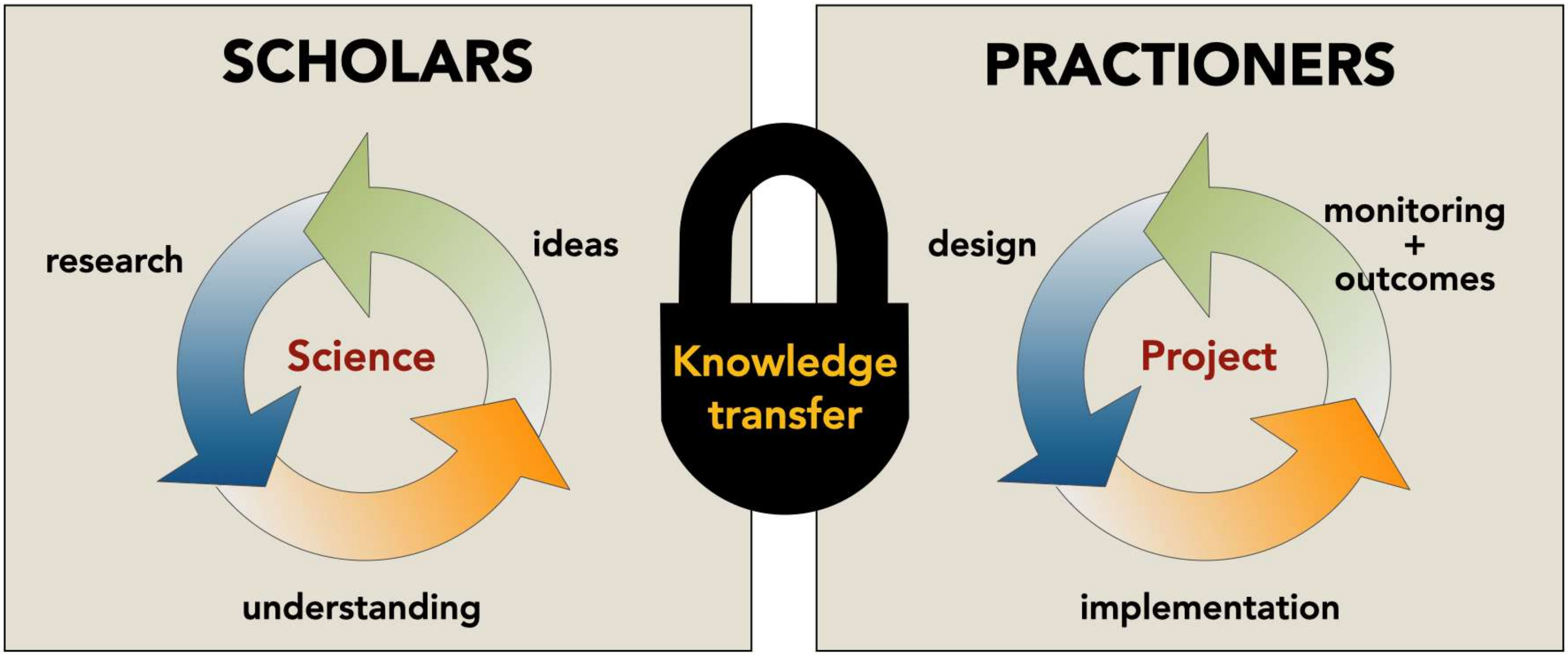
Benjamin R. Hayes

Bucknell University

From: Bonell and Askew 2000, Gregory (2004)

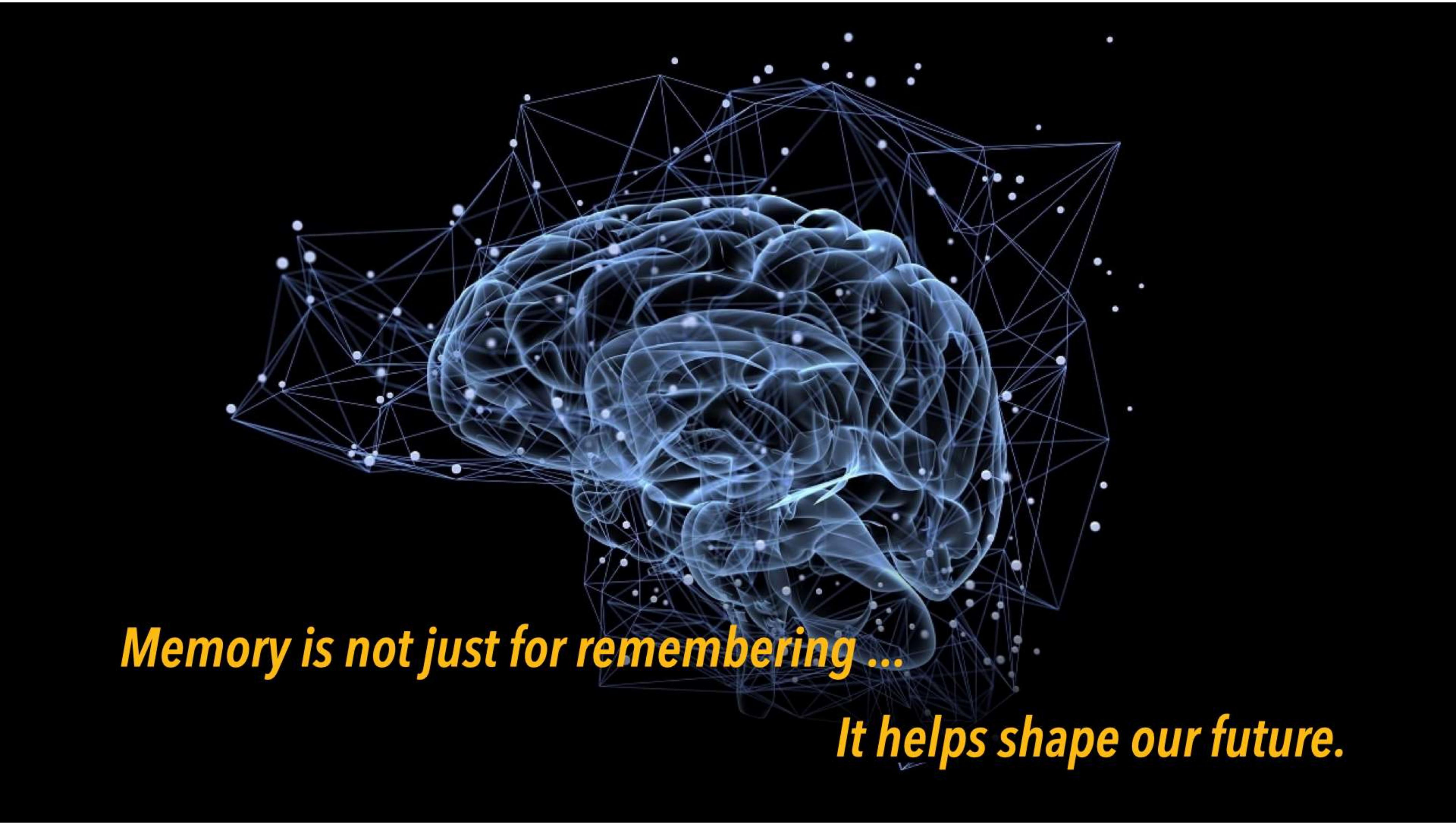
THE PARADIGM LOCK

Adapted from the United Nations' **Hydrology for Environment Life and Policy** (HELP) Project

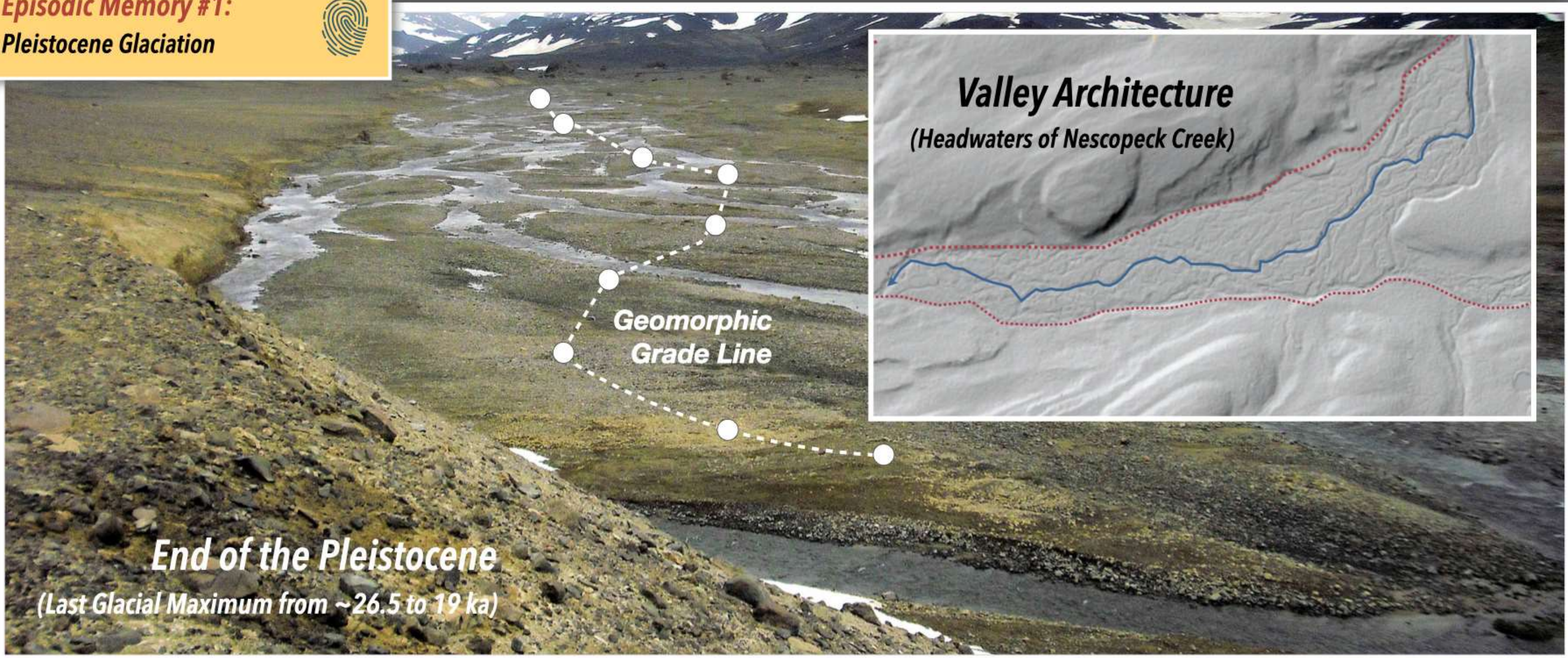


"Blue skies" strategic research

"Real world" accepted restoration practice


Memory is not just for remembering ...
It helps shape our future.

Episodic Memory #1:
Pleistocene Glaciation

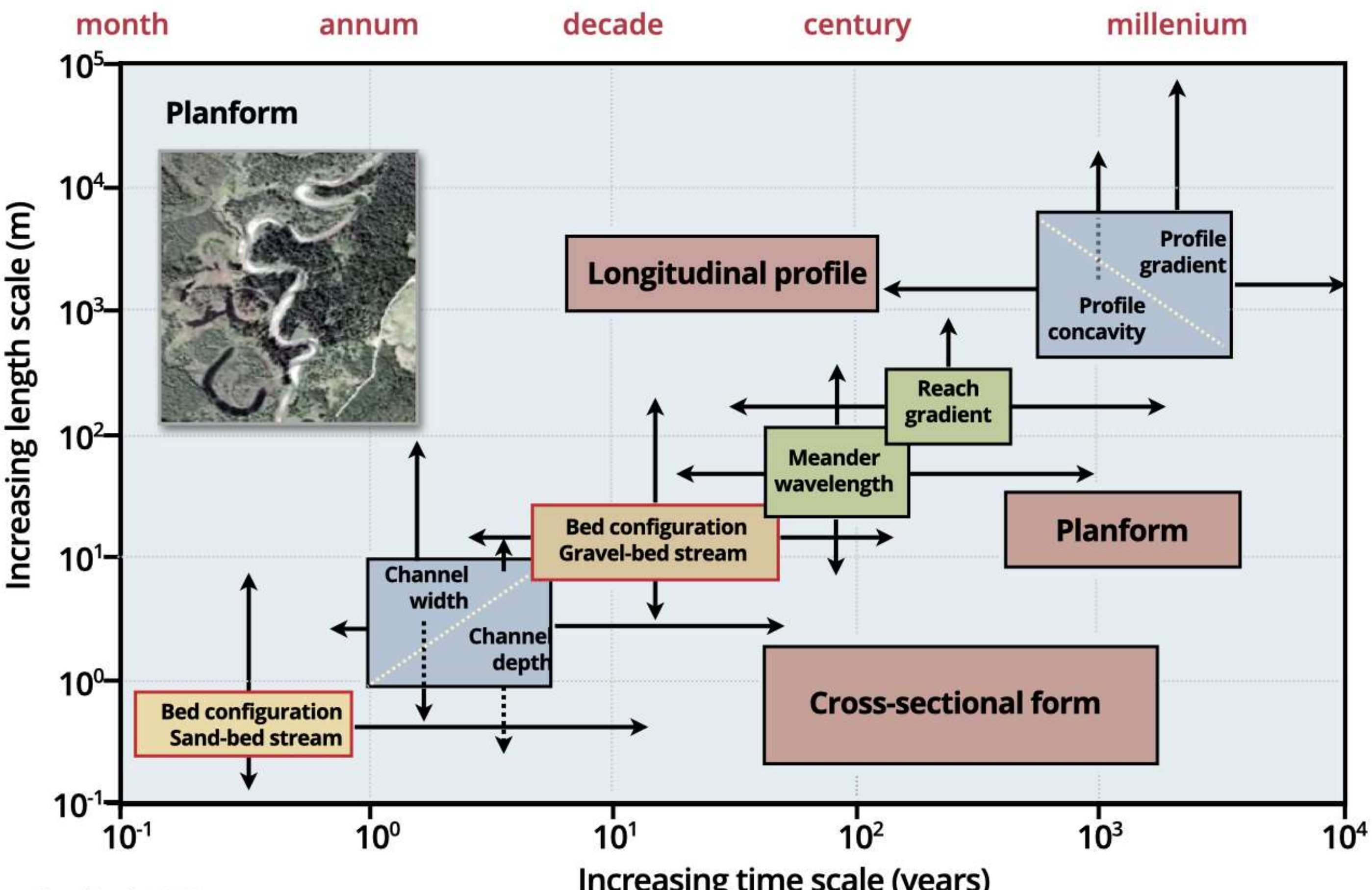


1 Key Concept

Watershed Scale (Stream-Valley Corridor) Setting

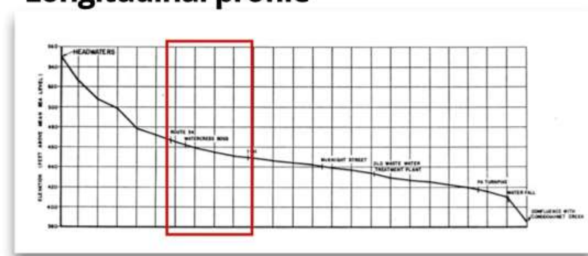
Geomorphic Grade Lines and Alluvial Architecture

SCALES OF FLUVIAL ADJUSTMENT

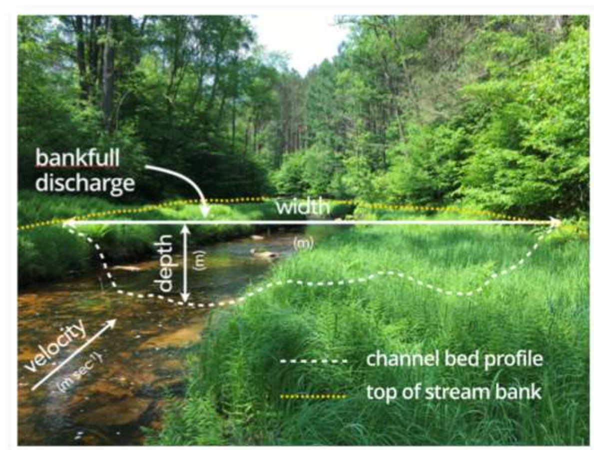


After Church (1998)

Longitudinal profile

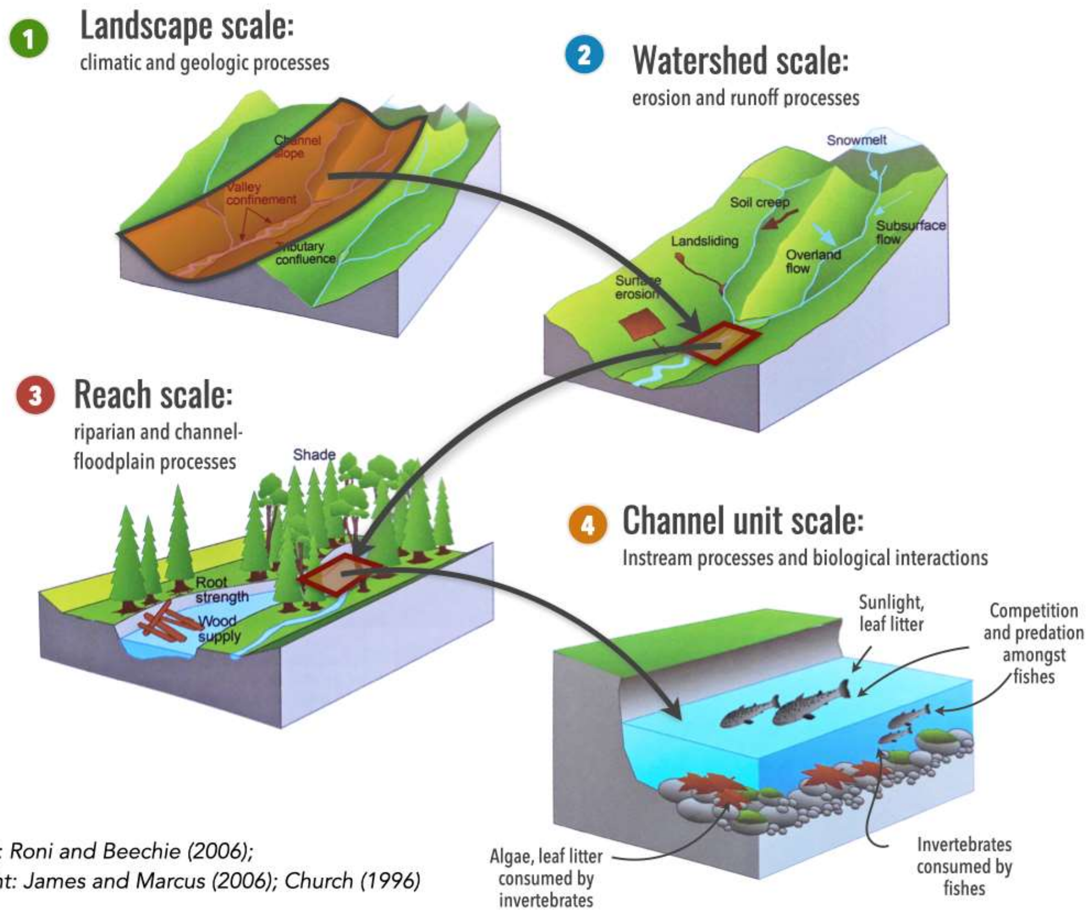


Cross-sectional form

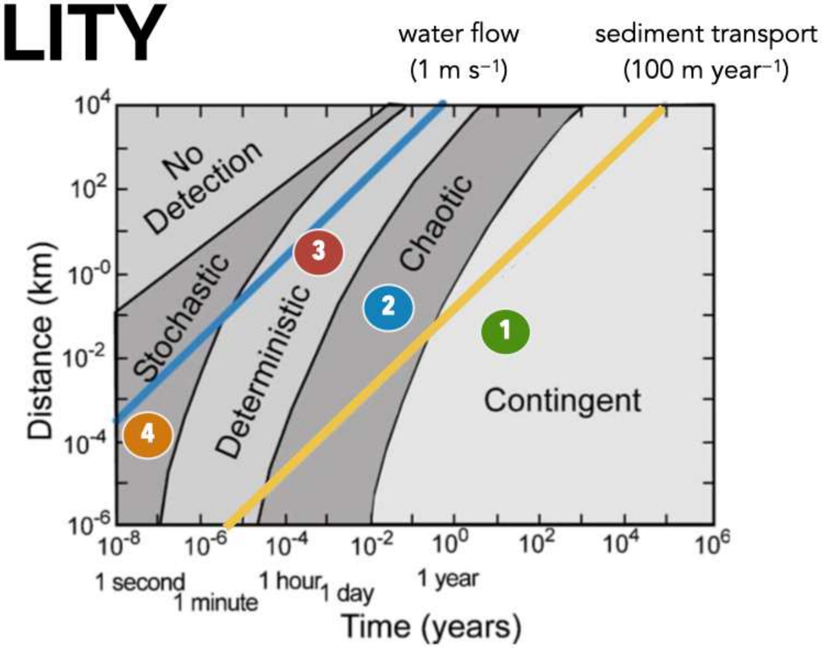


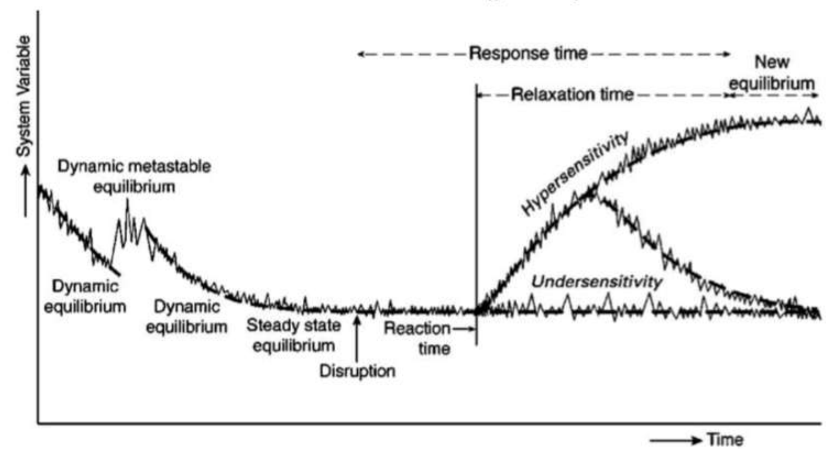
SCALE-DEPENDENCY OF CAUSALITY

Monitoring, assessment, explanation, valuation, and management



Left: Roni and Beechie (2006);
Right: James and Marcus (2006); Church (1996)

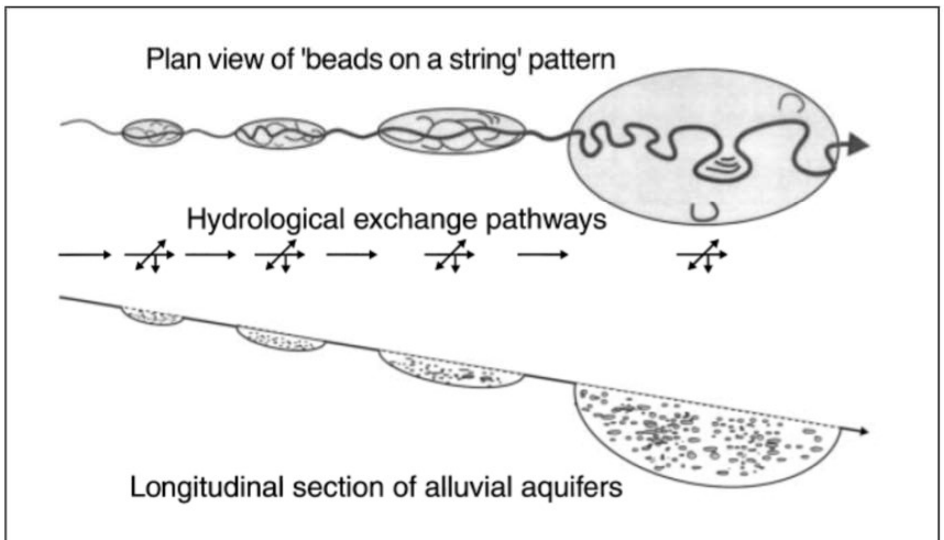




ECOSYSTEM STRUCTURE AND FUNCTION

How well do our stream restoration and valuation models reflect this?

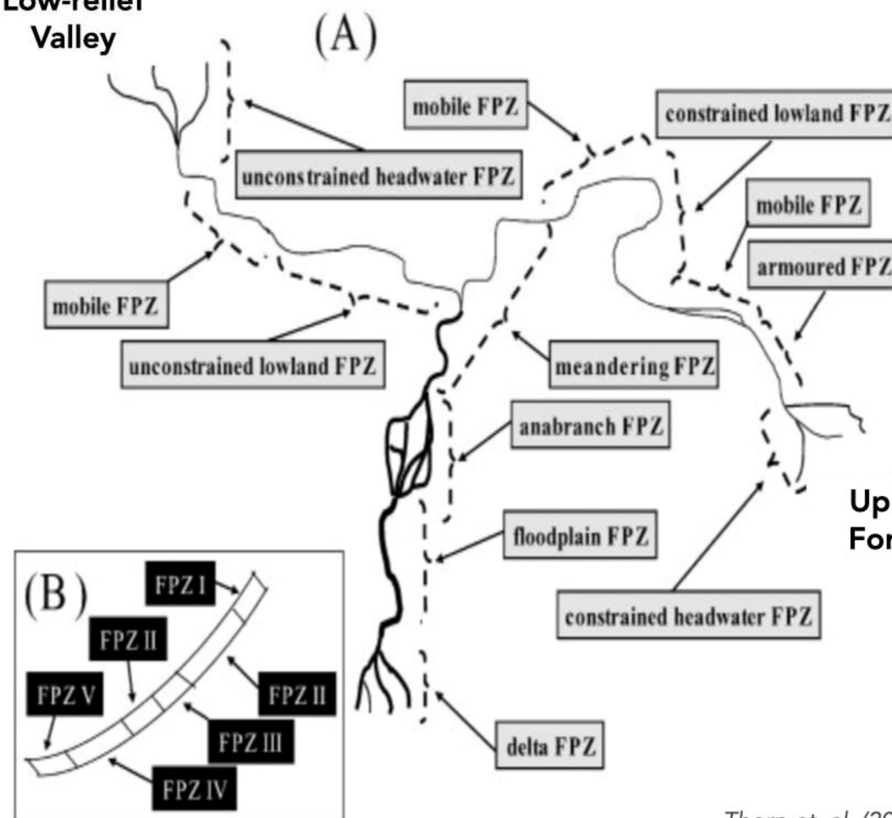
"Hydrogeomorphic Patches" - alternating constrained and unconstrained (floodplain) reaches



Ward, et. al. (2002)

Each patch has different valley architecture/geologic setting; flow regimes; histories, flood pulses and stream hydraulics (moving from long to short temporal scales)

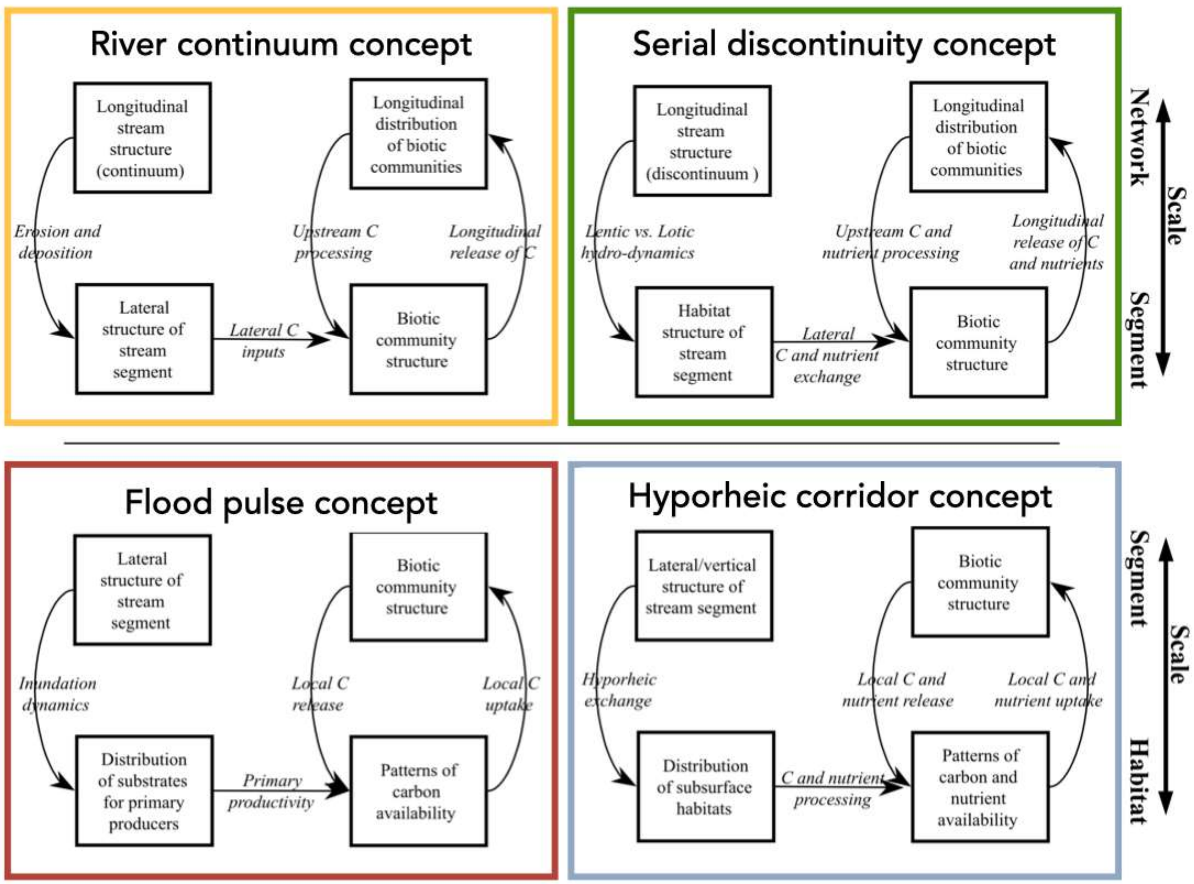
Ecological "functional process zones"



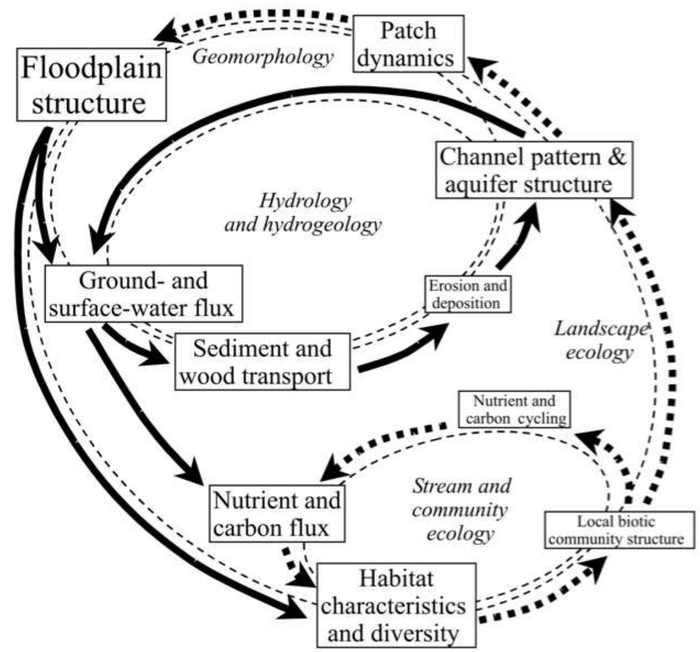
Thorp et. al. (2006)

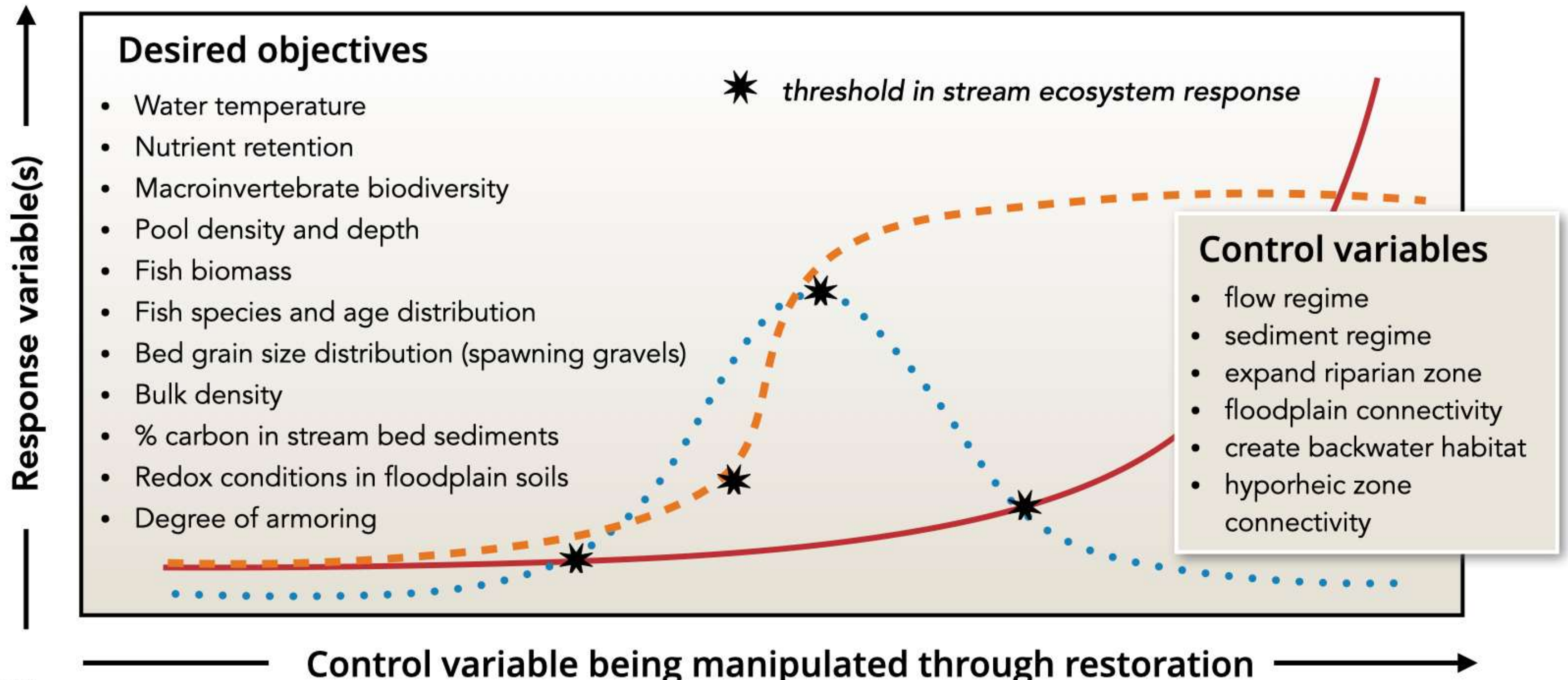
TRANS-SCALE ECOSYSTEM DYNAMICS

Linking physical and biological community



Poole. (2002)





Wohl et. al. (2015)

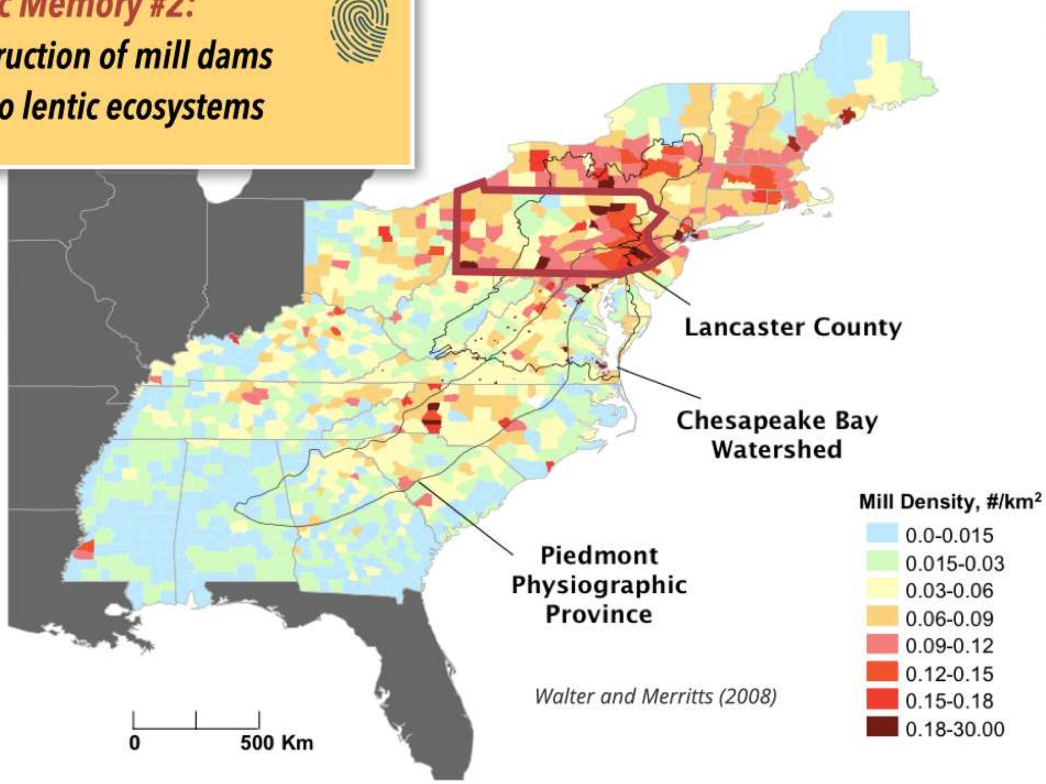
Ecosystem process-response and intrinsic thresholds

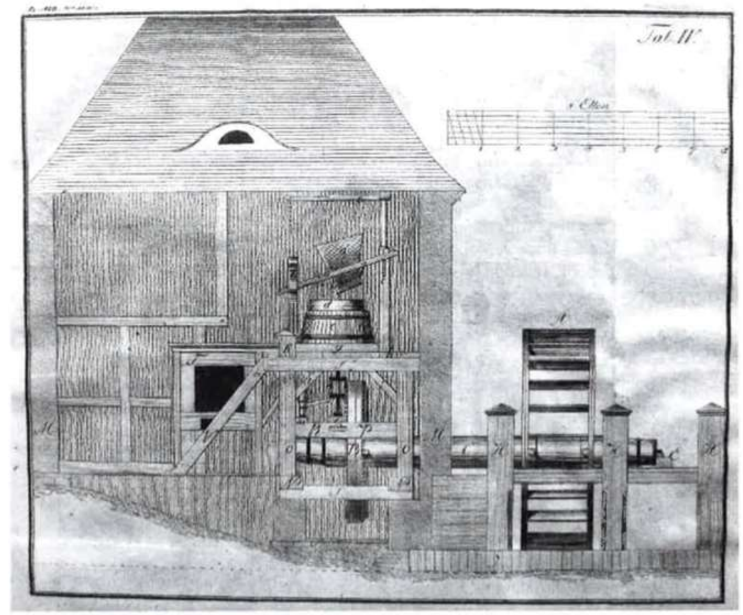
Response curve depends on pairings of control/response variables and different river ecosystems

Episodic Memory #2:

- ***Construction of mill dams***
- ***Lotic to lentic ecosystems***

Water-powered mills in the United States





~60,000 mills in 1840 census

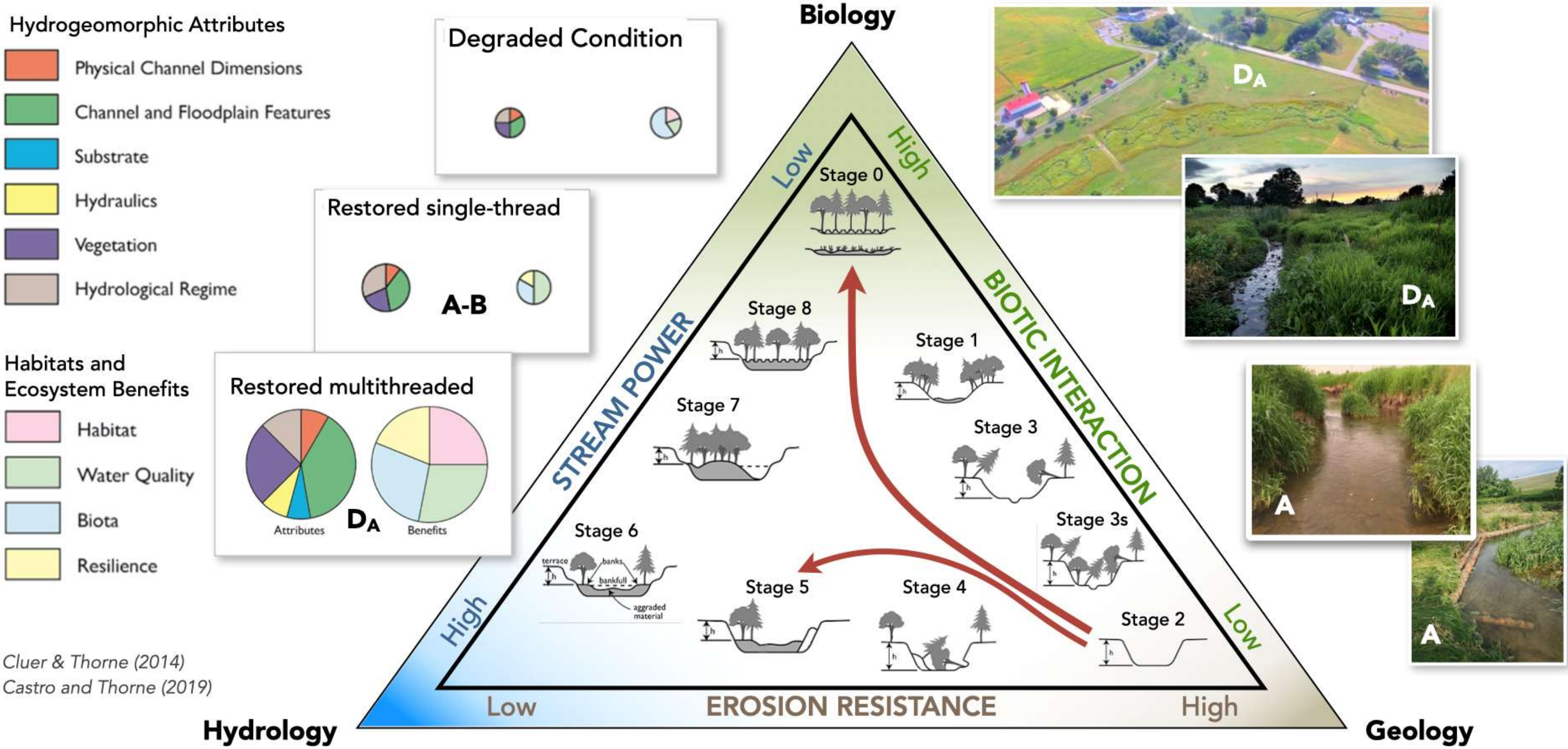
(A)

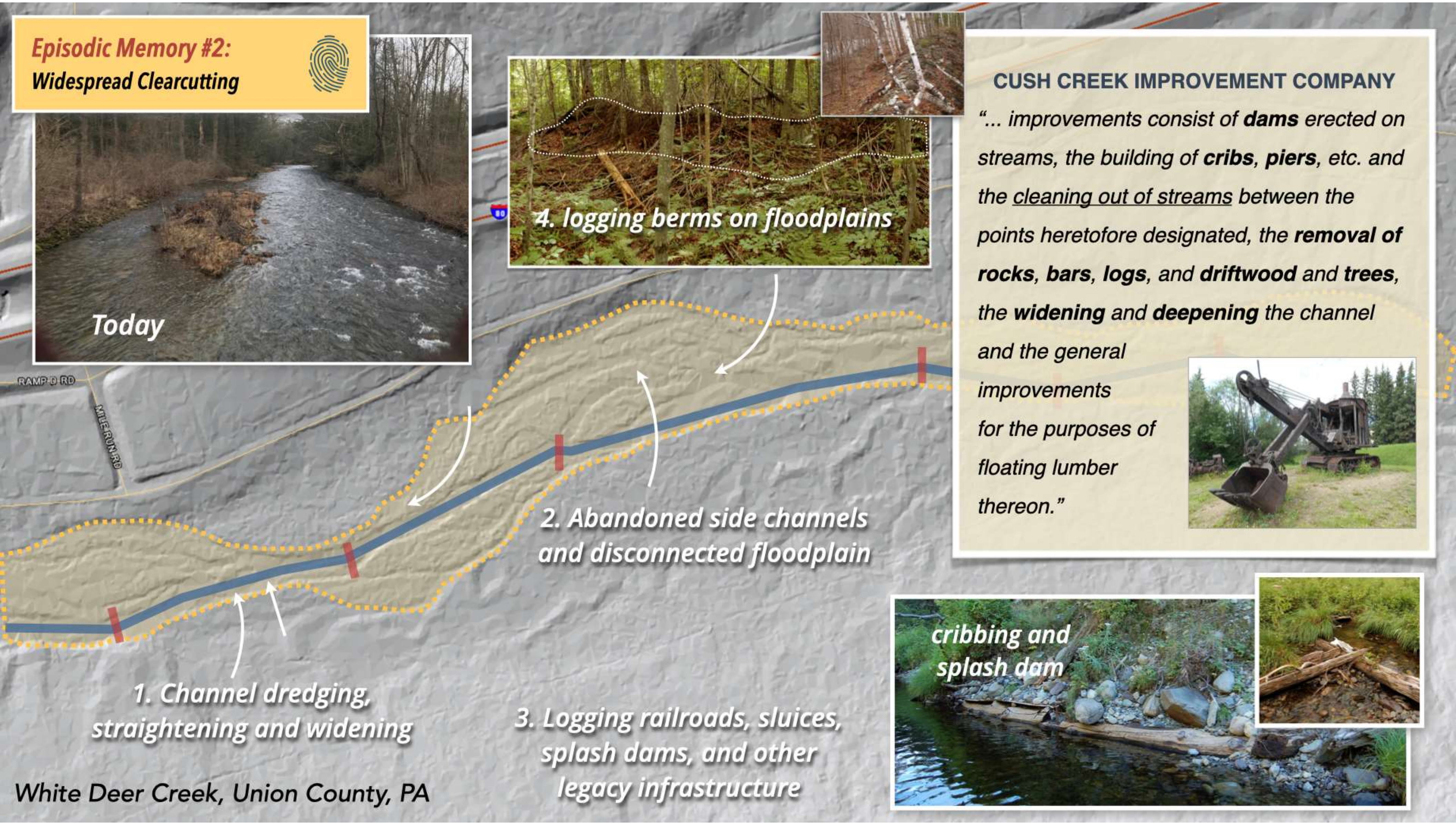
Key Concept 2

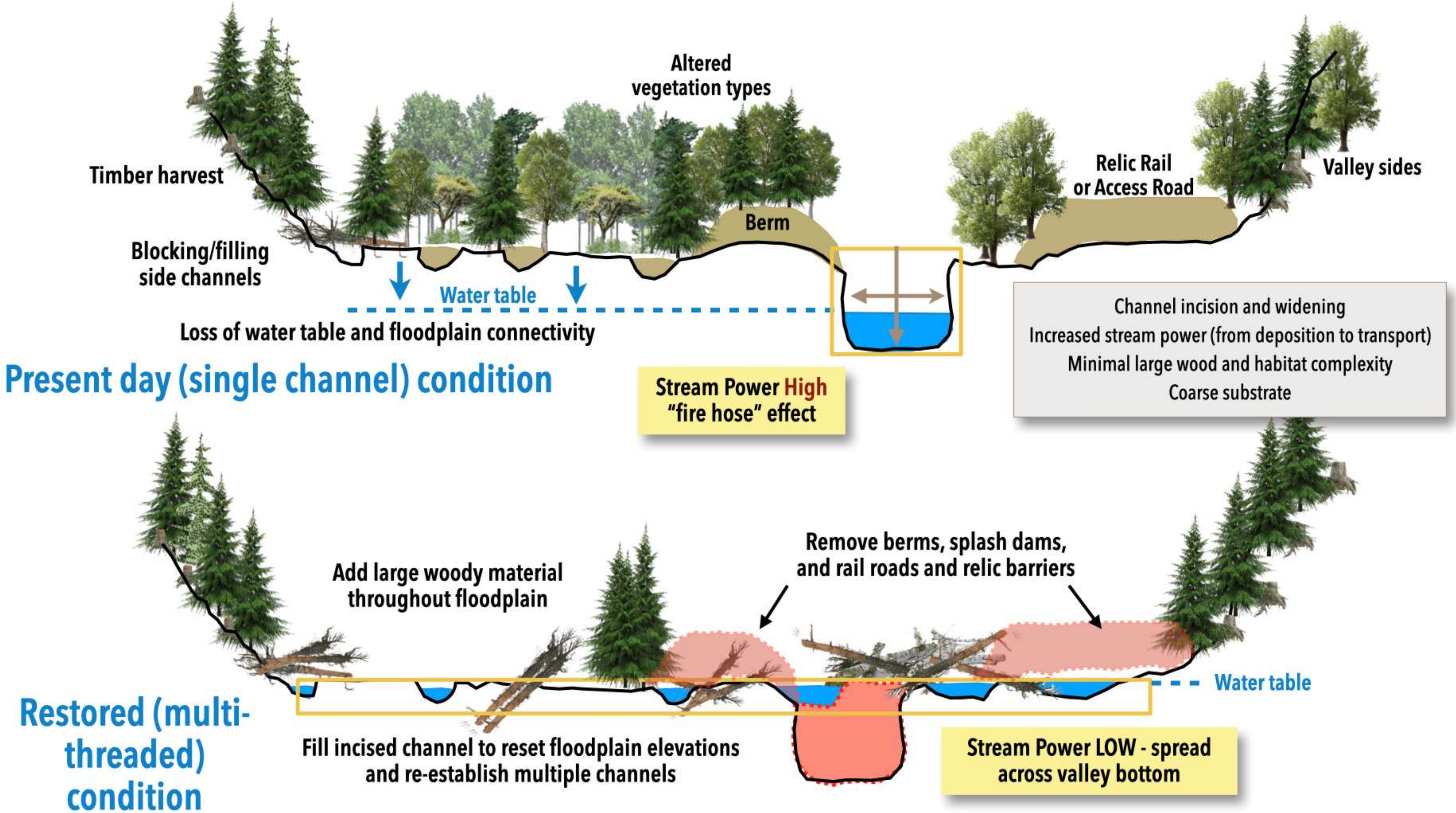
Present-day channel adjustments date back to

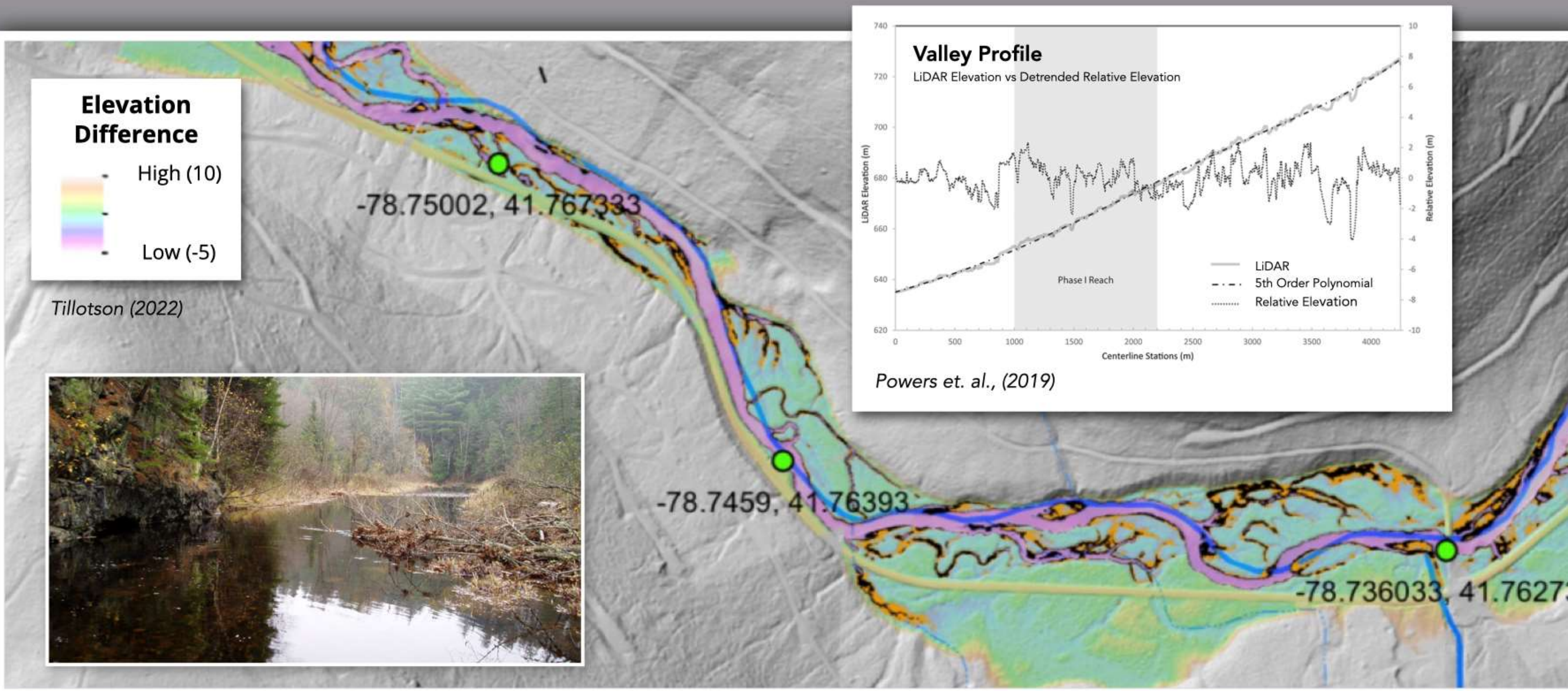
watershed changes associated with early settlement

FUNCTIONAL STREAM RESTORATION APPROACHES




Episodic Memory #2:
Widespread Clearcutting
Today
4. logging berms on floodplains
CUSH CREEK IMPROVEMENT COMPANY
"... improvements consist of **dams** erected on streams, the building of **cribs**, **piers**, etc. and the cleaning out of streams between the points heretofore designated, the **removal of rocks**, **bars**, **logs**, and **driftwood** and **trees**, the **widening** and **deepening** the channel and the general improvements for the purposes of floating lumber thereon."
RAMP D RD
MILE RUN RD
2. Abandoned side channels and disconnected floodplain
1. Channel dredging, straightening and widening
3. Logging railroads, sluices, splash dams, and other legacy infrastructure
cribbing and splash dam
White Deer Creek, Union County, PA

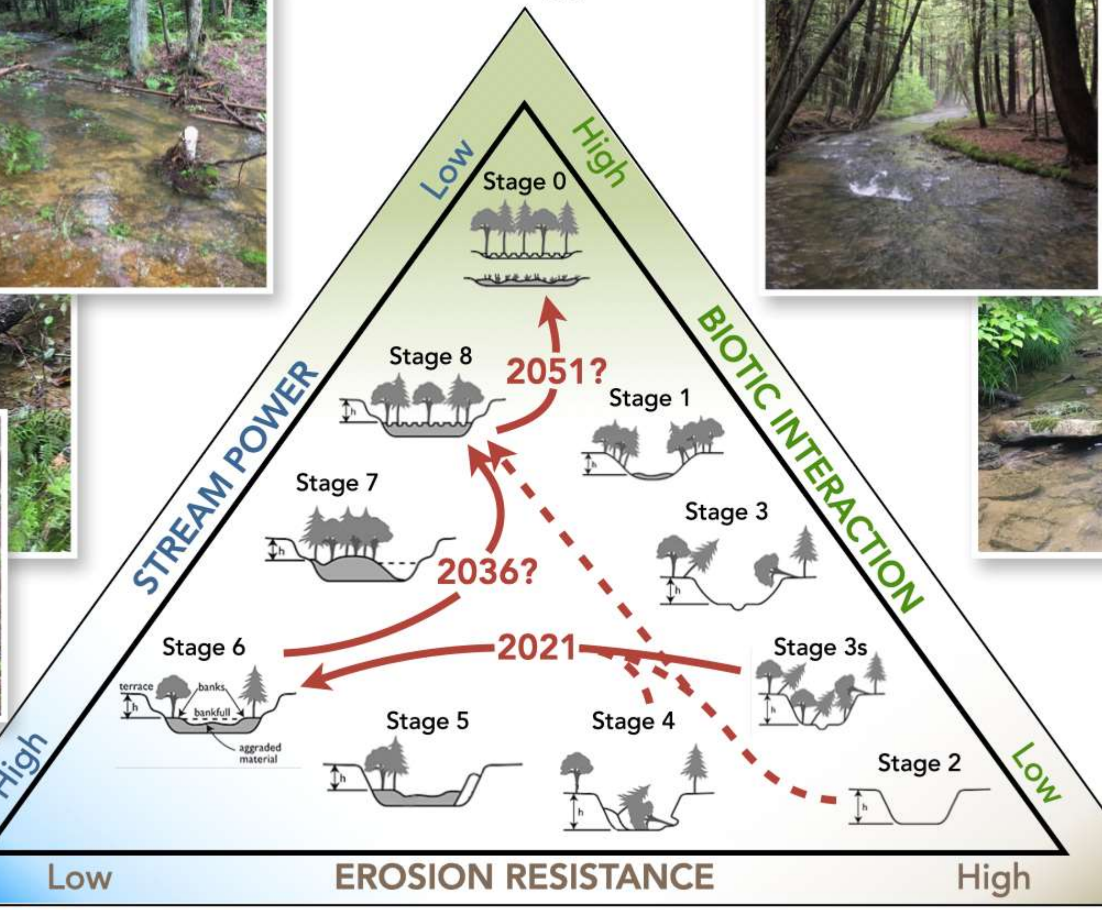

Altered
vegetation types
Timber harvest
Relic Rail
or Access Road
Valley sides
Berm
Blocking/filling
side channels
Water table
Loss of water table and floodplain connectivity
Channel incision and widening
Increased stream power (from deposition to transport)
Minimal large wood and habitat complexity
Coarse substrate
Present day (single channel) condition
Stream Power High
"fire hose" effect
Remove berms, splash dams,
and rail roads and relic barriers
Add large woody material
throughout floodplain
Water table
Restored (multi-
threaded)
condition
Fill incised channel to reset floodplain elevations
and re-establish multiple channels
Stream Power LOW - spread
across valley bottom



Restoring stream power and energy distribution

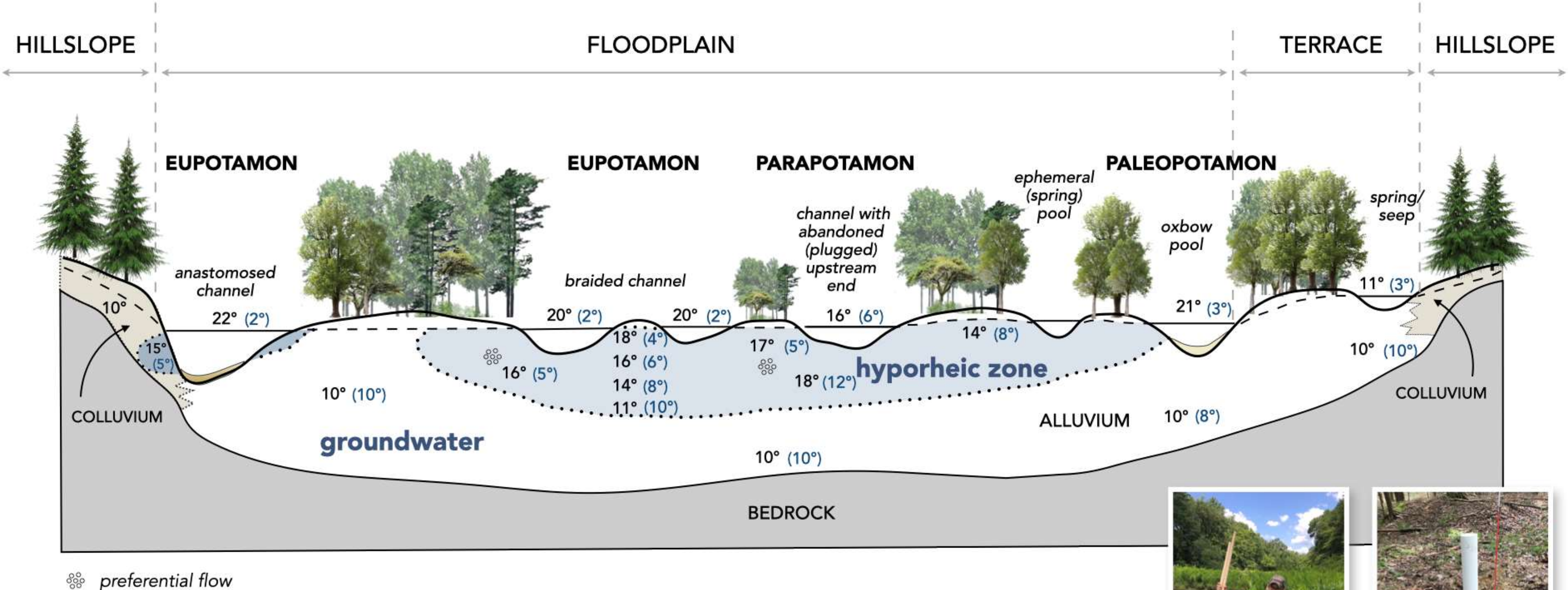
Present-day single channel remains over-steepened and isolated

FUNCTIONAL RESTORATION APPROACHES



Cluer & Thorne (2014)
Castro and Thorne (2019)

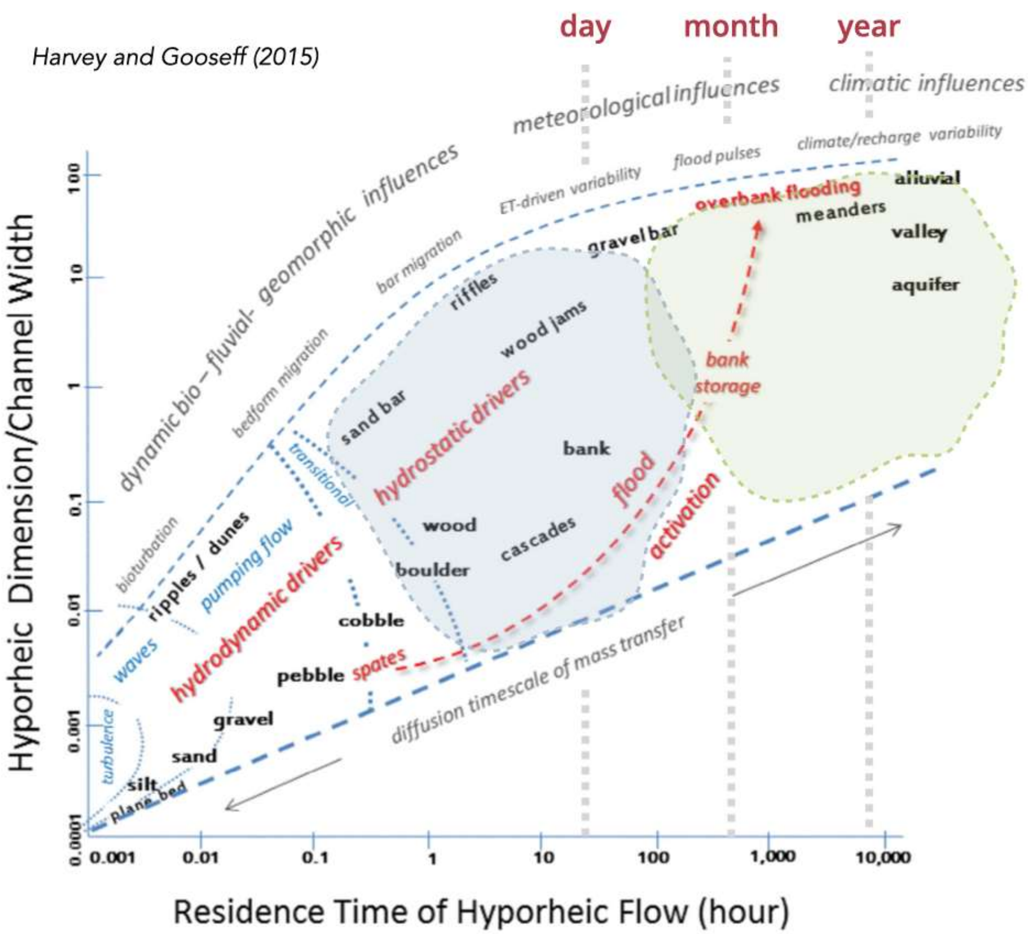
STREAM-WETLAND TEMPERATURE DIVERSITY

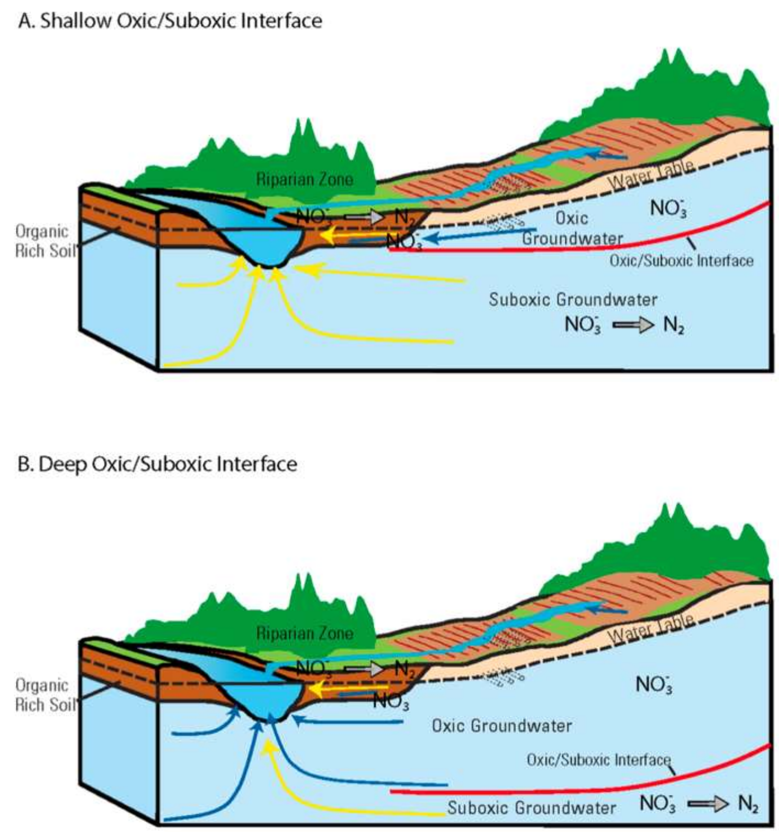


Based on author's field data and concepts by Amoros et al. (1987), Copp (1989) and Ward & Stanford (1995), and Brunke and Gonser (1997)

GROUNDWATER RESIDENCE TIME AND DIMENSIONS

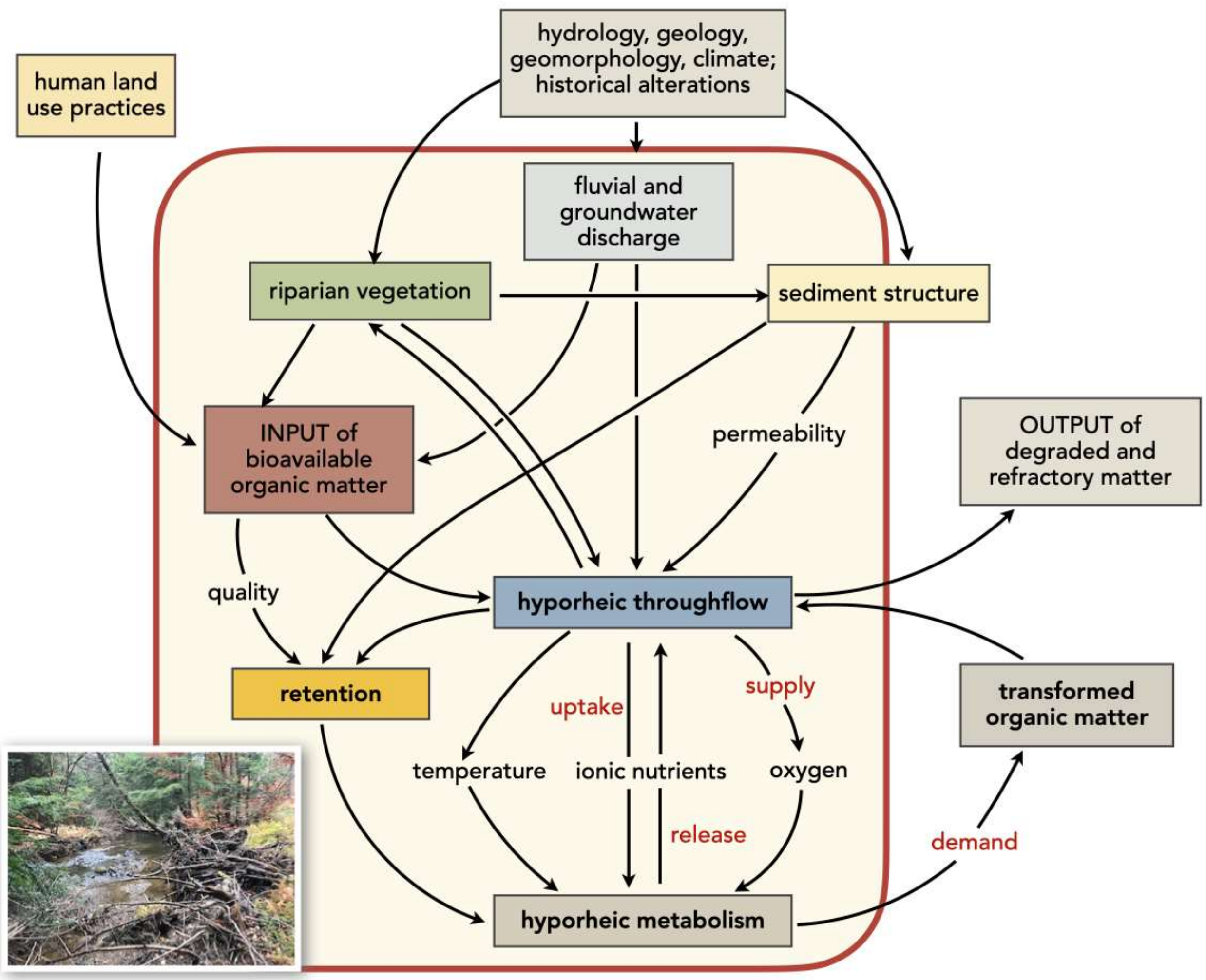
Harvey and Gooseff (2015)





Wherry et. al. (2021) Factors Affecting Nitrate Concentrations in Stream Base Flow, Environ. Sci. Technol. **55**: 902–911.

HYPORHEIC THROUGHFLOW AND METABOLISM



RESTORING RESILIENCE

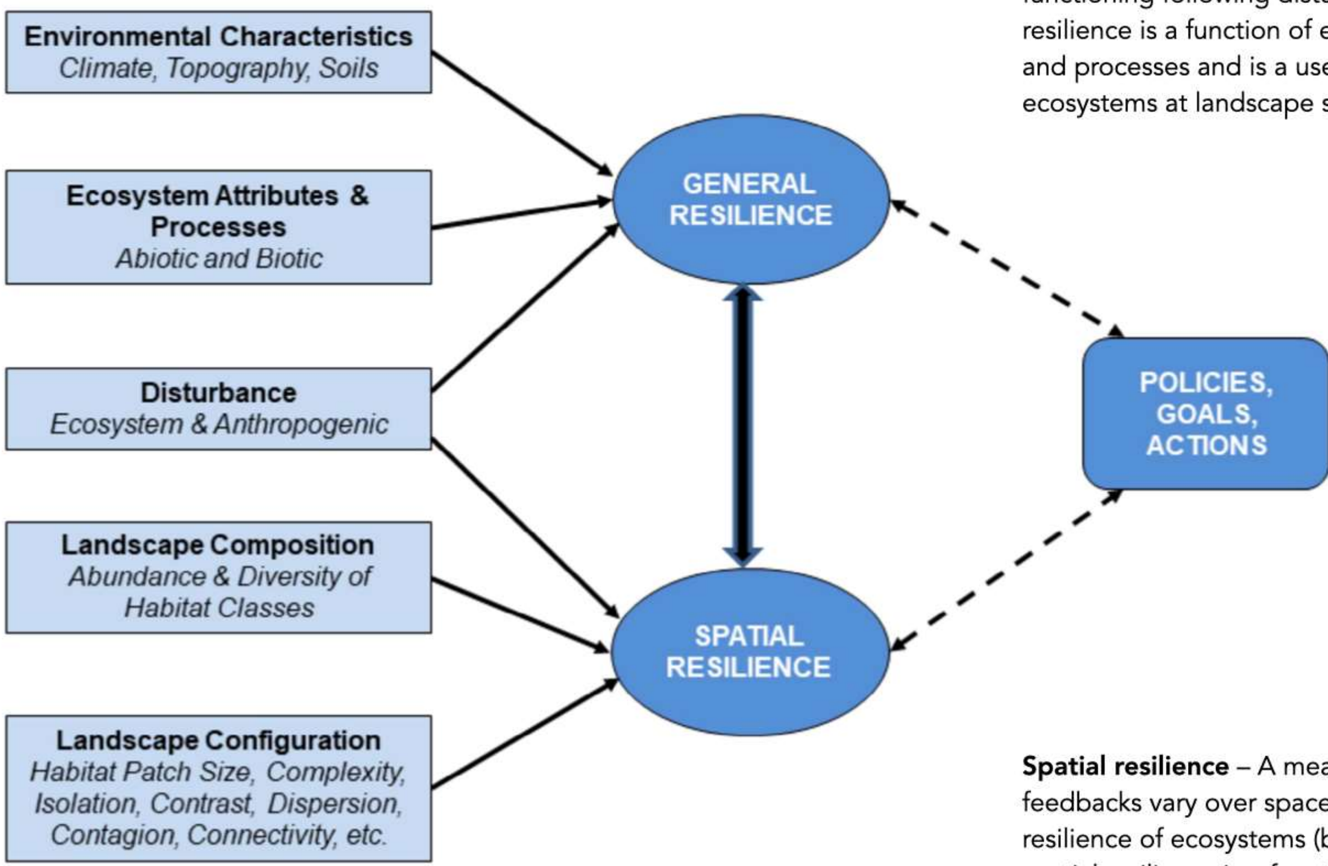
Common disturbances and stressors - factors contributing to ecological, general and spatial resilience

Disturbances and stressors	General resilience		Spatial resilience
	Environmental characteristics	**Ecosystem attributes and processes**	**Landscape context**
Ecosystem - Drought/wet periods - Fire - Plant invasions *Anthropogenic* - Agricultural, urban, and energy development - Over harvesting - Improper grazing - Species introductions - Nutrient enrichment, N deposition, acid rain - Rising CO_2, climate change - Restoration and mitigation efforts	*Climate* - Precipitation - Temperature - Seasonality *Topography* - Elevation - Slope and aspect - Landform *Soils* - Depth and texture - %OM and nutrients - pH	*Abiotic* - Temperature and precipitation regimes - Hydrologic fluxes and water storage - Geomorphic processes *Biotic* - Biological productivity - Structure and composition - Functional groups, interactions, phenology, and traits - Population regulation and regeneration	*Landscape Composition* - Richness - Evenness - Diversity *Landscape Configuration* - Patch size distribution and complexity - Patch shape complexity - Core area - Isolation/proximity - Contrast - Contagion and interspersion - Subdivision - Connectivity

Chambers, et. al. (2019)

MANAGING ECOSYSTEMS AT RISK

Operationalizing Ecological Resilience Concepts



General resilience – A general and generic property of systems that describes the broad ability of a system to regain fundamental structures, processes, and functioning following disturbances (based on Folke et al., 2010). General resilience is a function of environmental characteristics and ecosystem attributes and processes and is a useful concept for describing differences among ecosystems at landscape scales.

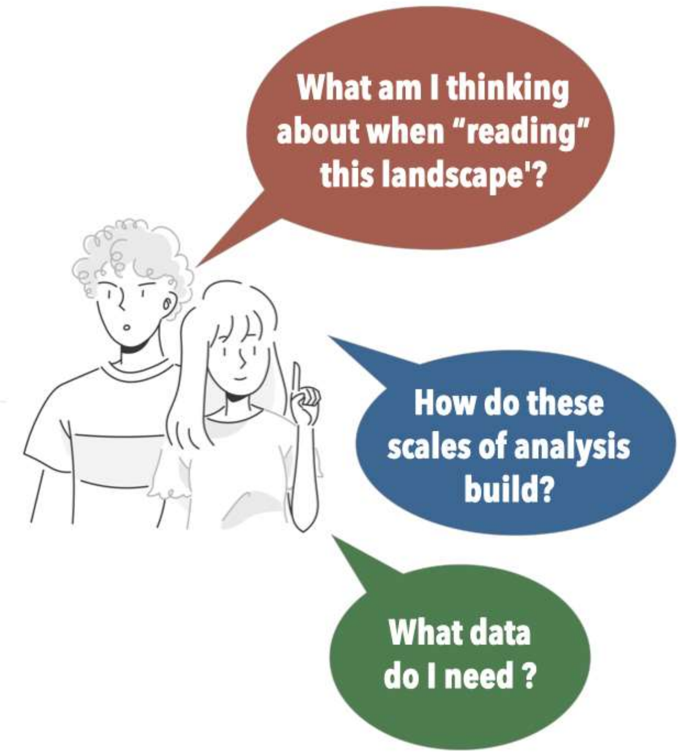
Spatial resilience – A measure of how spatial **attributes**, processes, and feedbacks vary over space and time in response to disturbances and affect the resilience of ecosystems (based on Allen et al., 2016). In a landscape context, spatial resilience is a function of landscape composition and configuration.

FOOD FOR THOUGHT .....

1. Both social and ecological systems are far from being in **equilibrium**;
2. They are characterized by **thresholds**, **multiple states**, and **surprising phenomena**.
3. Because of the connection between ecological and societal systems, cross-scale **interactions happen**. These interactions must be recognized and anticipated.
4. One should be aware of **slowly evolving conditions**.
5. **Short-term measures do not resolve persistent, chronic problems,** nor can they deal with continuous change.

KEY CONCEPTS

- **Space & time**
- **Character, behavior, evolution**
- **Controls and explanation**



PROCESSES INFLUENCING HABITAT AND ECOSYSTEMS

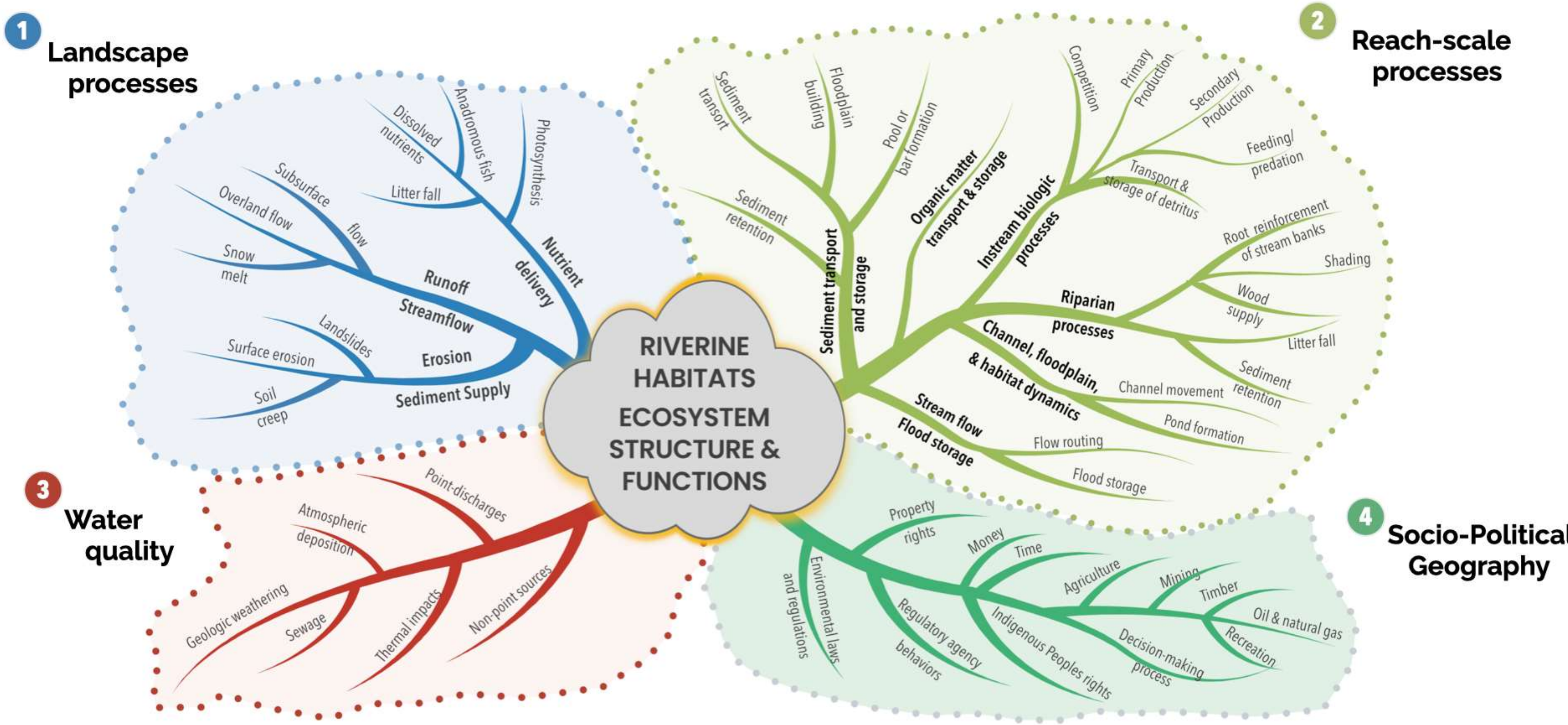


Figure 2.1 in textbook