Messy Rivers are Healthy Rivers

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Background

- shifting baseline of perception
- environmental context (process domain, biome)
- what is natural? (natural range of variability, reference conditions, land use history, natural flow & sediment regimes)
- the 4 Cs of river health (connectivity, complexity, change, capacity)
Shifting baseline of perception

River Pollution: An Ecological Perspective

Haslam (1994)
Natural flow & sediment regimes

Water ($Q$) & sediment ($Q_s$) inputs include downstream + lateral.

Valley context:
- Valley geometry
- Substrate
- Vegetation

River geometry:
- Cross sectional geometry
- Planform
- Gradient

Wohl et al. (2015), BioScience
Connectivity
(water, sediment, solutes, nutrients, contaminants, biota)

lateral

longitudinal

vertical

uplands

floodplain

channel

hyporheic zone

matter & organisms
Forms of Physical Complexity in Rivers

- **stream bed** *(sediment, bedforms, wood)*
- **stream banks** *(vegetation, sediment, other)*
- **cross-sectional form** *(bedforms, meander bends)*
- **planform (river & floodplain)** *(sinuosity, no. of channels)*
Implications of Physical Complexity in Rivers

• habitat abundance & diversity

• resistance & resilience (fire, flood, drought, climate change, resource use)

• retention (water, sediment, nutrients – bio-availability, dispersal)
Implications of Complexity

- connectivity
  (channel-subsurface, channel-floodplain, upstream-downstream)

East Inlet Creek, RMNP
Mountain river metamorphosis

complex to simple

driven by presence or absence of channel-spanning logjams beaver dams
active beaver meadow on North St. Vrain Creek
abandoned beaver meadow on Beaver Brook

Beavers
1940 315
1964 102
1980 12
1999 6

Elk
1940 1200
1968 500
1999 3000

Moraine Park
Logjams and/or beaver dams =

overbank floods
high water table
surface-subsurface exchange
complex channels
sediment storage
nutrient storage
biotic diversity
River metamorphosis: leaky rivers as biotic drivers – & physical complexity – are lost
Evidence that Messy = Healthy

• valley bottom organic carbon storage
  (unconfined valley segments < 25% of total river length, but contain ~75% of carbon present in valley bottoms: this is ~23% of total carbon in landscape, although river valleys occupy <1% of landscape)

• riverine complexity & bioproductivity
  (greater physical complexity, OM storage, nutrient uptake, & biomass & diversity of fish and riparian spiders in streams with old-growth forest)

![Fish biomass per unit length of river](image)

<table>
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<th>low wood</th>
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Alternative states for river physical complexity

logjams

wood-rich

wood-poor

beaver dams

beaver meadows

elk grasslands
Increasing length scale, m

Increasing time scale, years

land use, river engineering

Primarily reduce physical complexity

climate, tectonics

profile form

profile concavity

profile gradient

reach gradient

meander wavelength

bed configuration: gravel-bed streams

channel width

channel depth

bed configuration: sand-bed streams

cross-sectional form

plan form

profile form

Knighton, 1998
River Pollution: An Ecological Perspective

Illustration by Maisie Richards
Conceptual Model for Logjams

- extensive
- persistent
- complex

Multiple channels

- bank erosion
- overbank flow

Wood recruitment

Upstream sedimentation (>2X channel width)

- threshold based on valley geometry

Logjam

- steep
- narrow

Local
- transient
- simple

Treefall ➔ ramped piece

Local gradient
- wide
- old growth