Rethinking Riverine and Riparian Connectivity

Jock Conyngham[1], S. Kyle McKay[1], and Sarah Miller[1]

1. Environmental Laboratory, U.S. Army Engineer Research and Development Center

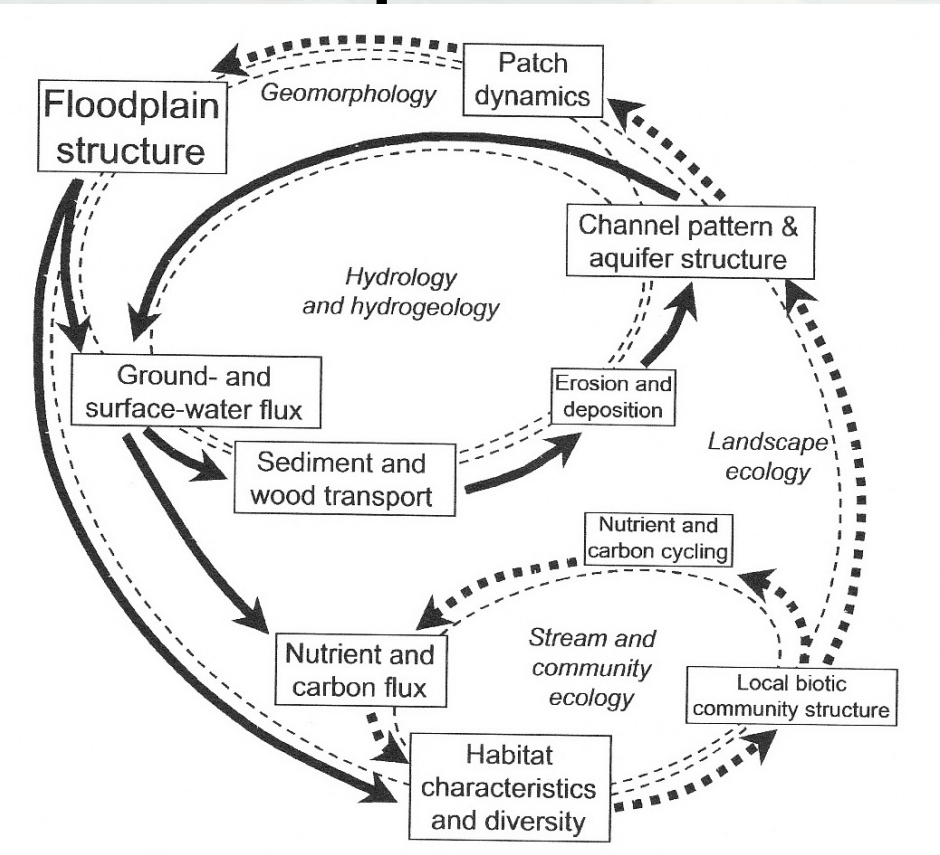
Ecosystem Management and Restoration Research Program

US Army Corps of Engineers
BUILDING STRONG®

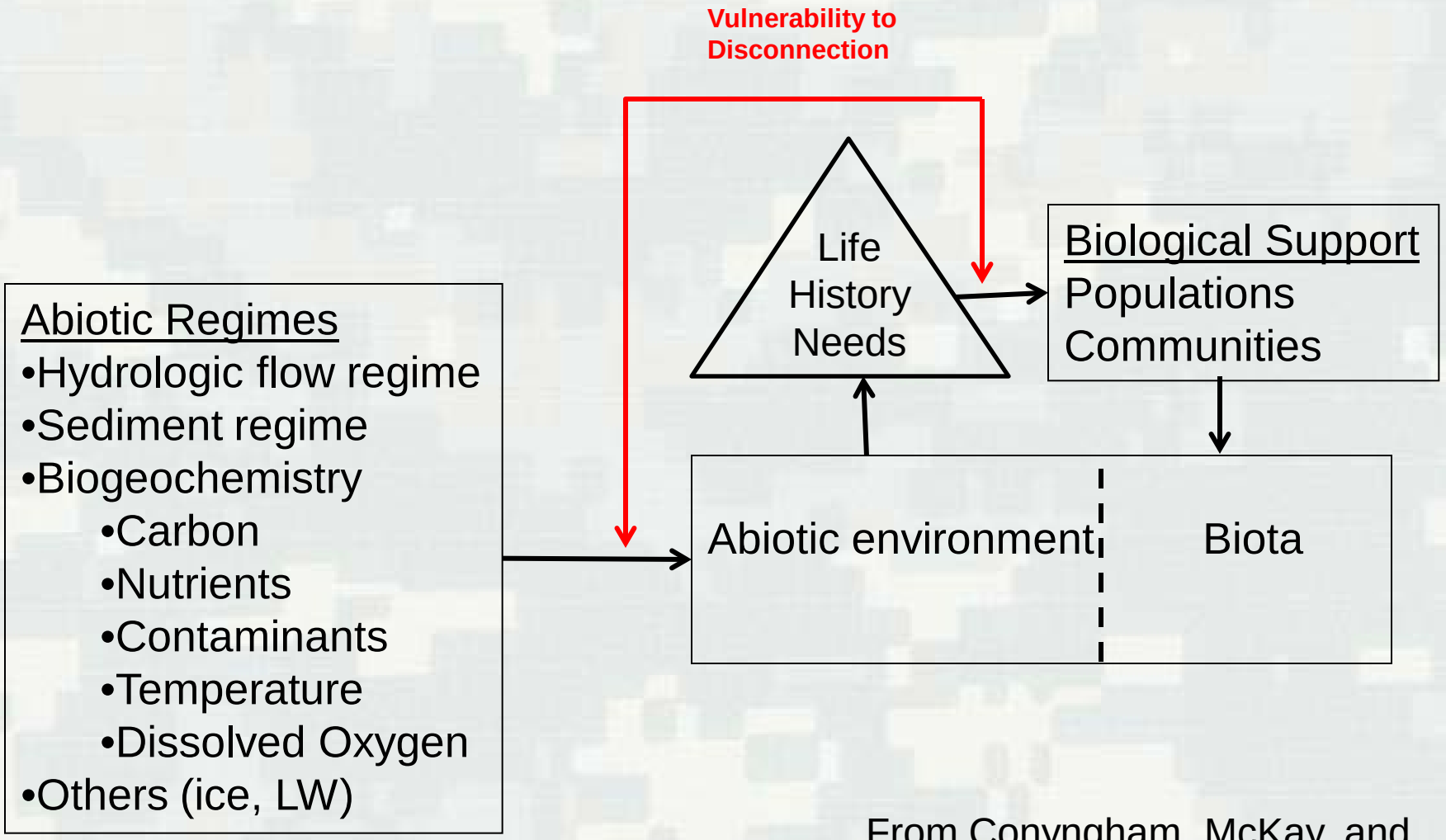
Traditional connectivity concerns

- Fish passage over obstructions for listed species, usually only in upstream direction, usually only at site scale
- More recently, floodplain connectivity for storage of floodwaters and energy attenuation

Central processes of a floodplain river



From Poole, 2002



From Conyngham, McKay, and Miller, in prep.

Fish Passage Alternative Formulation

Objectives

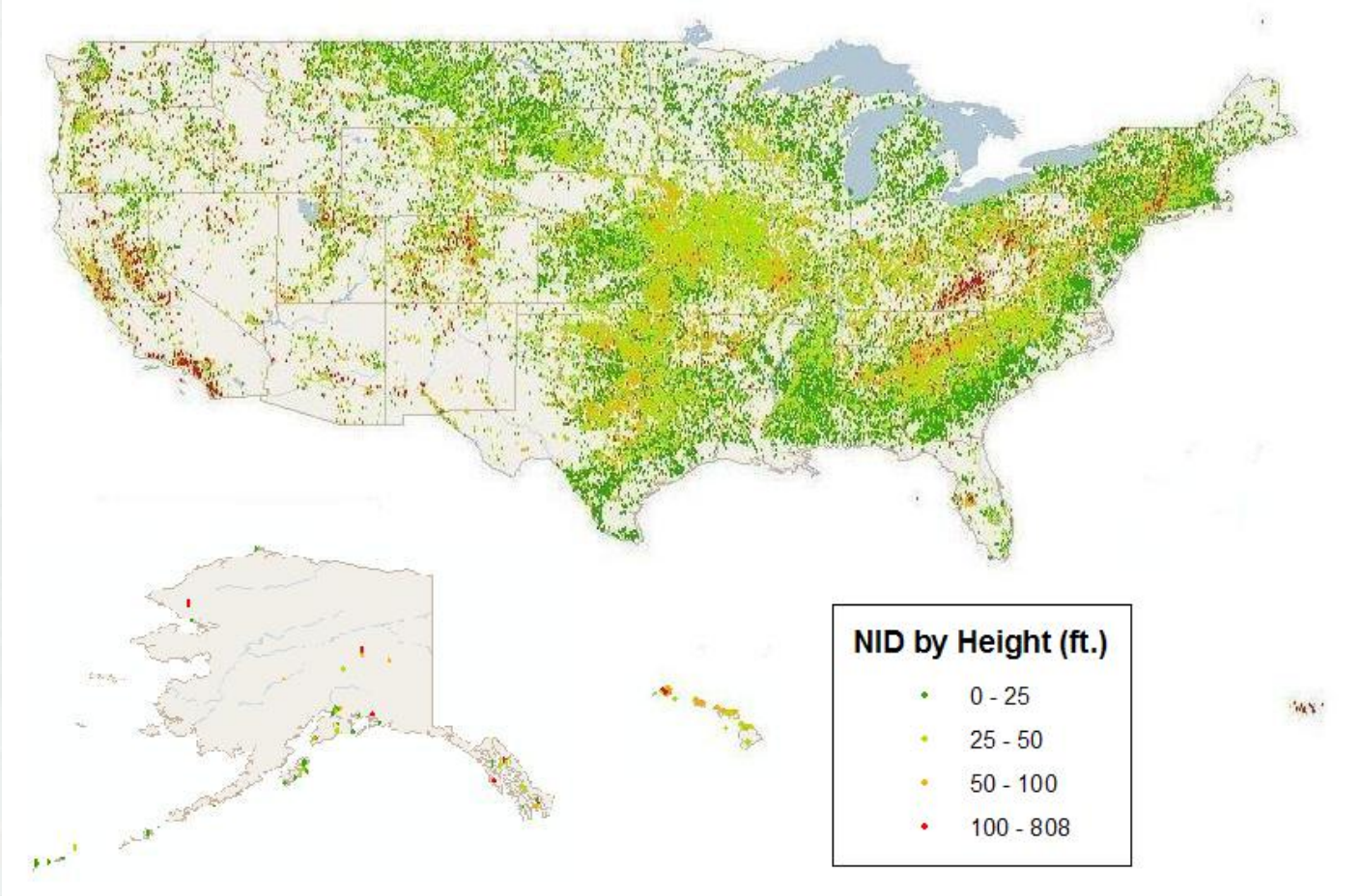
Target Species

Passage Alternatives

Passage Measures

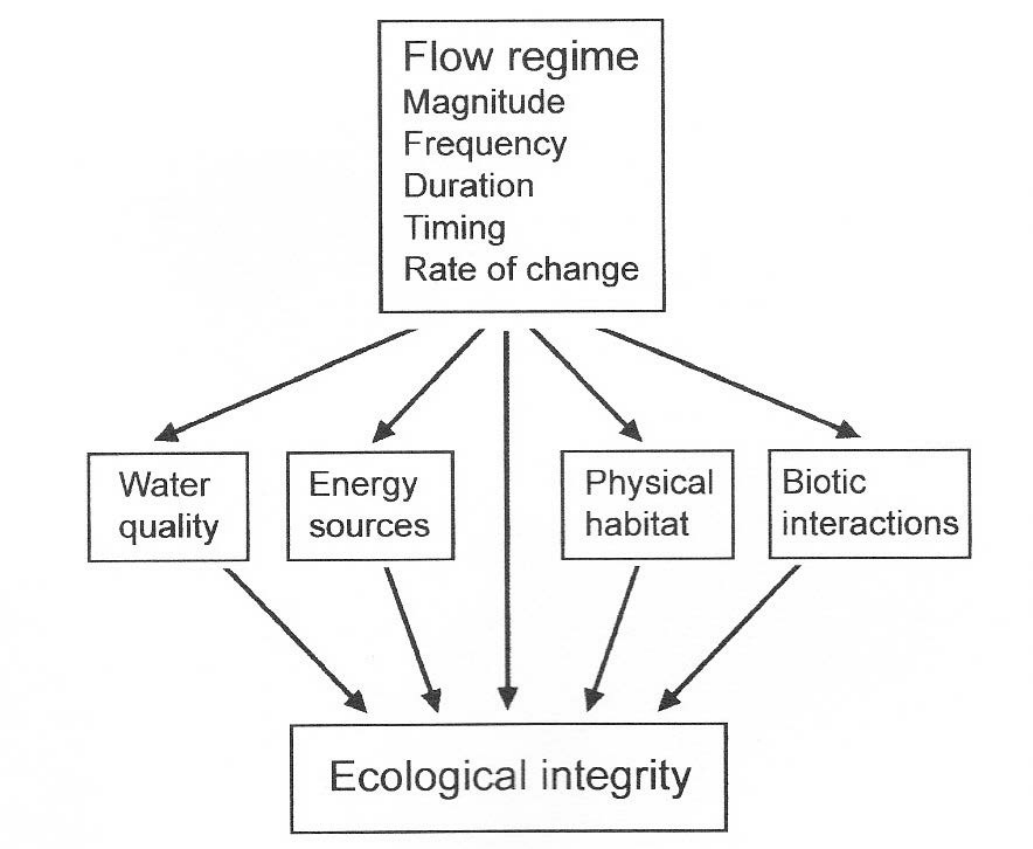
Site Conditions

Structural fragmentation



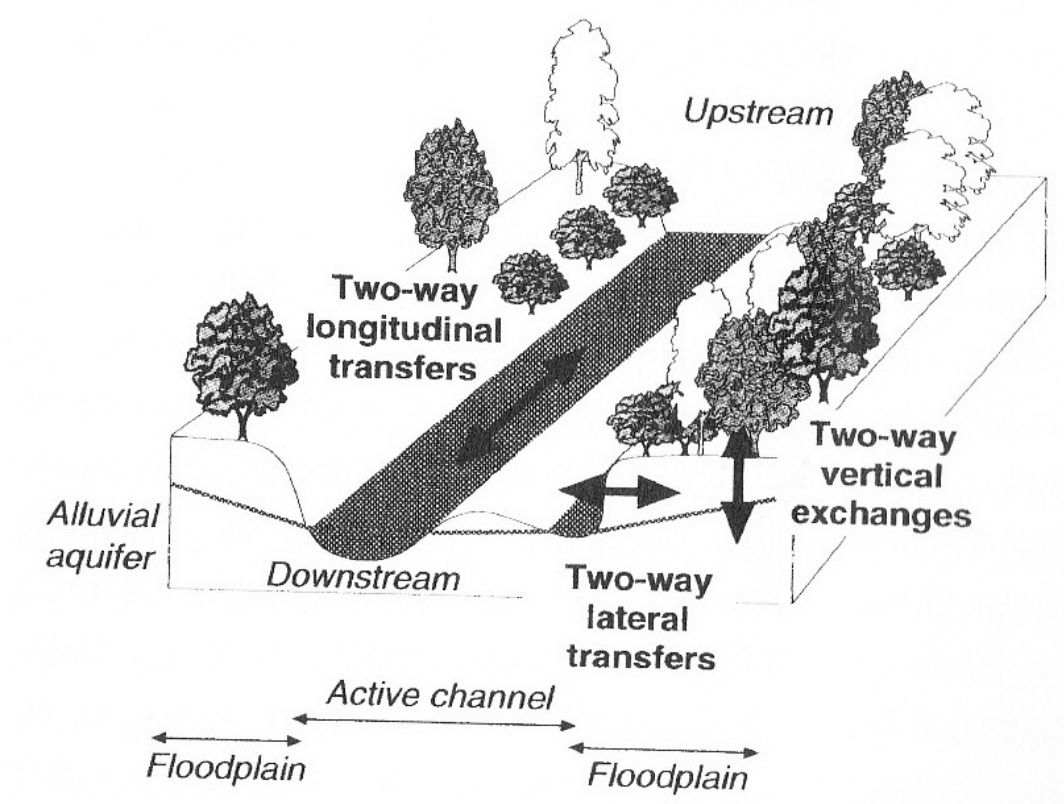
Distribution of fragmentation—trunk, tributaries, or both?

Hydrology as master connectivity variable; nodes of alteration and vulnerability



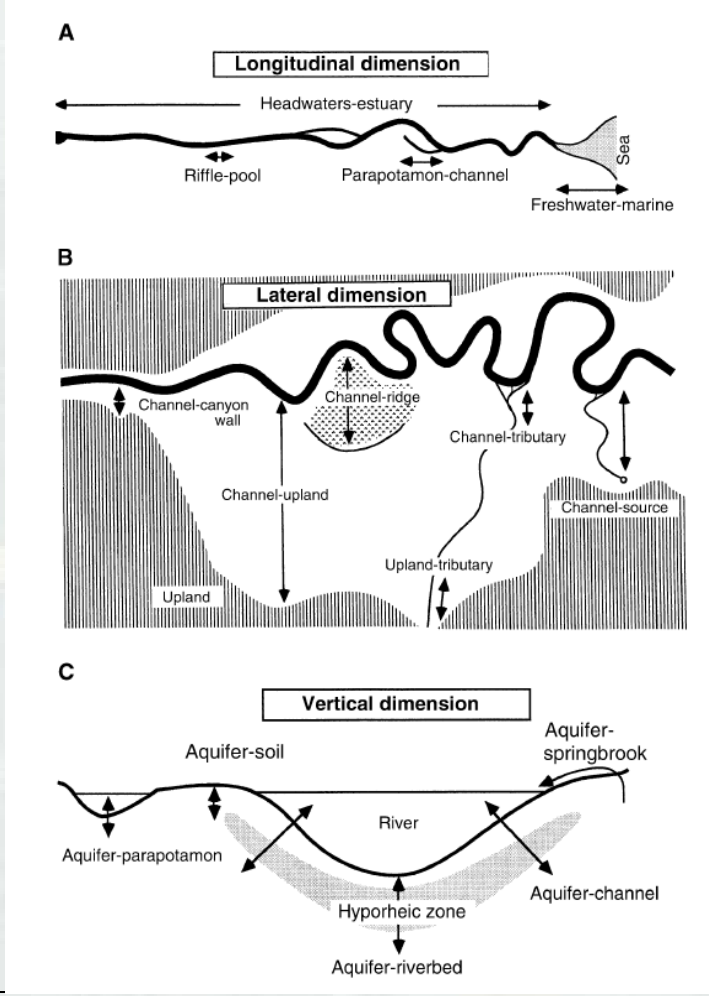
Poff et al., 1997

The three major connectivity axes of the fluvial ecosystem: longitudinal, latitudinal, and vertical



Piegay and Schumm 2003

The three major connectivity axes of the fluvial ecosystem: longitudinal, latitudinal, and vertical



Wiens 2002

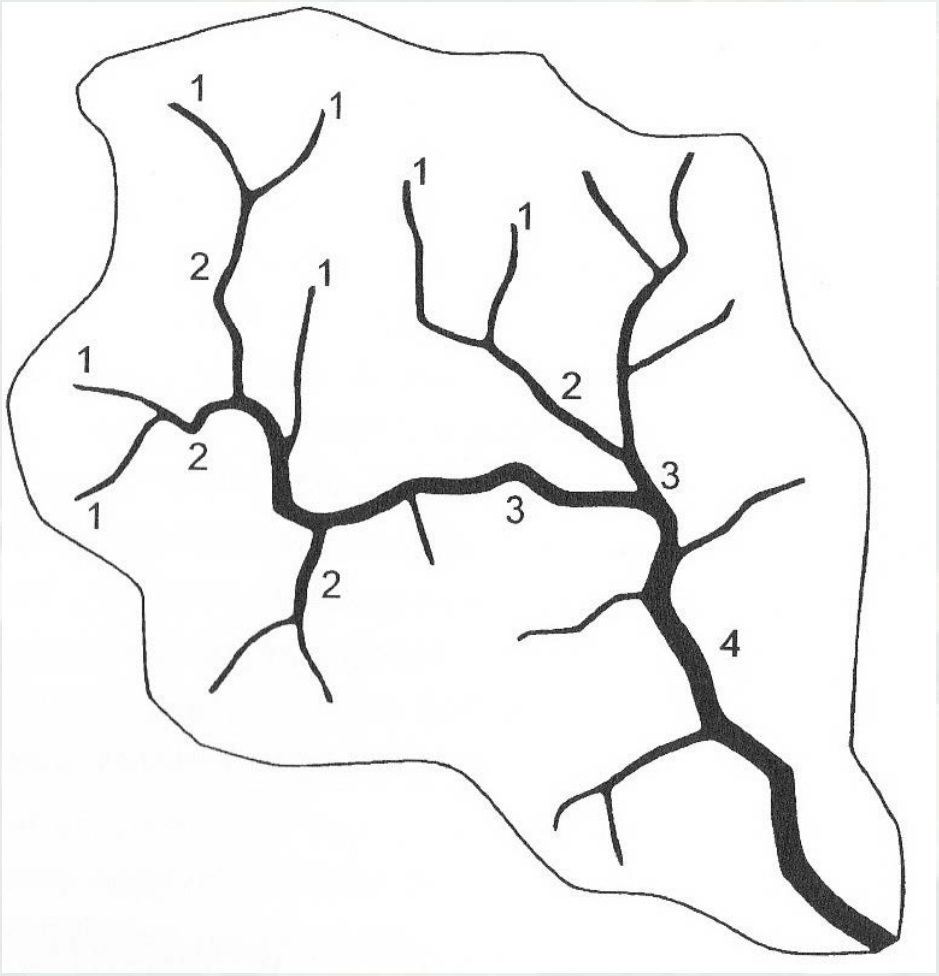
Some points about three dimension connectivity model

- All are important, but priority depends on project objectives
- If one is lost or truncated, others become more important
- Target connectivity values depend on objective; more connectivity is not always the goal. Ex: vernal pools, systems with invasive species

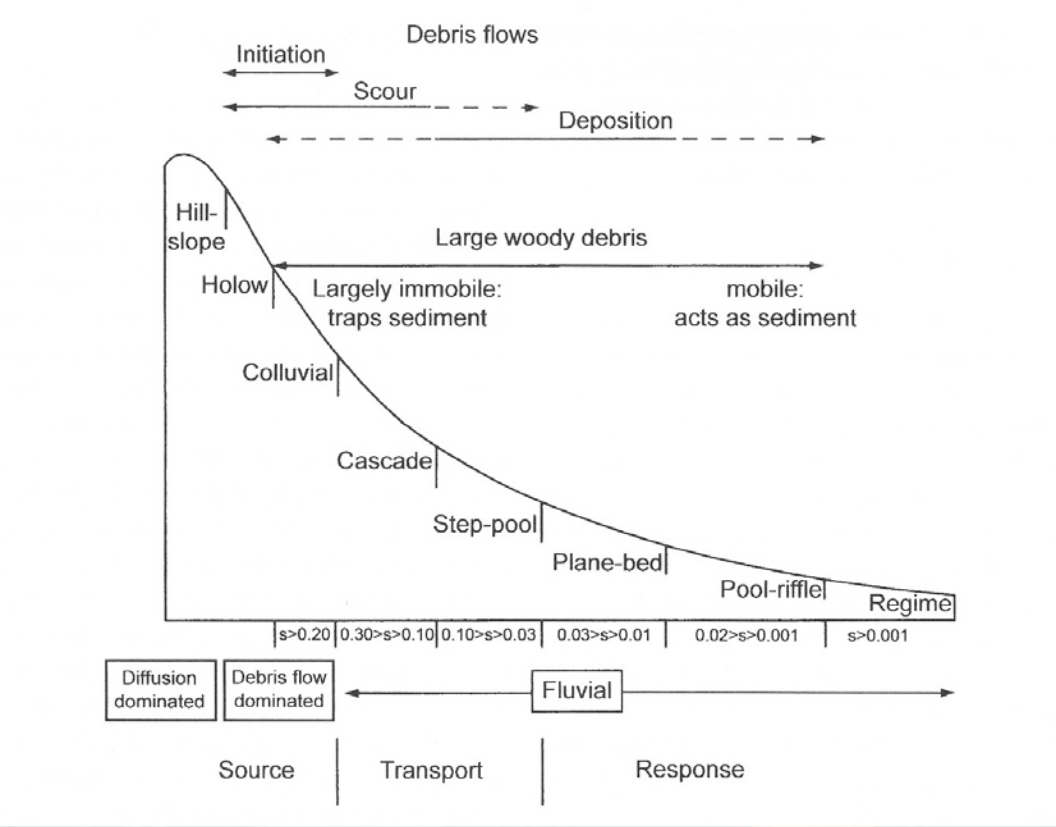
All three dimensions are subject to a further, temporal dimension

- Longitudinal – drying of a ephemeral channel as a disruption to fish movement (Jaeger et al. 2014)
- Lateral – seasonal deposition of sandy substrate on a floodplain prior to cottonwood germination
- Vertical – A reach of river may shift from inflow to outflow of groundwater (gaining v. losing)

Connectivity and scale

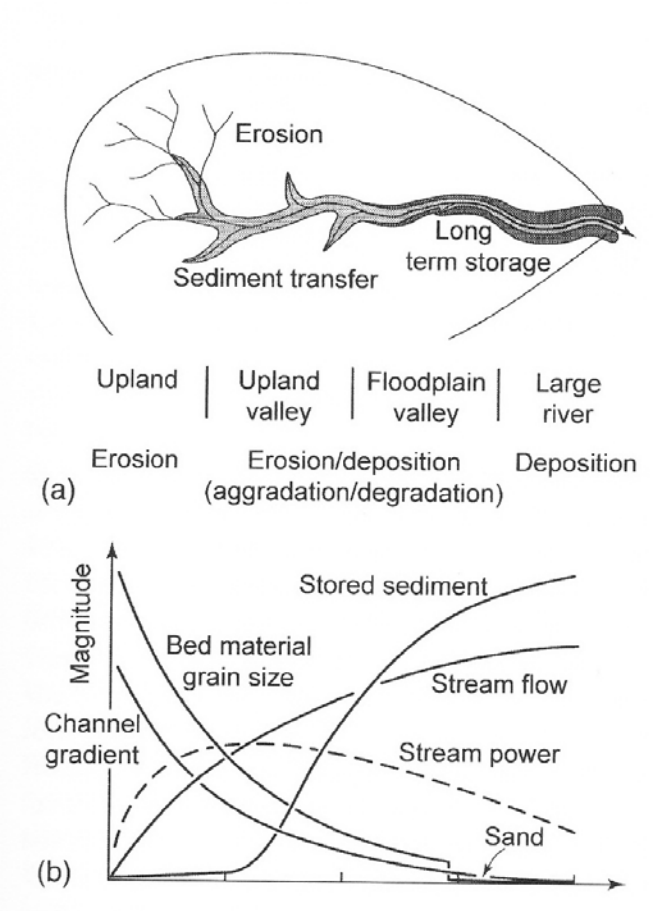


Longitudinal succession of channel types in Western mountains



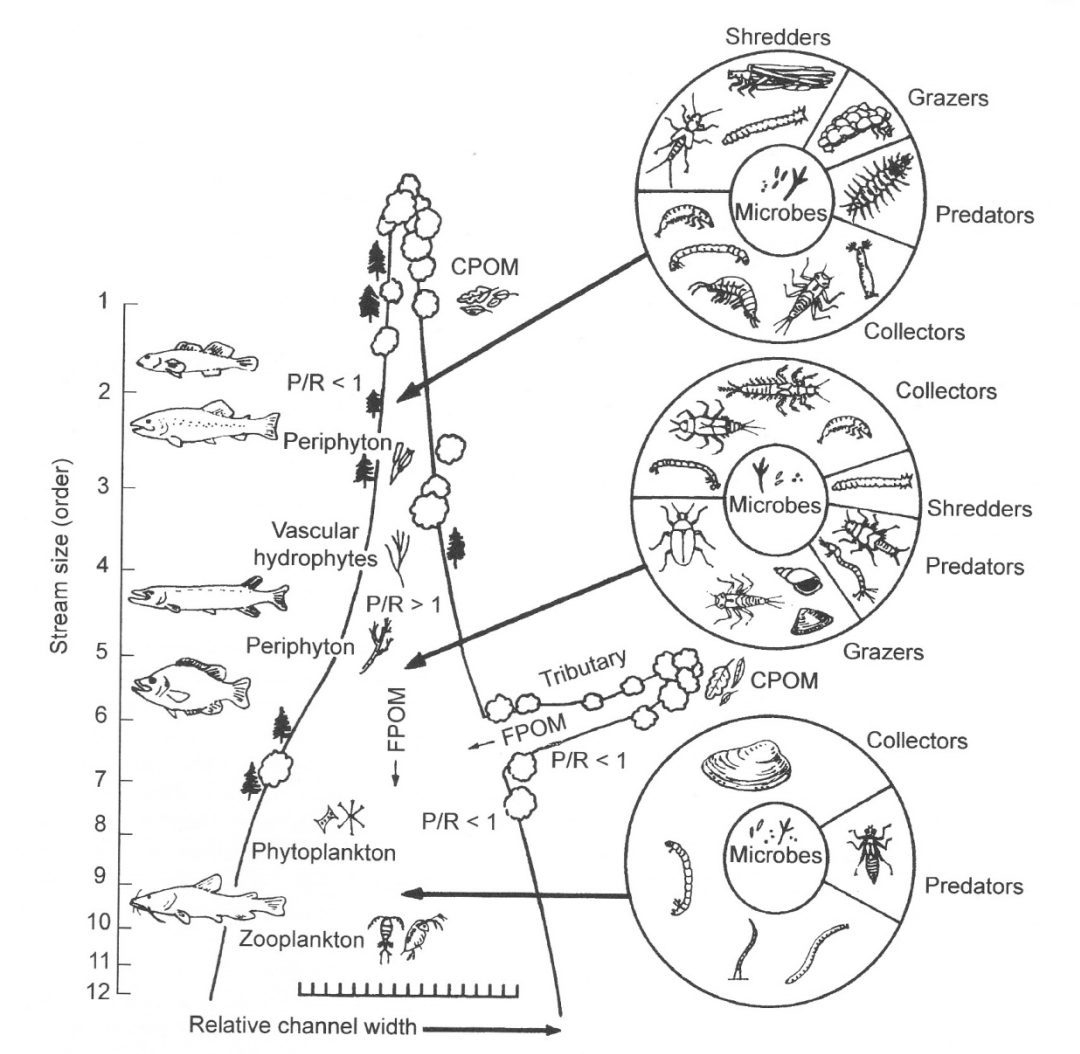
Montgomery and Buffington 1997

Longitudinal classification and transfers- underpinnings of the channel continuum concept



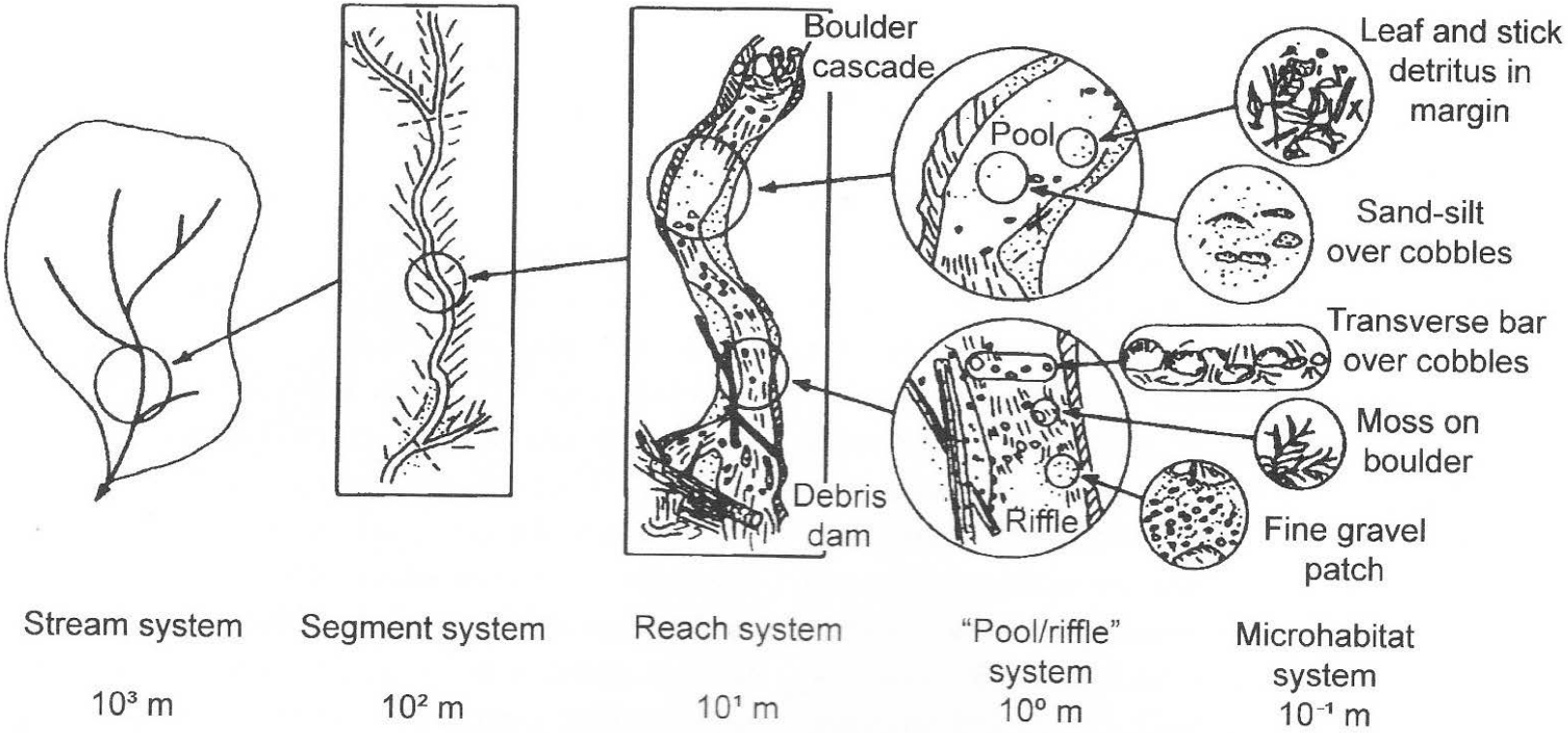
Church, 2002

Vannote's Channel Continuum Concept



Vannote et al. 1980

Unidirectional habitat heirarchy



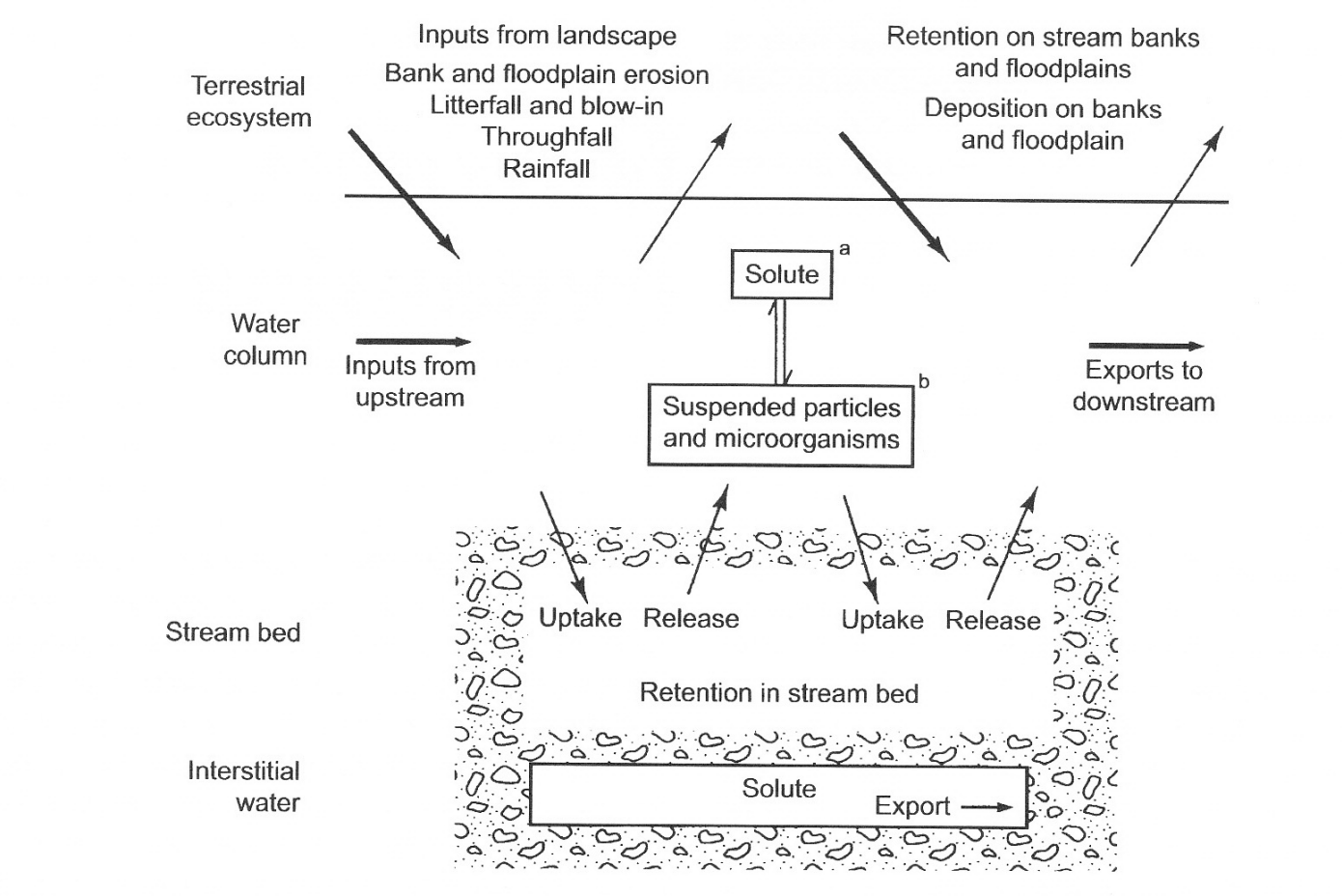
Frissell et al. 1986

Macroinvertebrate feeding guilds and niche partitioning

Feeding role	*Food resource*	*Feeding mechanism*	*Examples*
Shredder	Nonwoody CPOM, primarily leaves; and associated microbiota, especially fungi	Chewing and mining	Several families of Trichoptera, Plecoptera, Crustacea; some Diptera, snails
Shredder/gouger	Woody CPOM and microbiota, especially fungi; primarily surficial layers are utilized	As above	Occasional taxa among Diptera, Coleoptera, Trichoptera
Filterer-collector/ suspension feeder	FPOM and microbiota, especially bacteria and small autotrophs in water column	Collect particles using setae, specialized filtering apparatus, or nets and secretions	Net-spinning Trichoptera, Simuliidae and other Diptera, some Ephemeroptera
Collector-gatherer/ deposit feeder	FPOM and microbiota, especially bacteria, and biofilm	Collect surface deposits, browse on amorphous material, burrow in soft sediments	Many Ephemeroptera, Chironomidae, and Ceratopogonidae
Grazer	Periphyton, especially diatoms; and biofilm	Scraping, rasping, and browsing adaptations	Several families of Ephemeroptera and Trichoptera, some Diptera, Lepidoptera, and Coleoptera
	Macrophytes	Piercing	Hydroptilid caddis larvae
Predator	Animal prey	Biting and piercing	Odonata, Megaloptera, some Plecoptera, Trichoptera, Diptera, and Coleoptera

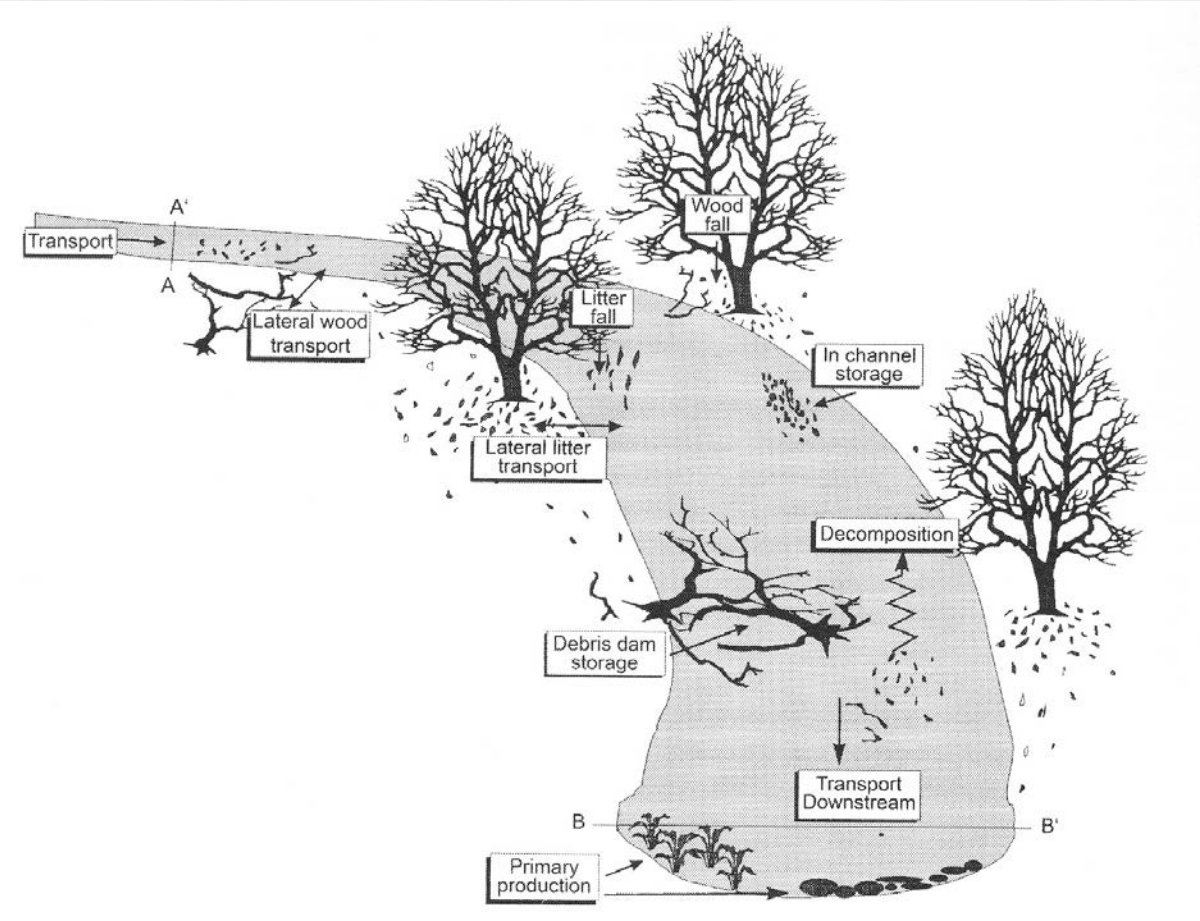
Cummins and Klug 1979

Nutrient spiraling and connectivity



Stream Solute Workshop 1990

Inputs, outputs, and standing stock of organic matter in a forested stream



Minshall 1996

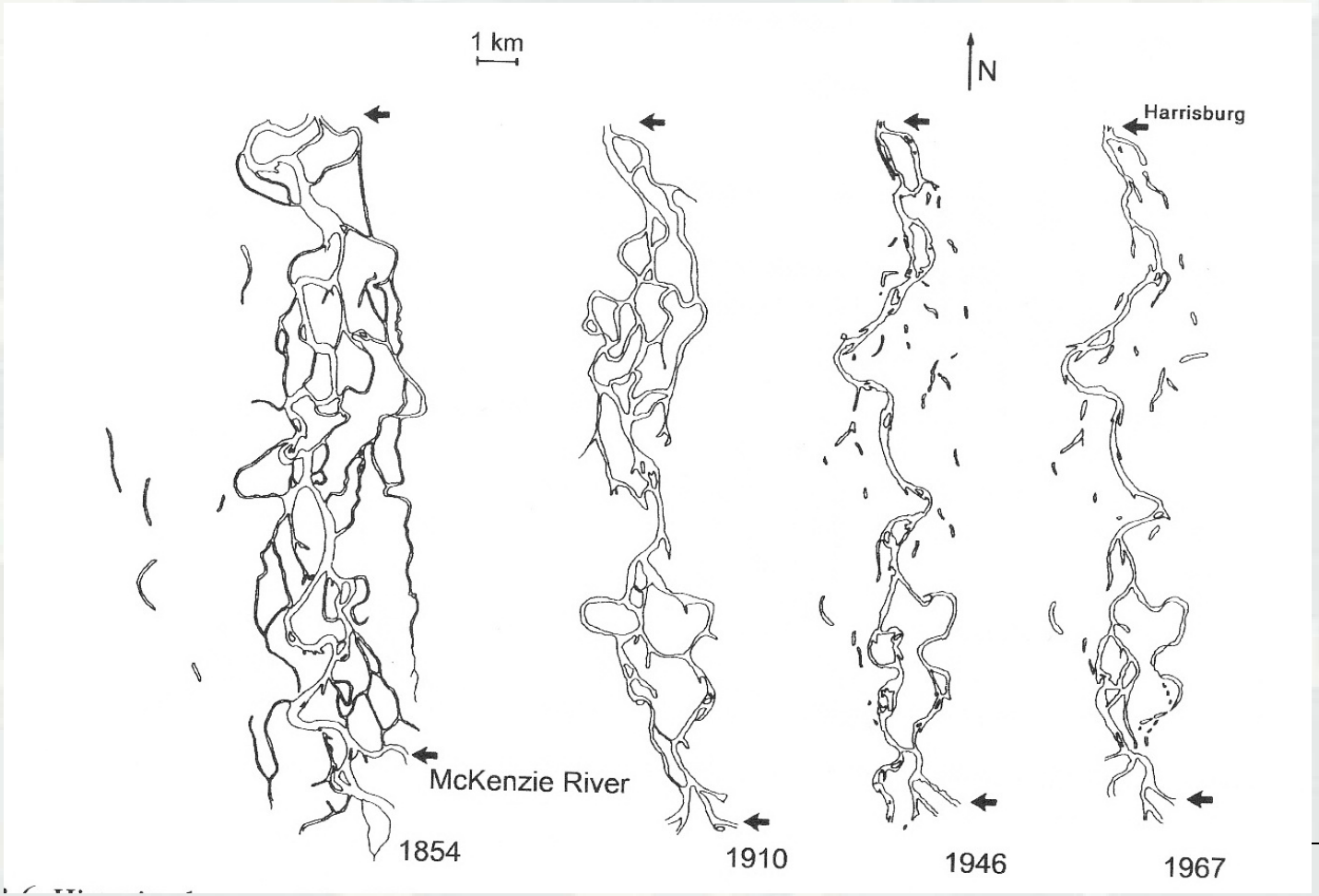
Major roles of woody material in streams and rivers

- Physical
- Hydrologic
- Thermal
- Chemical
- Processual
- Biological
- Recreational

Great Raft, Red River

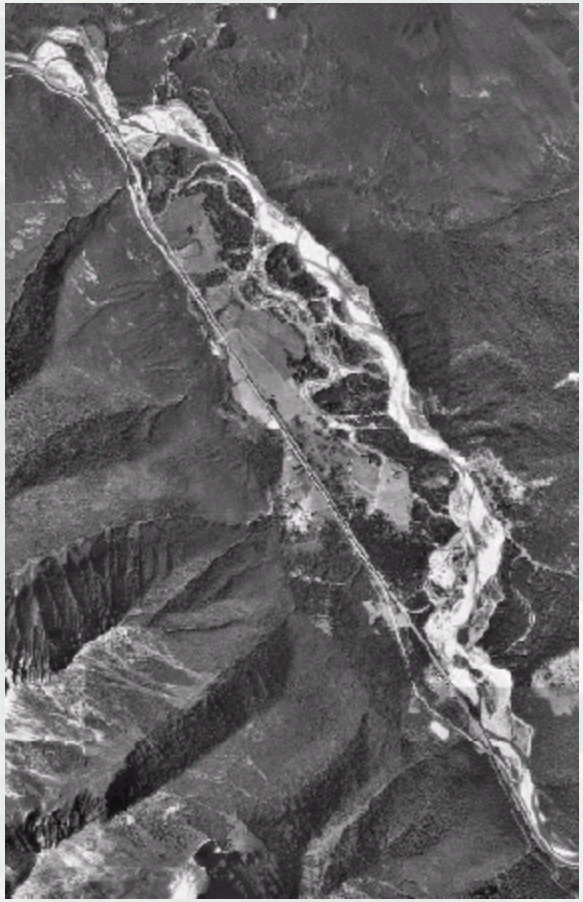
- Formation began 1100-1200 AD
- Peak length 165 mi; impeded navigation and settlement
- Henry Shreve (USACE) initiated removal efforts in early 1800's, opening Red River in 1838. Shreveport named in his honor.
- 2nd raft formed, removed in 1873.
- Drove partial capture of Mississippi by Atchafalaya and $multibillion Old River Control Structure (USACE)

Connectivity in secondary channels: change in the Willamette River, OR

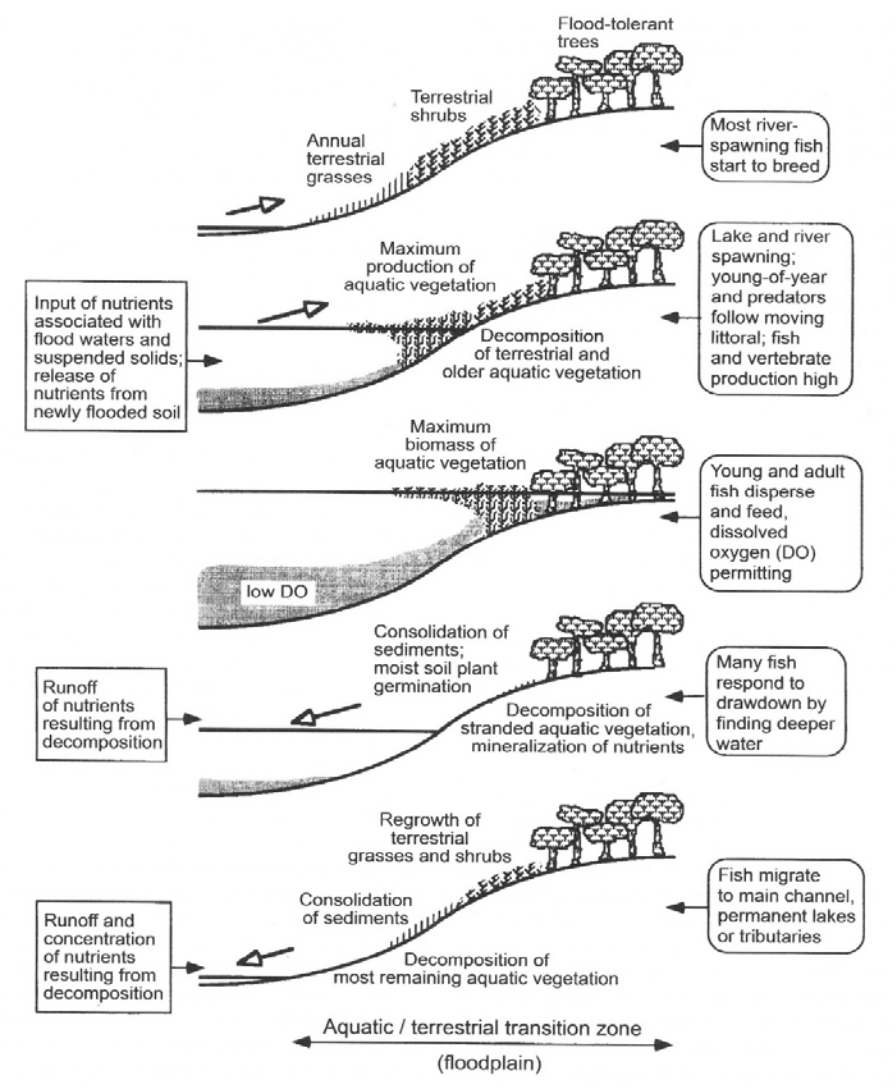


Sedell and Froggat 1984

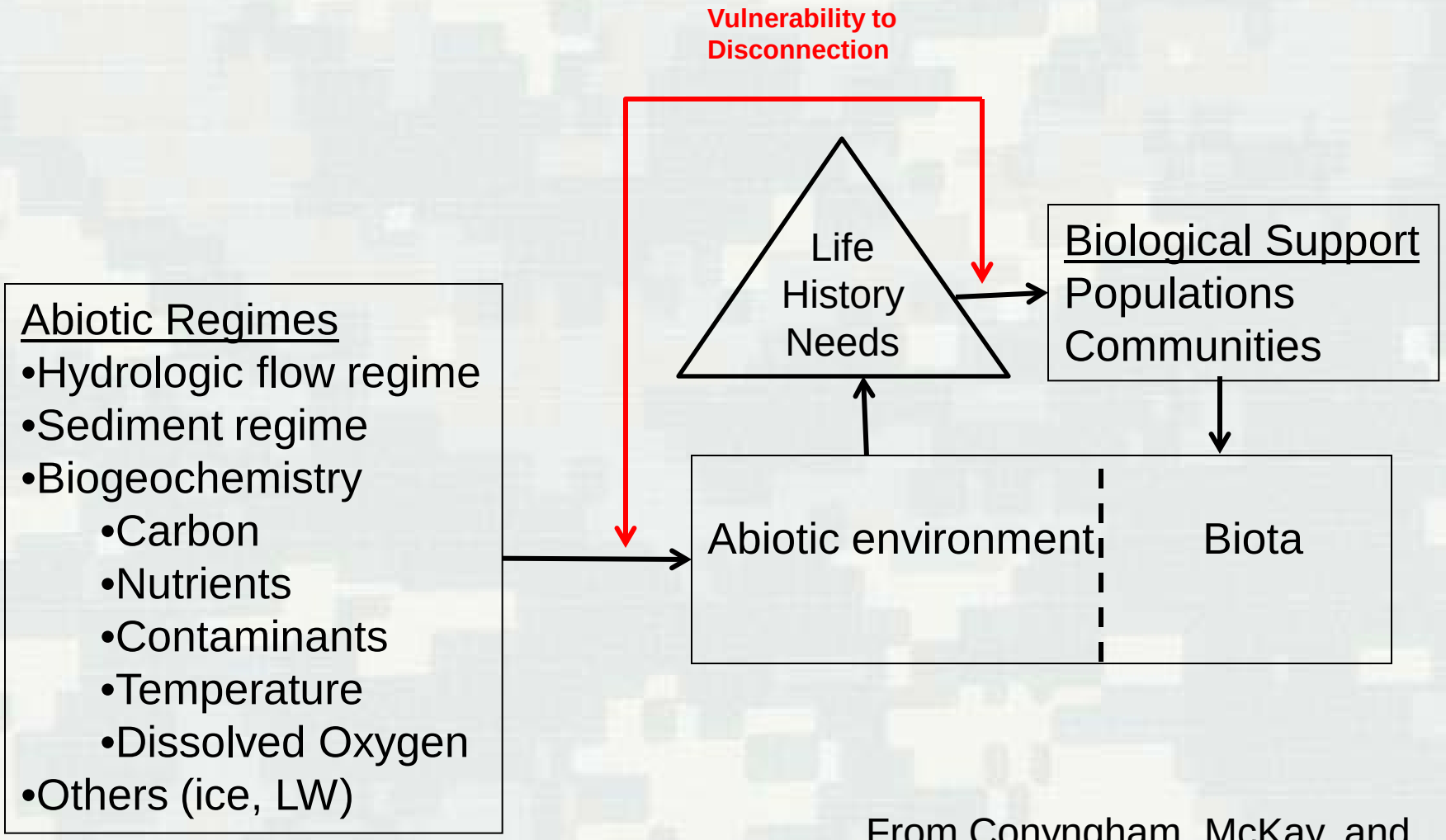
Dynamism: a critical determinant in structure, community, and process



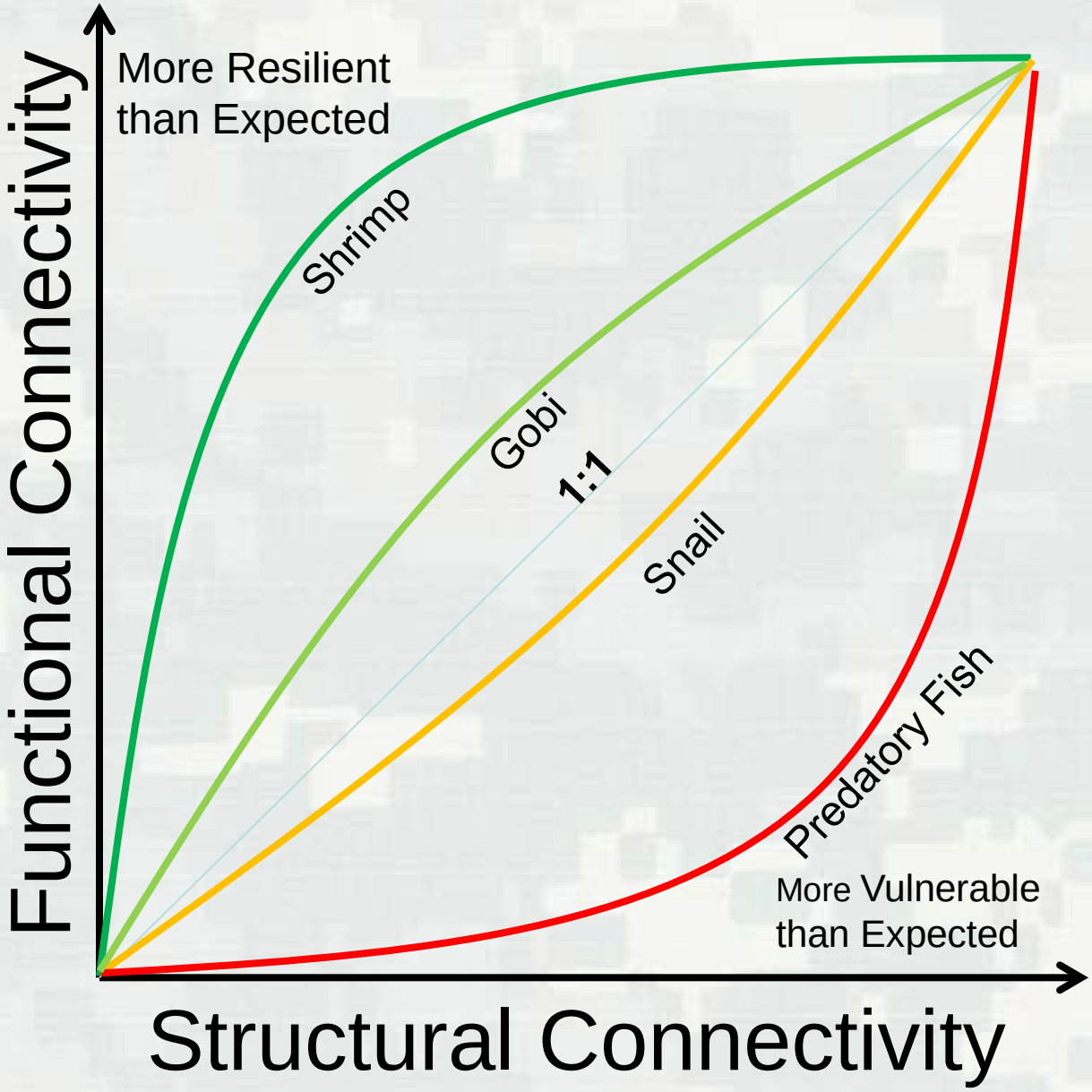
Connectivity addresses energy, materials, and organisms, as mediated by flow



Bailey, 1995



From Conyngham, McKay, and Miller, in prep.


Functional Connectivity
More Resilient
than Expected
Shrimp
Gobi
1:1
Snail
Predatory Fish
More Vulnerable
than Expected
Structural Connectivity

Some complicating factors in biotically robust connectivity restoration

- The temporal dimension can be very important. Example: cottonwood colonization and survival for recruitment
- Inserting life history elements is scale-dependent (Species? Guild? Community?)
- Tools for characterizing, categorizing, and aggregating life history strategies for use in quantitative and qualitative tools are only just becoming available.

Some life history strategy/connectivity models (Hughes et al., 2013)

- Stream Hierarchy Model
- Death Valley Model
- Isolation by Distance
- Panmixia
- Headwater model

Problem: blending of life history, movement capability, habitat structure, but different levels of discreteness and quantification.

Addressing connectivity restoration projects

Connectivity restoration has particularly high probability of achieving biotic success (Roni et al., 2002, 2005), but depends on strong conceptualization:

- *What is the connectivity problem?*
- *What is the dimensionality of connectivity in the system?*
- *What abiotic regimes influence connectivity?*
- *What ecological processes and interactions contribute to or result from connectivity?*
- *What is the role of temporal variability in connectivity and the associated ecological processes?*
- *How do relevant life histories constrain realized, functional connectivity?*
- *How do the above points influence project objectives?*

Questions & Feedback

Contact Information
Jock Conyngham
406-541-4845, x324
Jock.N.Conyngham@usace.army.mil

Kyle McKay
601-415-7160
Kyle.McKay@usace.army.mil

Products:
Technical report:
Principles for Assessing Connectivity (technical report)—In prep.

Organismic case studies (tropical fauna, oyster reefs, fish passage and mussels)—In prep.

Transport-mediated case studies (cumulative effects of dams, levees and floodplain connectivity, others TBD)—In prep.