Messy Rivers are Healthy Rivers

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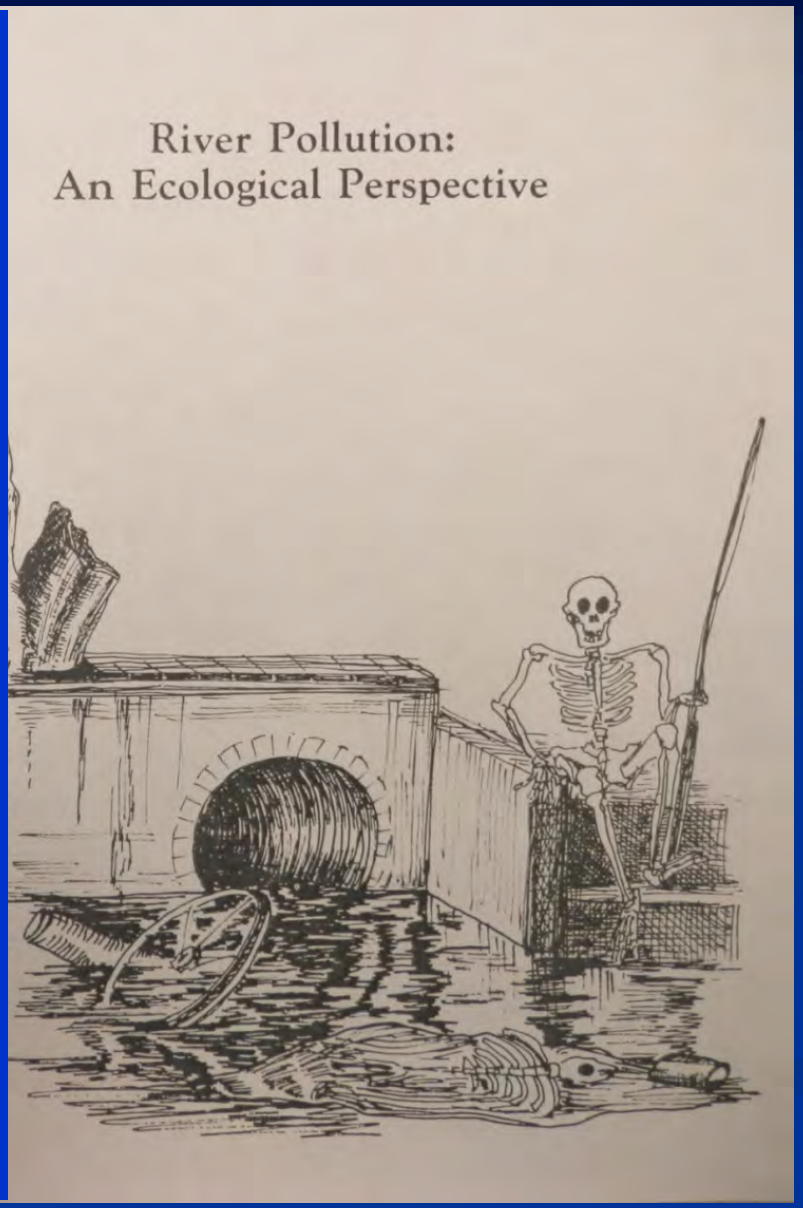
Background

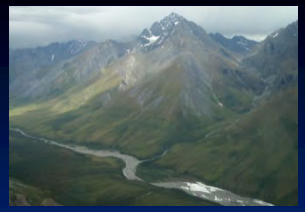
- shifting baseline of perception
- environmental context (process domain, biome)
- what is natural? (natural range of variability, reference conditions, land use history, natural flow & sediment regimes)
- the 4 Cs of river health (connectivity, complexity, change, capacity)

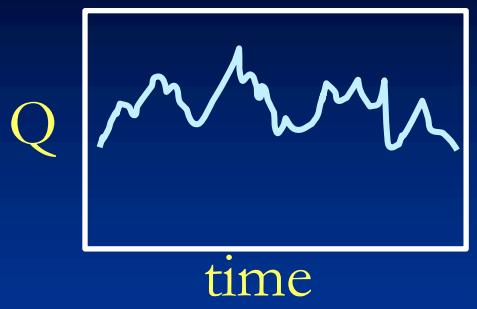
Shifting baseline of perception

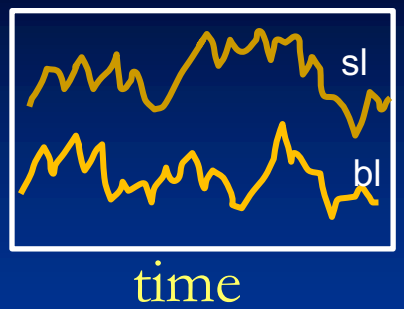


Haslam (1994)

Natural flow & sediment regimes







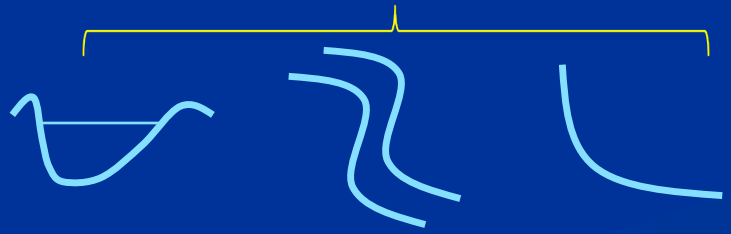
water (Q) & sediment (Q_s) inputs include downstream + lateral

valley geometry

substrate

vegetation

valley context



river geometry

Wohl et al. (2015), BioScience

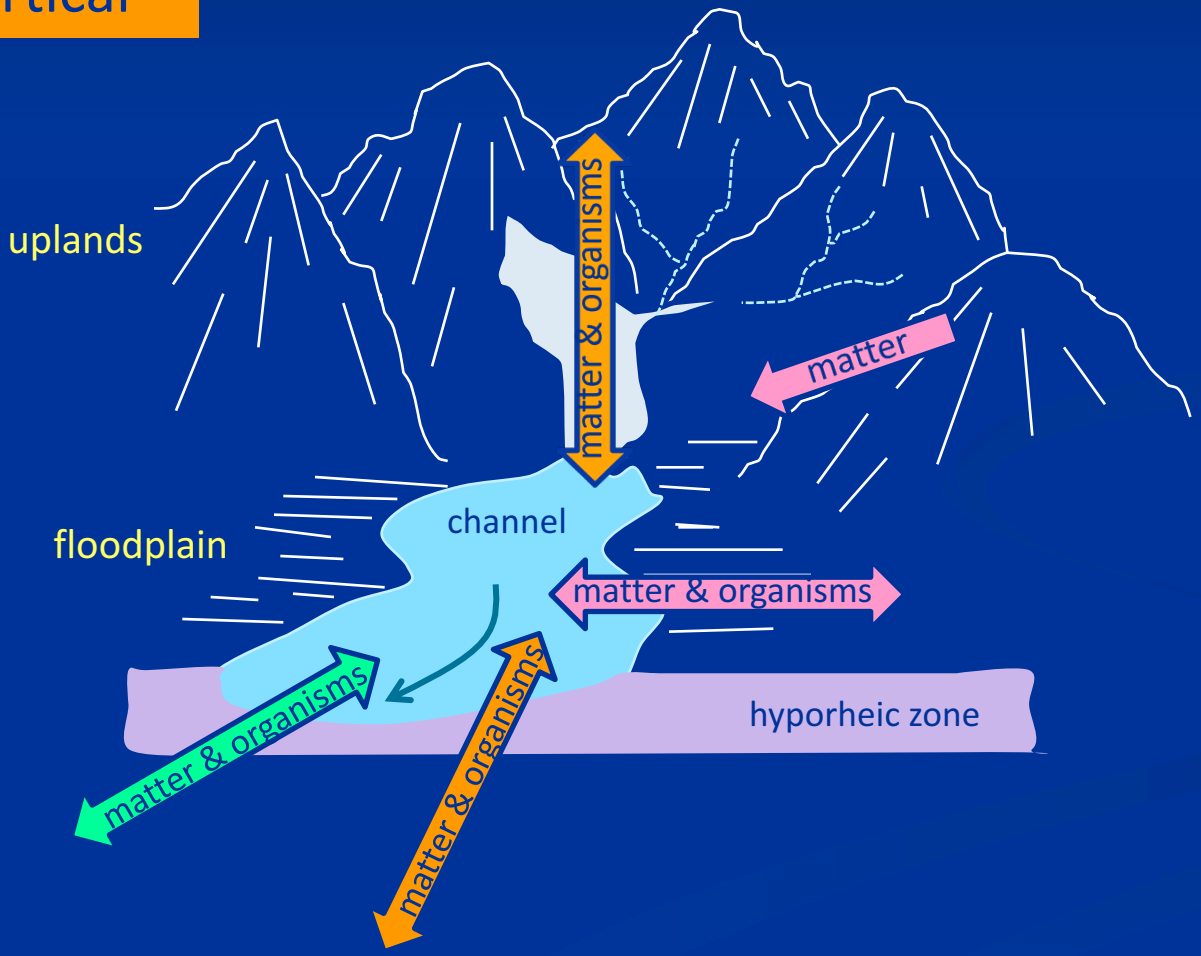
Connectivity

(water, sediment, solutes, nutrients, contaminants, biota)

lateral

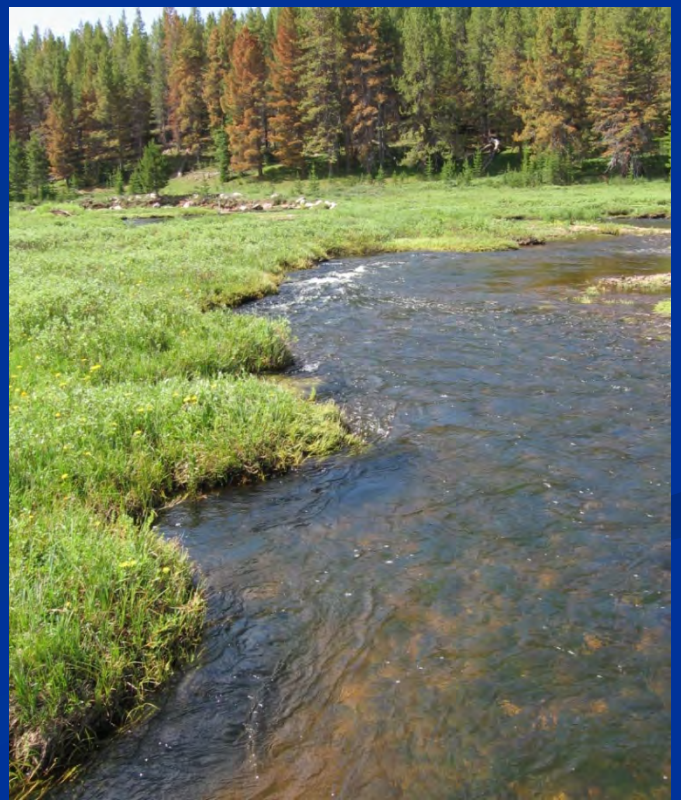
longitudinal

vertical



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)



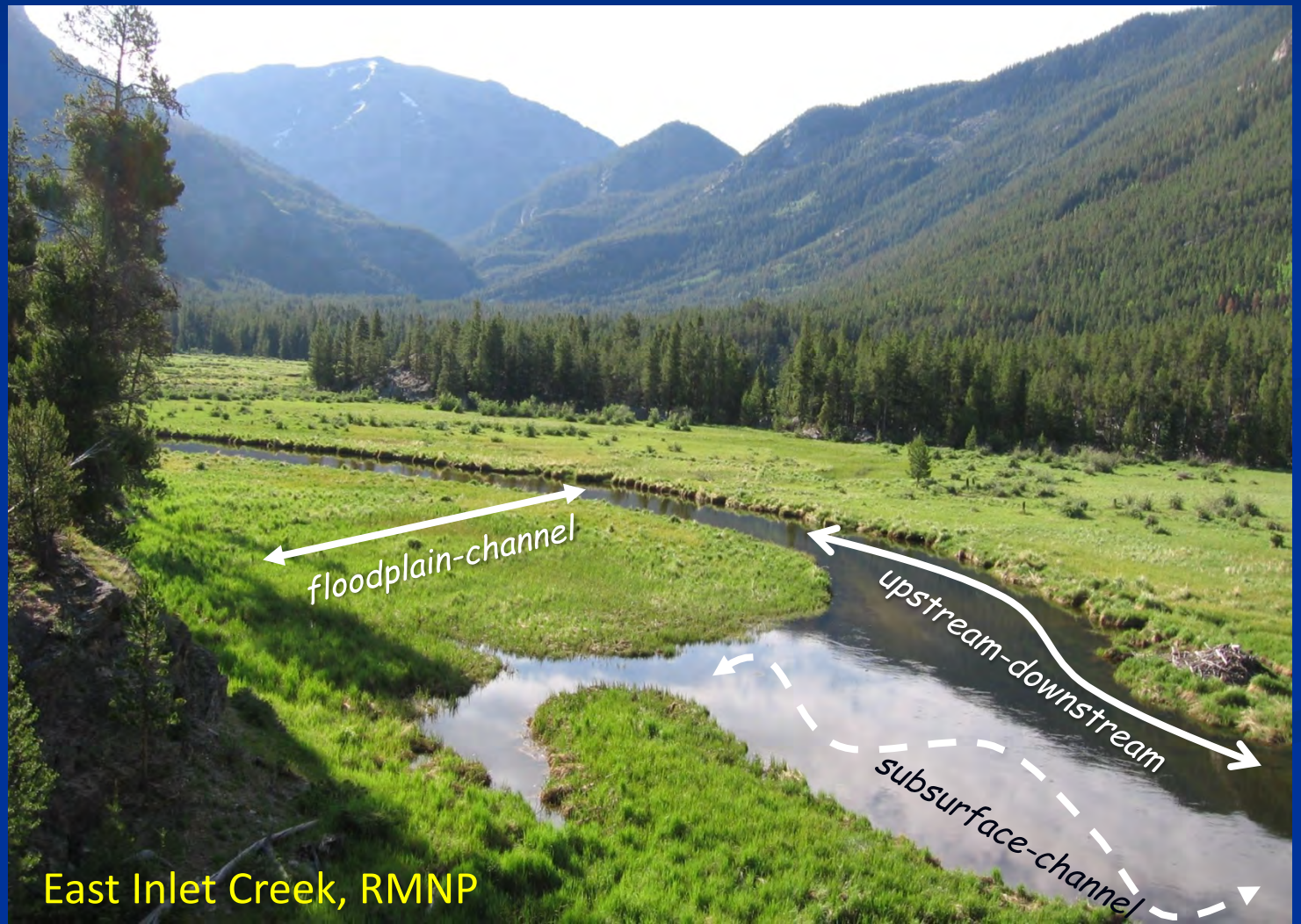
Implications of Physical Complexity in Rivers

- 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)



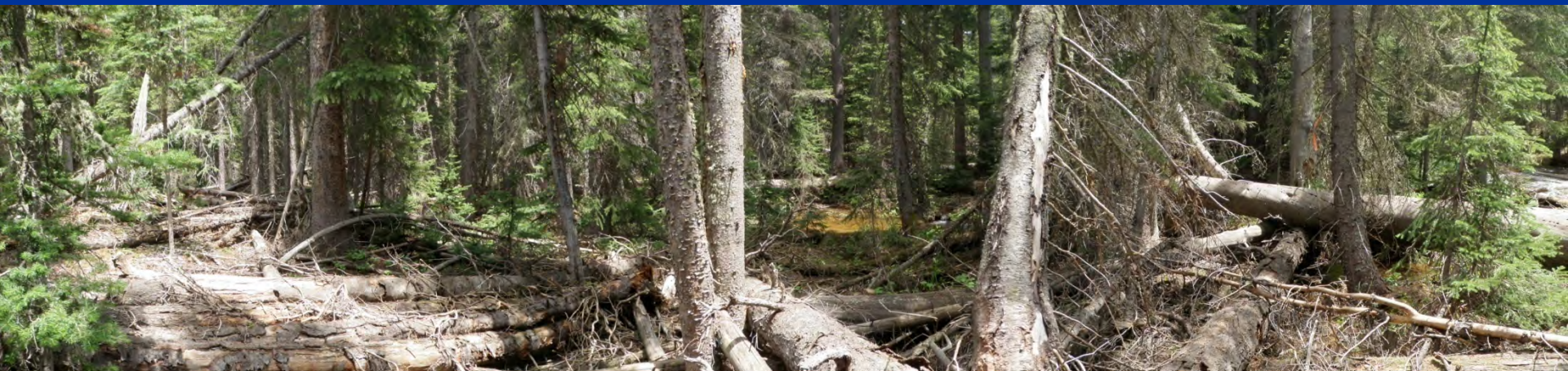
Mountain river metamorphosis

complex to simple

driven by presence or absence of
channel-spanning logjams
beaver dams

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

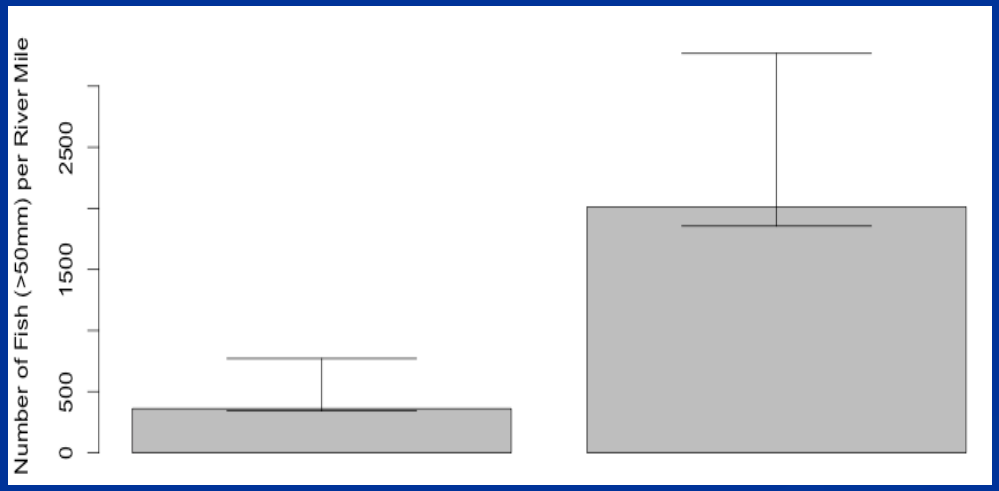
Evidence that Messy = Healthy

- 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

Alternative states for river physical complexity

logjams

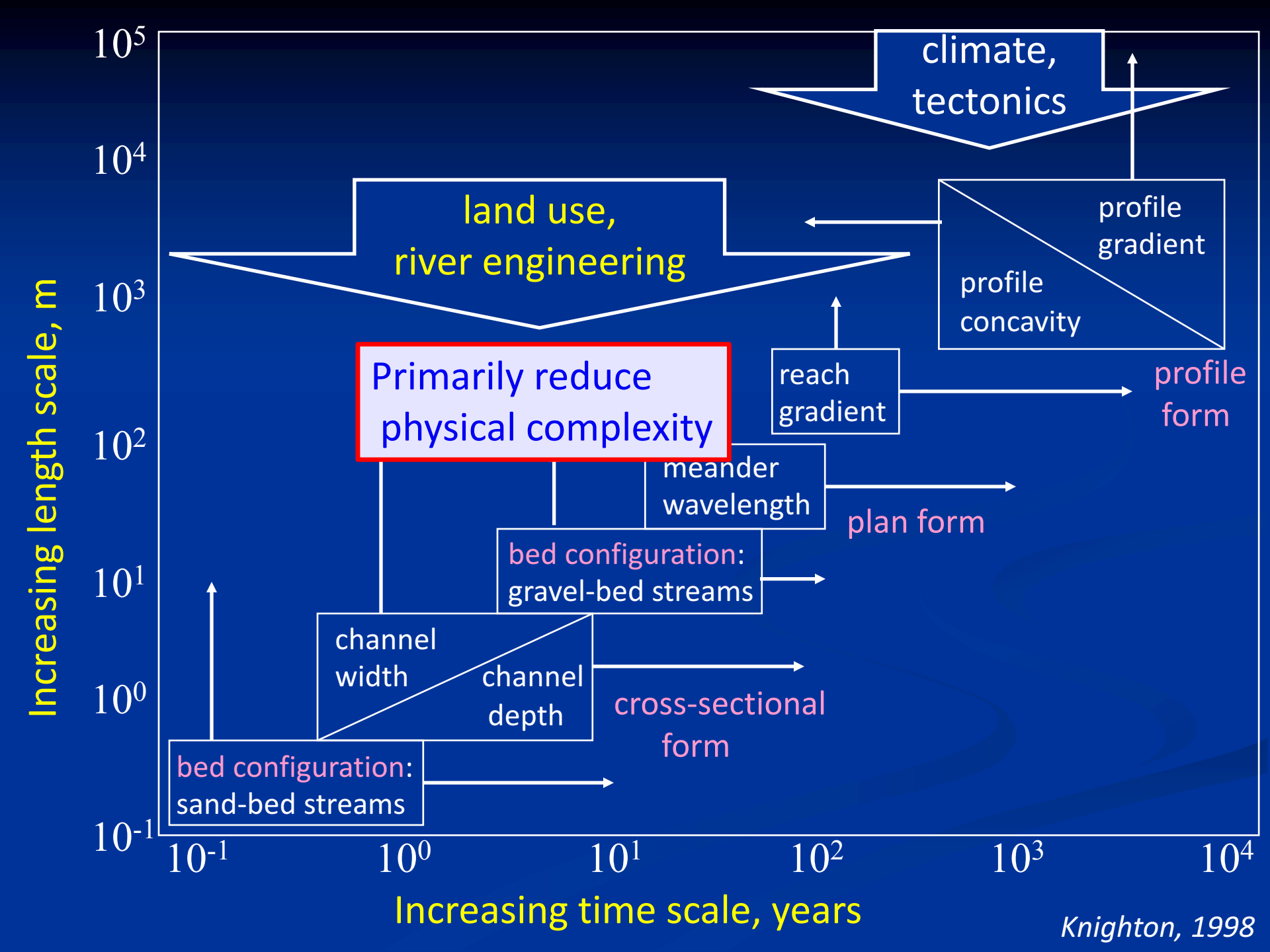
wood-rich

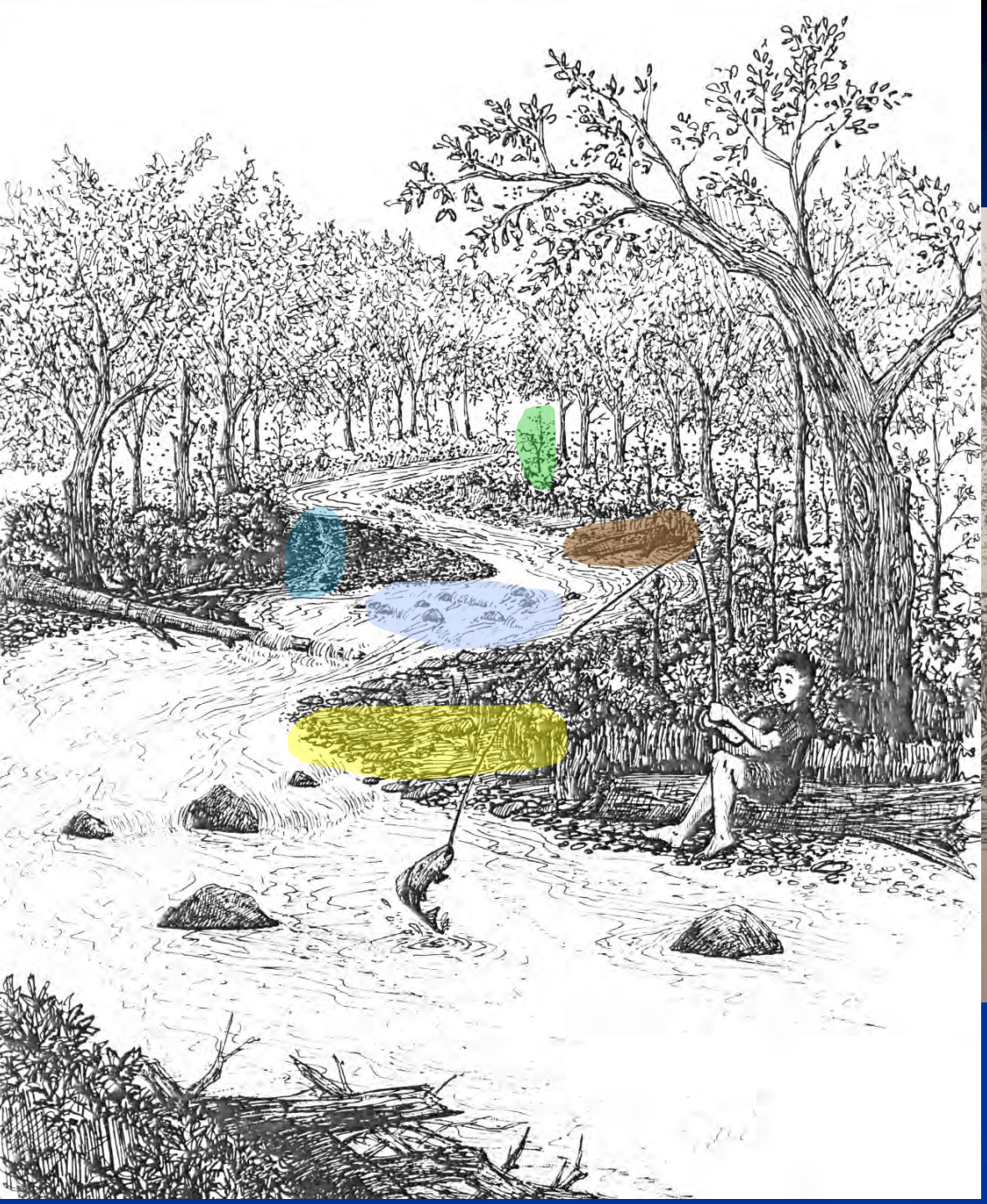
wood-poor

beaver dams

beaver meadows

elk grasslands


10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
Increasing length scale, m
climate, tectonics
land use, river engineering
profile gradient
profile concavity
Primarily reduce physical complexity
reach gradient
profile form
meander wavelength
plan form
bed configuration: gravel-bed streams
channel width
channel depth
cross-sectional form
bed configuration: sand-bed streams
10^{-1}
10^0
10^1
10^2
10^3
10^4
Increasing time scale, years
Knighton, 1998



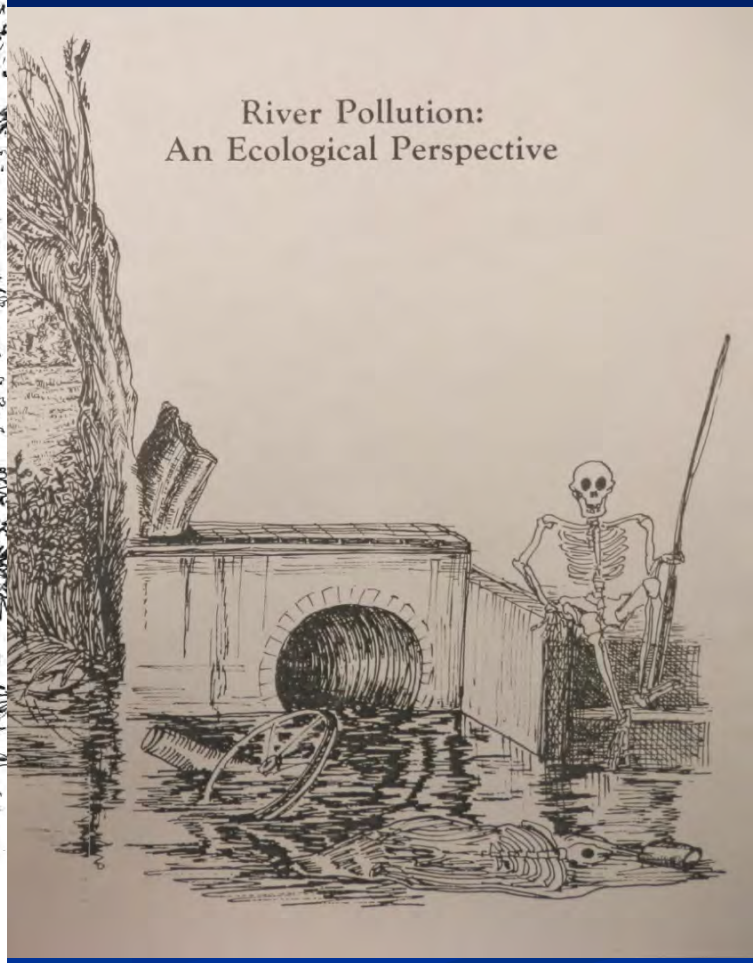


Illustration by Maisie Richards

Conceptual Model for Logjams

extensive
persistent
complex

multiple channels

bank erosion
overbank flow

wood
recruitment

low gradient
wide
old growth

upstream sedimentation
(>2X channel width)

treefall → ramped piece → logjam

threshold based on valley geometry

upstream sedimentation
(1-2X channel width)

local
transient
simple

steep
narrow