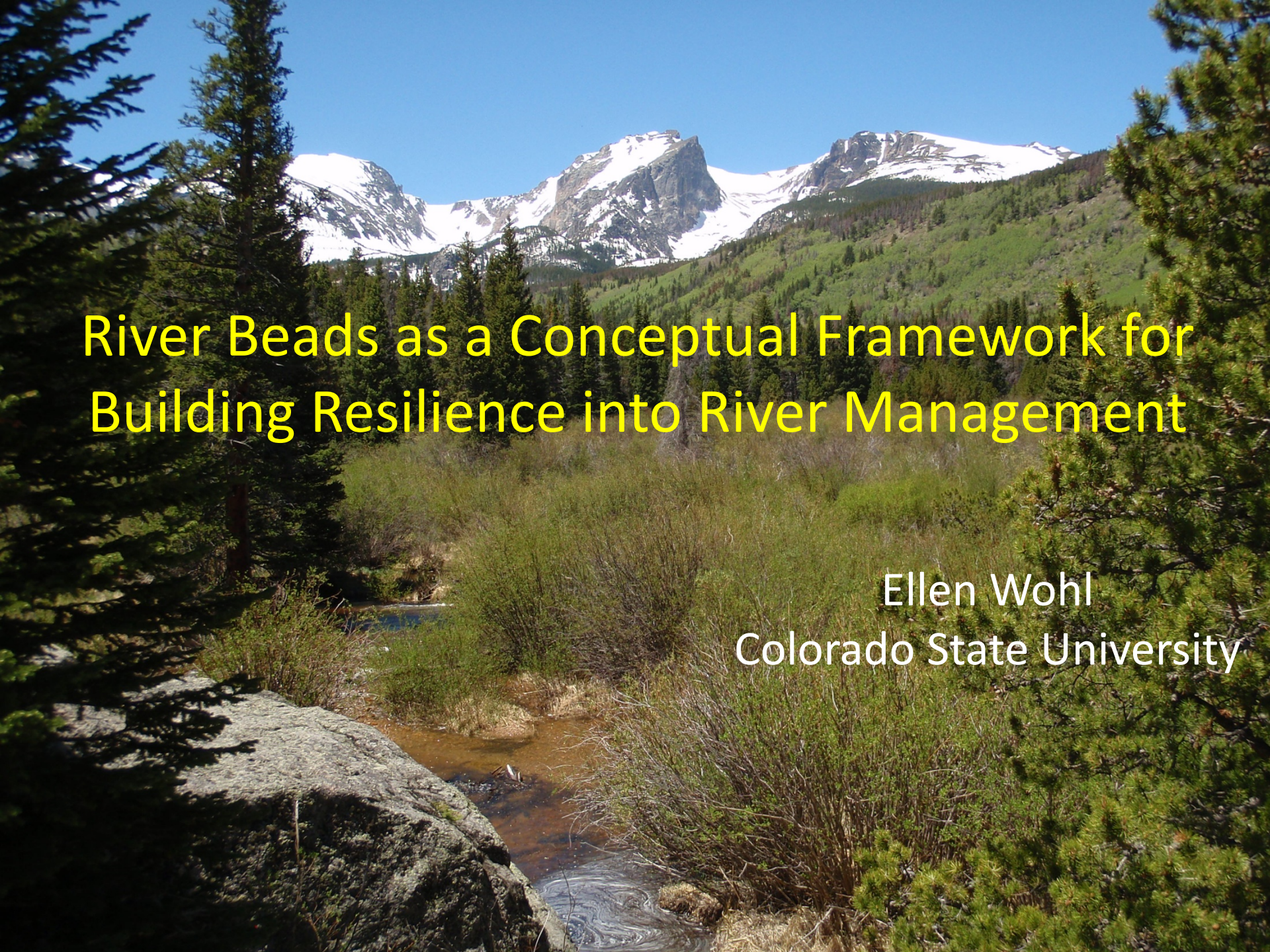
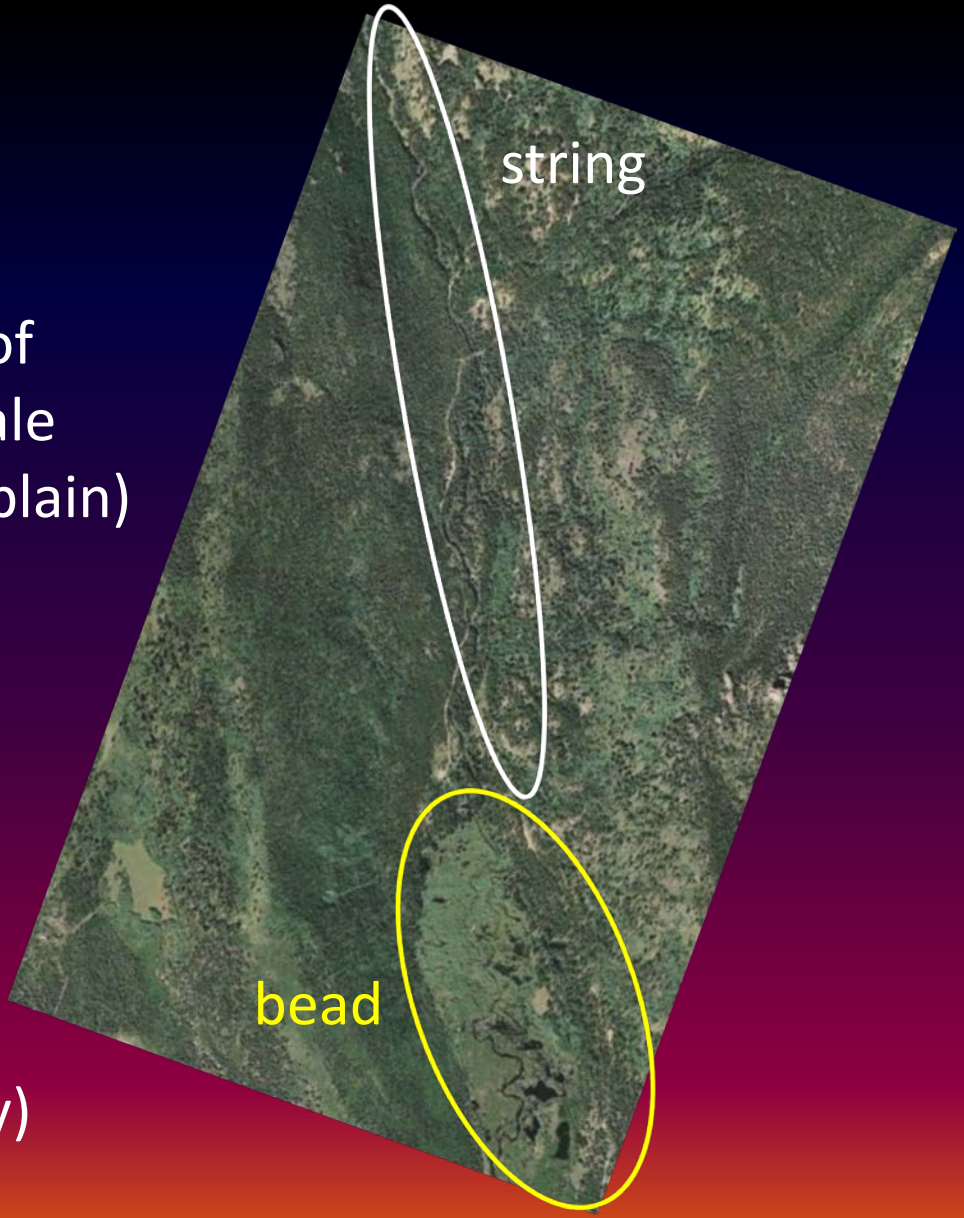


River Beads as a Conceptual Framework for Building Resilience into River Management

Ellen Wohl
Colorado State University

Theme of presentation

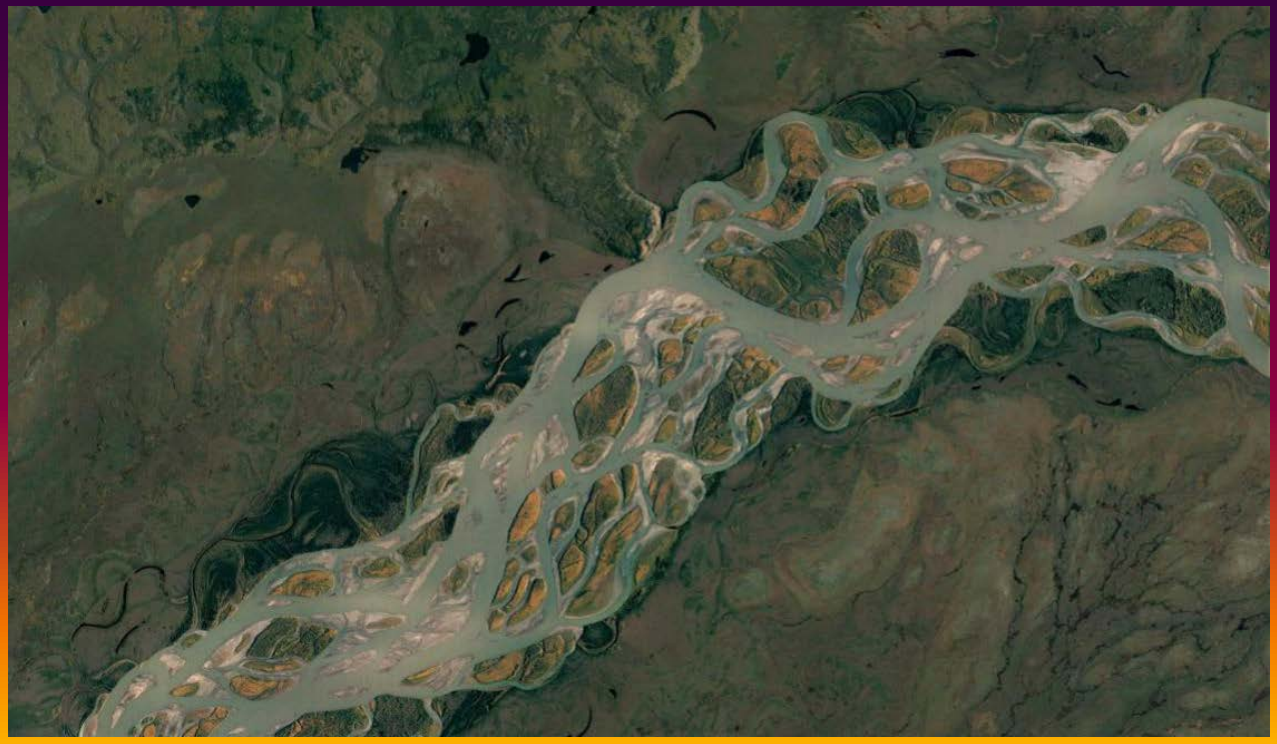
Exploring resiliency through lens of
spatial heterogeneity at reach scale
of river corridor (channel + floodplain)
& longitudinal variability,
with focus on beads & strings
(Stanford et al., 1996, Regulated Rivers)



(resilience = resistance + recovery)

Basic understanding of river ecosystems, & limited studies, indicate that beads are more retentive & biologically productive

Thorp et al., 2006, River Research & Applications
Appling et al., 2014, Journal of Geophysical Research: Biogeosciences
Beckman & Wohl, 2014, Water Resources Research,
Bellmore & Baxter, 2014, River Research & Applications
Livers & Wohl, 2016, Water Resources Research
Wohl et al., in press, Biogeochemistry



Beads & strings = habitat for diverse organisms

- strings
  - migration corridors

- beads
  - attenuation of downstream fluxes (water, sediment, nutrients, organic matter, carbon)
  - greater habitat abundance & diversity
  - greater lateral (channel-floodplain) & vertical (channel-hyporheic) connectivity

Greater spatial heterogeneity & higher riparian water table

Greater resilience

Background

Traditional river management emphasizes conveyance , uniformity, & stability

Negative consequences include high rates of extinction among freshwater organisms, homogenization of flow, loss of species diversity, eutrophication, loss of river ecosystem services, & loss of carbon storage

channelized river, Colorado

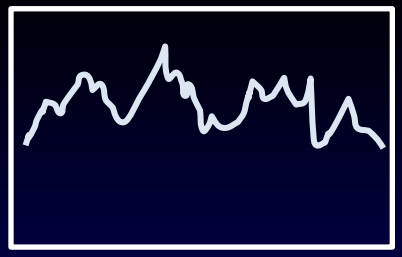
Yukon River, Alaska

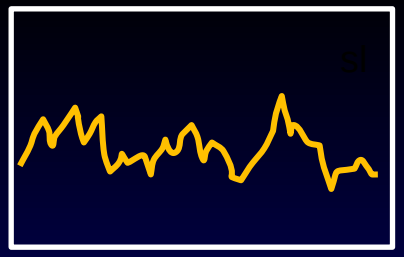
Management is shifting toward restoring heterogeneity of process & form across space and through time

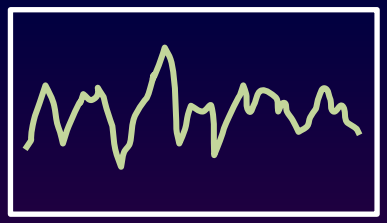
Heterogeneity =

- physically complex channel boundaries
- lateral & vertical connectivity
- natural water, sediment, (& large wood) regimes
- room for rivers to adjust

Briefly review how spatial heterogeneity within river corridors influences resilience of the river corridor to natural & human disturbances







natural flow (Q), sediment (Q_s) & large wood (LW) regimes

valley geometry

room to adjust (human influence)

gradient

planform

xs geometry

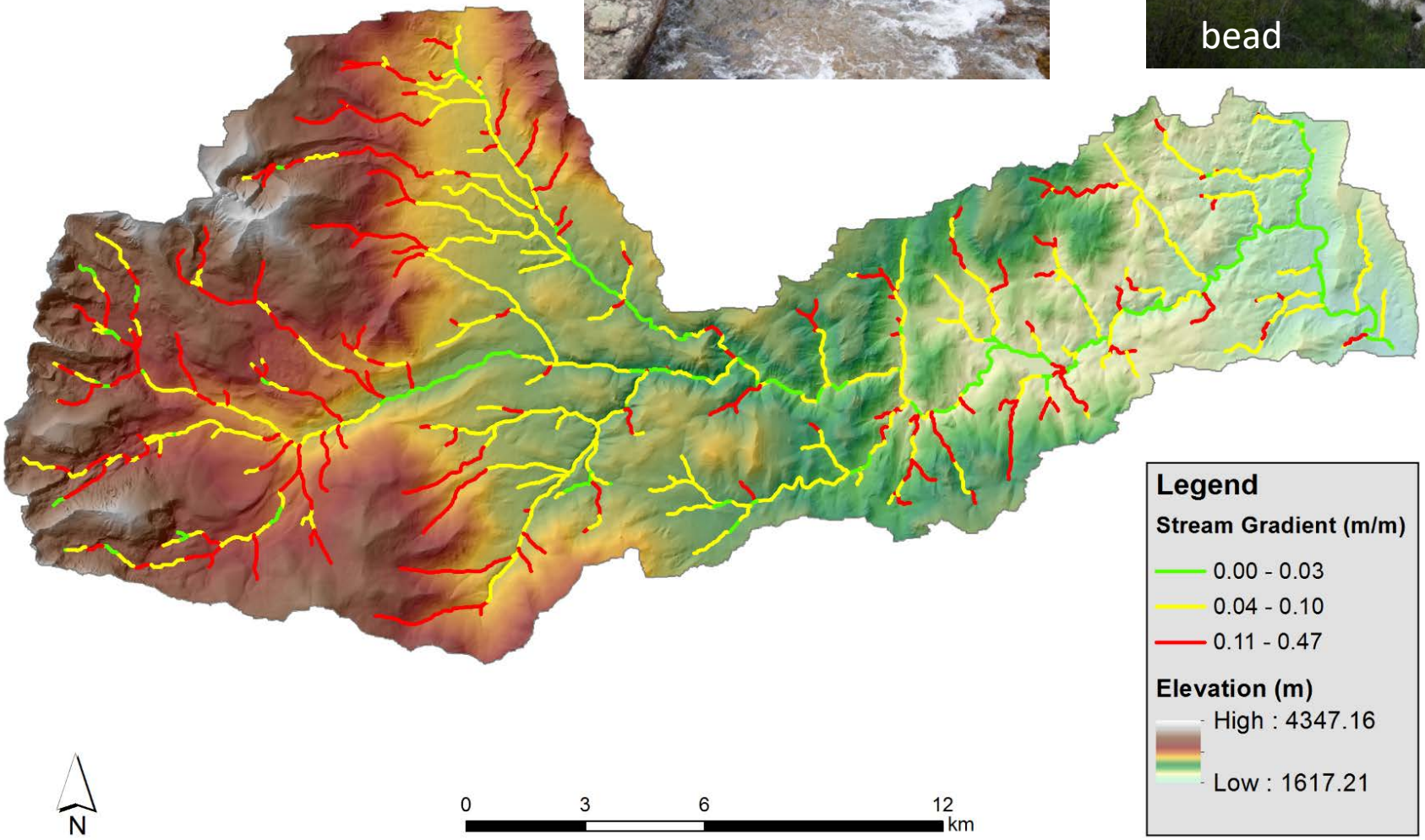
substrate, hydraulics

river geometry, connectivity, heterogeneity

Examples from mountain streams in the Colorado Front Range

~400 km^2

North St. Vrain Creek, CO

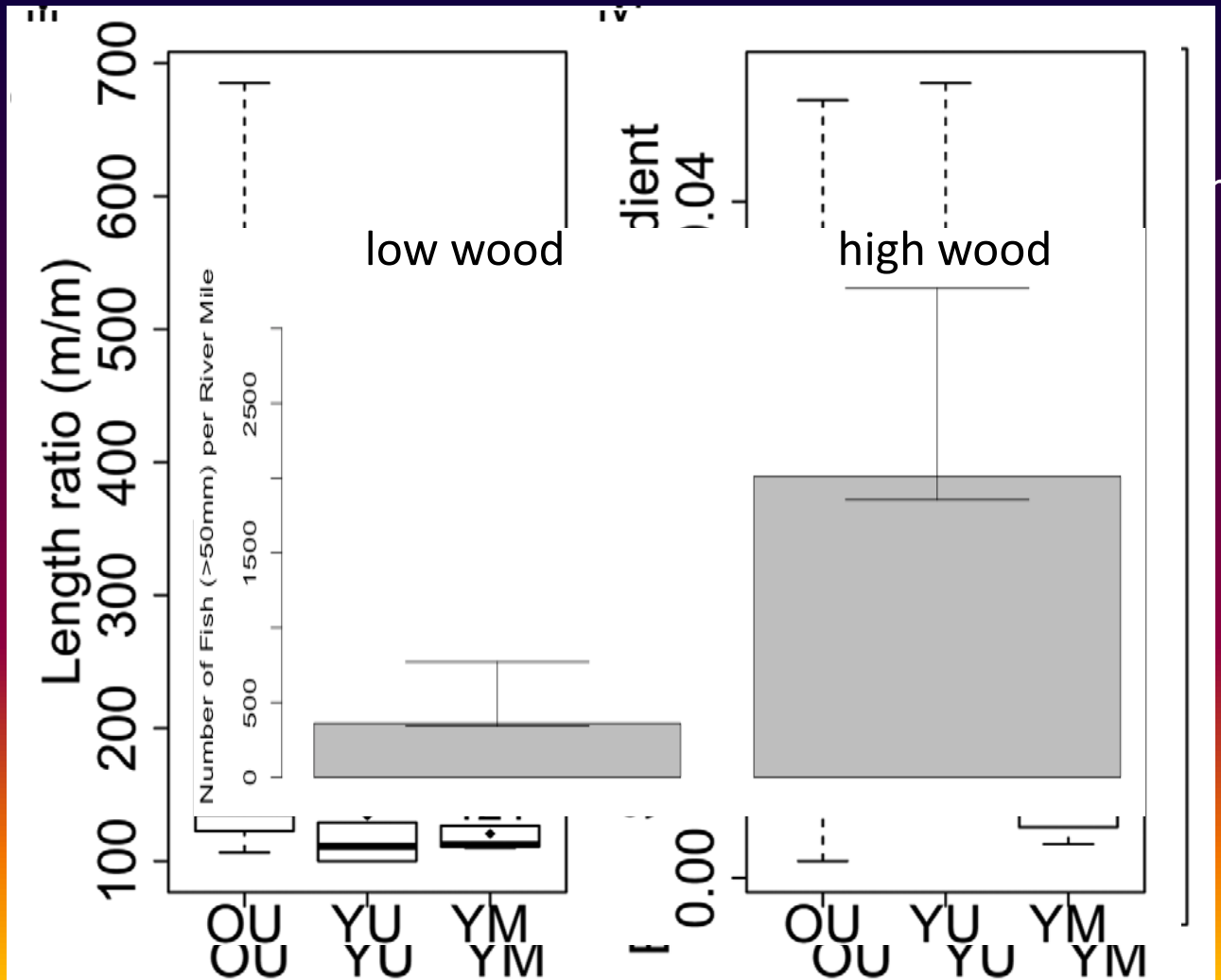


- riverine spatial heterogeneity & bioproductivity

(greater spatial heterogeneity, OM storage, nutrient uptake, & biomass & biodiversity in streams with old-growth forest)

Livers & Wohl, 2016, Water Resources Research

Livers et al., 2018, Earth Surface Processes & Landforms



backwater pool volume

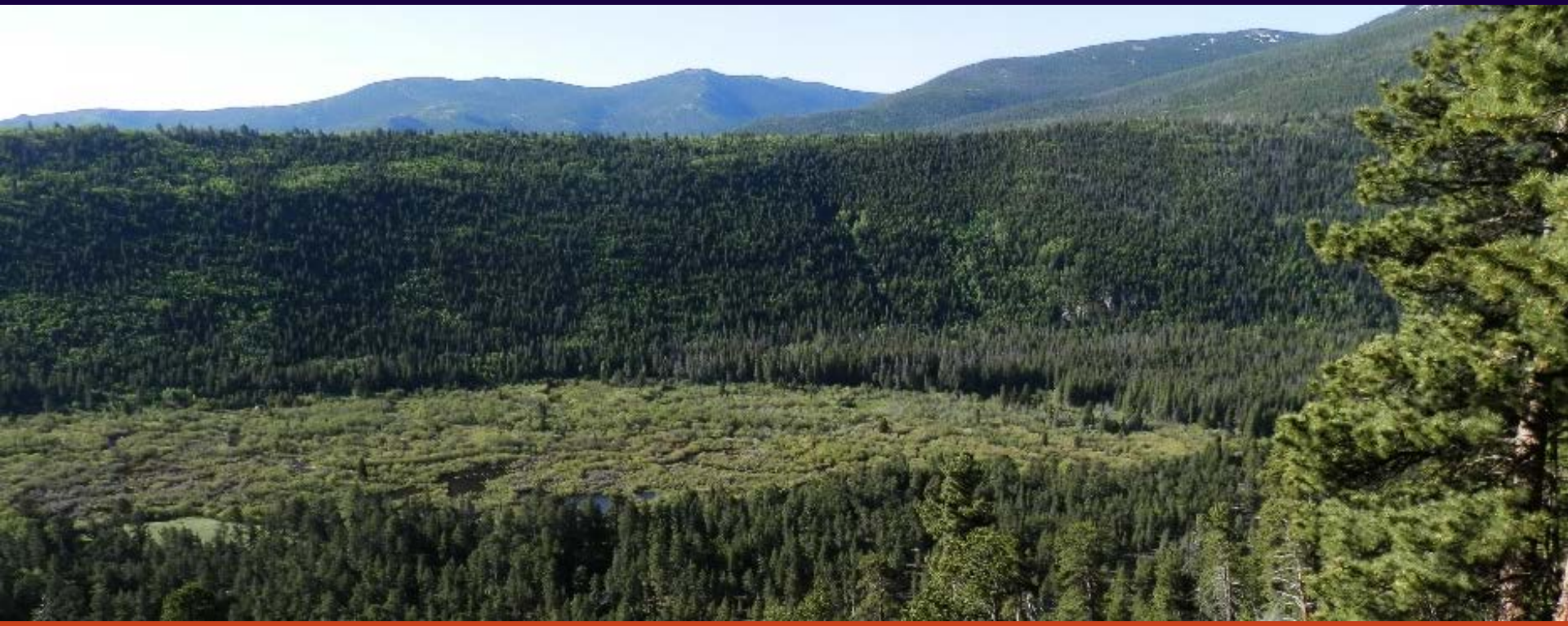
ratio of channel to valley length & gradient

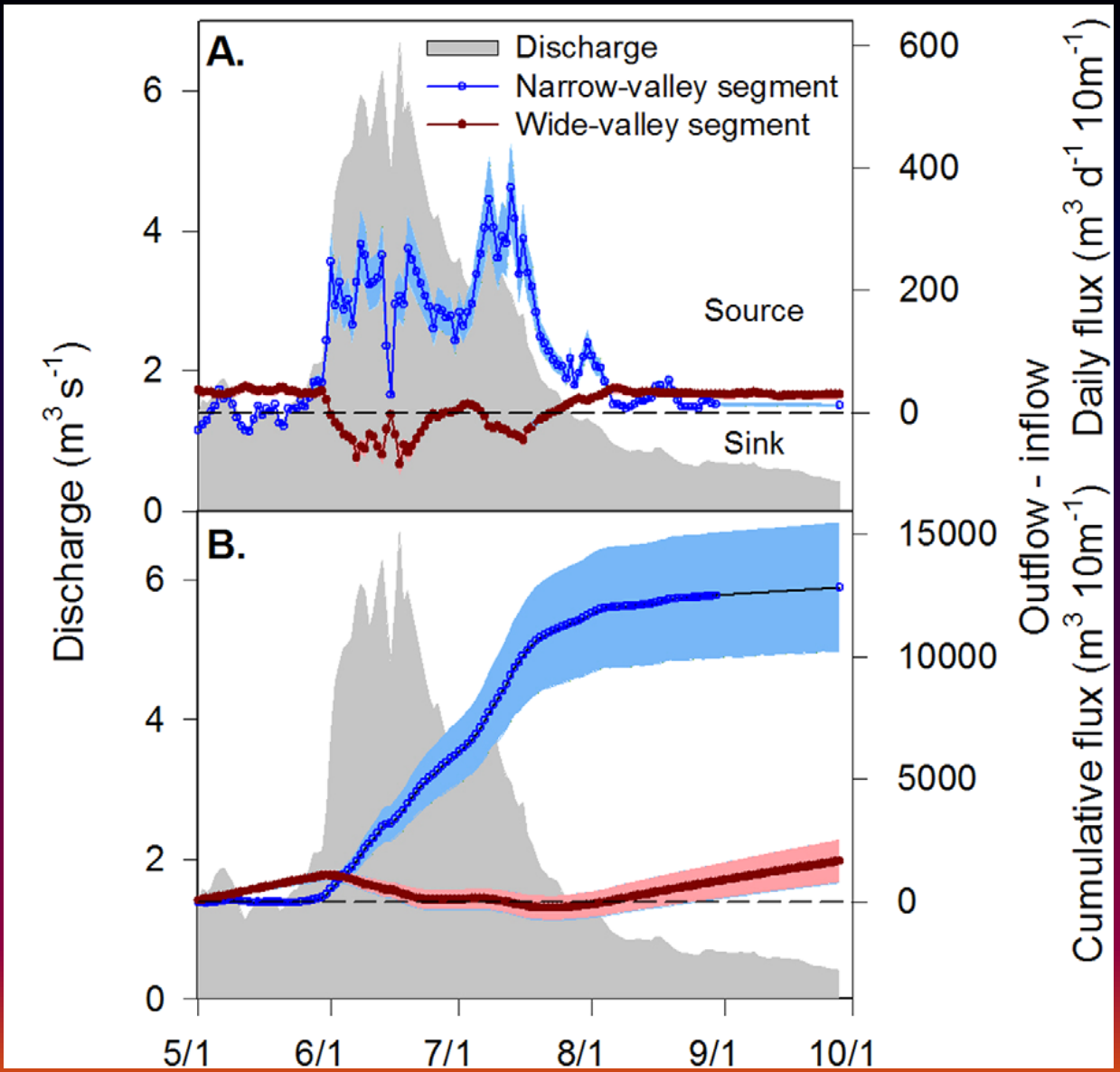
mass per unit length of river variation

OU old unmanaged
YU young unmanaged
YM young managed

- resilience to disturbance

(spatially heterogeneous river beads more resilient to drought, fire, and flood)

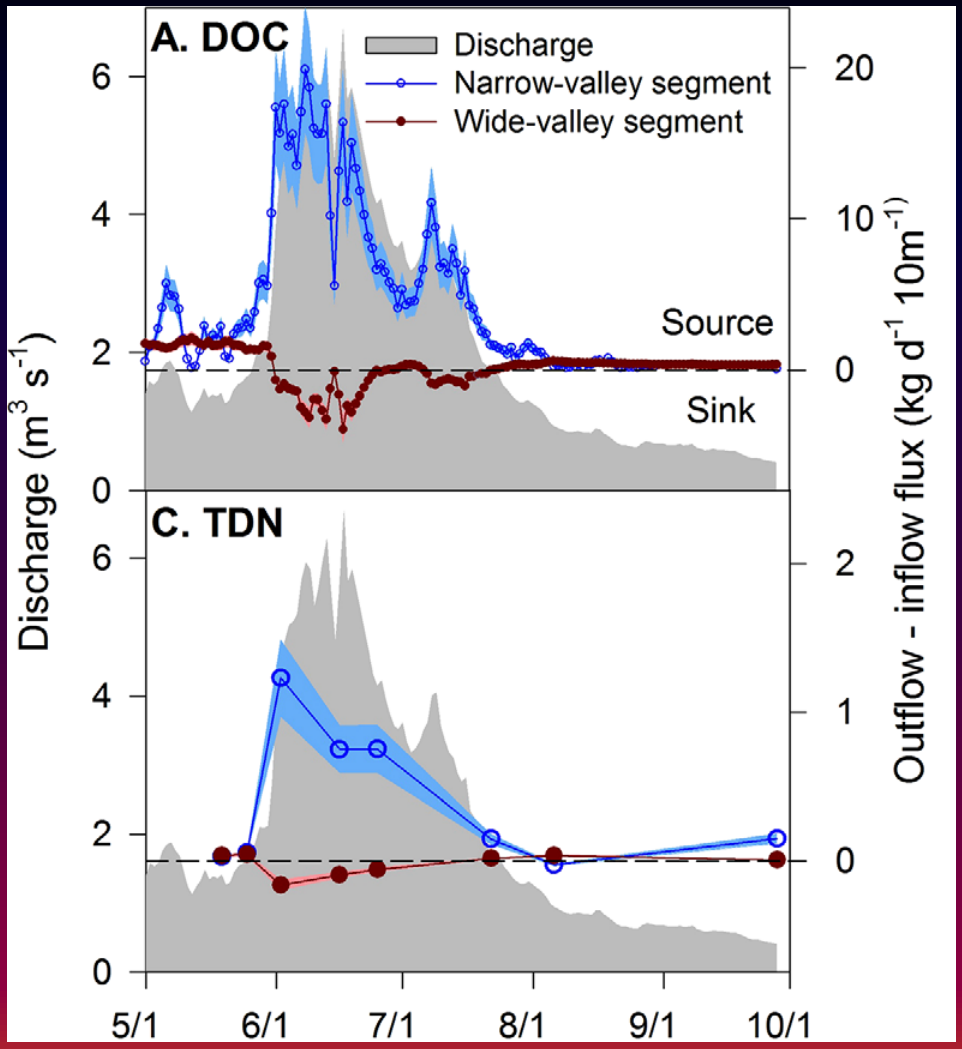




beaver meadow

Wegener et al., 2017, Water Resources Research

Daily mean & cumulative water flux balances during snowmelt runoff (shading indicates uncertainty)



Dissolved organic carbon (DOC) & total dissolved nitrogen (TDN)

Function of river beads strongly influenced by factors that promote spatial heterogeneity & associated retention, connectivity, and resilience

logjams

beaver dams

Conceptual Model for Logjams

extensive
persistent
heterogeneous
connected

multiple channels

↑ ood

↑ overbank flow tment

R E S I L I E N T

upstream sedimentation
(>2X channel width)

Bead
low gradient
wide
old growth

treefall → ramped piece

logjam

threshold based on valley geometry

upstream sedimentation
(1-2X channel width)

local
transient
simple

String
steep
narrow

Conceptual Model for Beaver Meadows/Elk Grasslands

beaver meadow:
extensive
persistent
heterogeneous
connected

beaver food
& habitat

floo
decidu
multiple channels

dams
onds

RESILIENT

beaver present

↑ backwater
↑ overbank flow

beaver dam

threshold based on presence of beavers & dams

elk grassland:
simple
disconnected

↓ backwater
↓ overbank flow

beaver absent

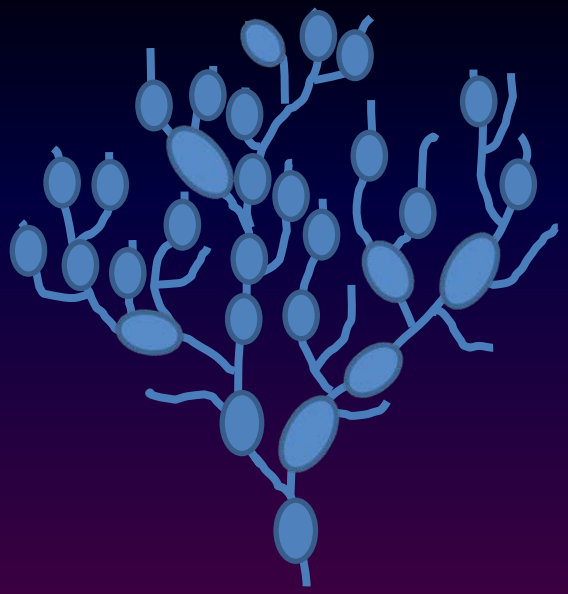
drier floodplain
single channel

River management that emphasizes identification & protection of river beads is critical to maintaining vitality of river systems under a changing climate

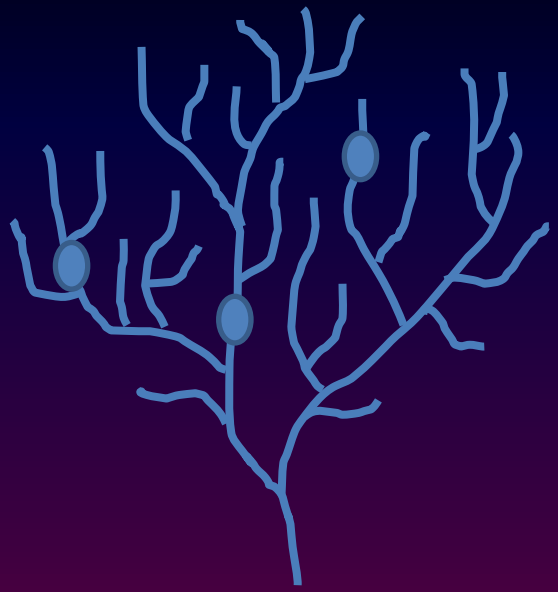
Floodplain reconnection along the River Tweed, Scotland (courtesy of Derek Robeson)

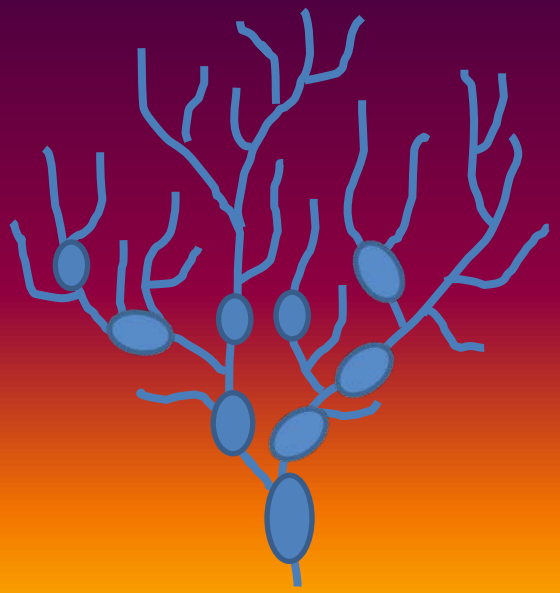
Reconnecting secondary channels along the Mareit River, Italy (courtesy of Francesco Comiti)

Pre-settlement



Today



Future

Or?