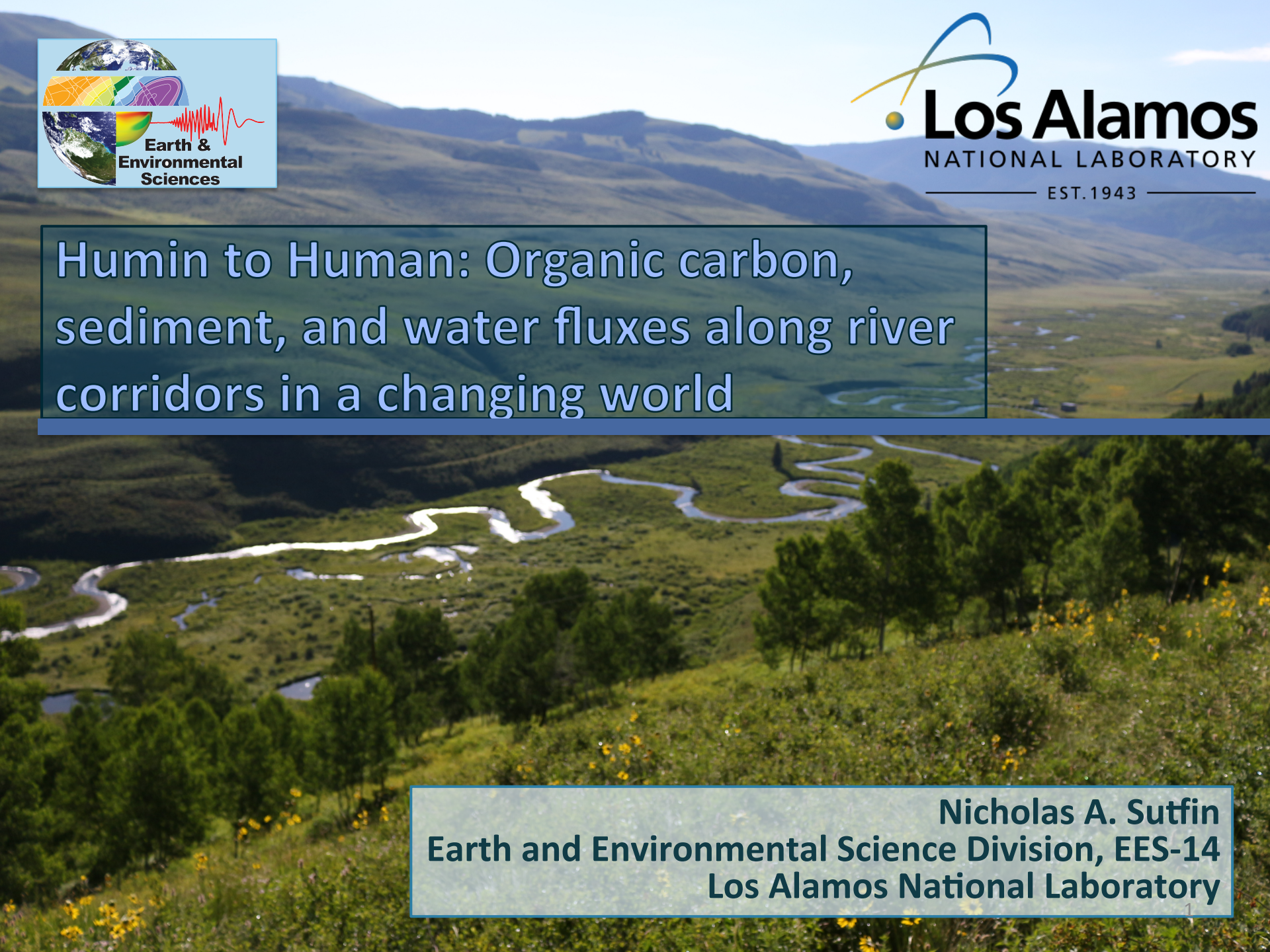
LA-UR-17-30616
Approved for public release; distribution is unlimited.

Title:	Humin to Human: Organic carbon, sediment, and water fluxes along river corridors in a changing world
Author(s):	Sutfin, Nicholas Alan
Intended for:	Research Seminar Faculty Candidate Presentation at Texas State University
Issued:	2017-11-20



Humin to Human: Organic carbon, sediment, and water fluxes along river corridors in a changing world

Nicholas A. Sutfin
Earth and Environmental Science Division, EES-14
Los Alamos National Laboratory

Collaborators

Joel Rowland, Sophie Stauffer, Mulu Fratkin, Meghan King, , Katrina Bennett, Richard Middleton, George Perkins
Earth and Environmental Science Division, Los Alamos National Laboratory

Ellen Wohl, Laurel Lynch, Bridget Livers, Katherine Lininger, Tim Covino, Claudia Boot, Matt Wallenstein
Colorado State University

Malak Tfaily, A. Kerem Bingol, Nancy Washton
Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory

Kathleen Dwire, Timothy Fegel
Rocky Mountain Research Station, US Forest Service

Rosemary Carroll - Desert Research Institute

Ken Williams - Lawrence Berkeley National Laboratory

Helen Malend - Colorado School of Mines

Funding

NSF IGERT I-WATER Grant No. DGE-1061 0966346 and NSF DDRI grant No. 1536186

Joel Rowland's Early Career Award from the Subsurface Biogeochemical Research Programs within the U.S. Department of Energy Office of Science, Biological and Environmental Research supported this work. Field support was provided by the Lawrence Berkeley National Laboratory Watershed Function Science Focus Area.

Research Interests

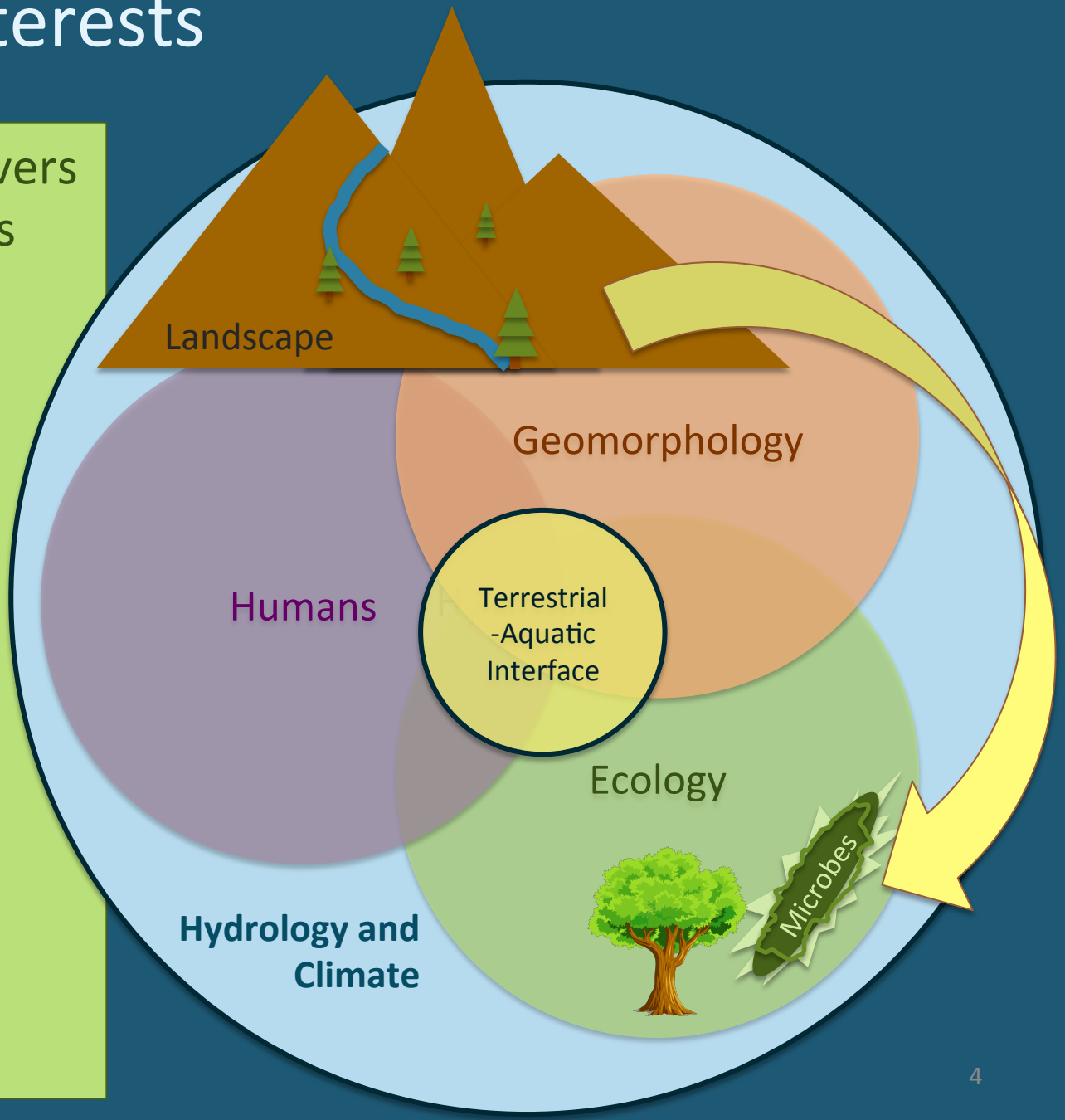
Physical process in rivers & healthy ecosystems

Feedbacks between flow, sediment, and biota

Climate & land use influence processes

How might these processes change

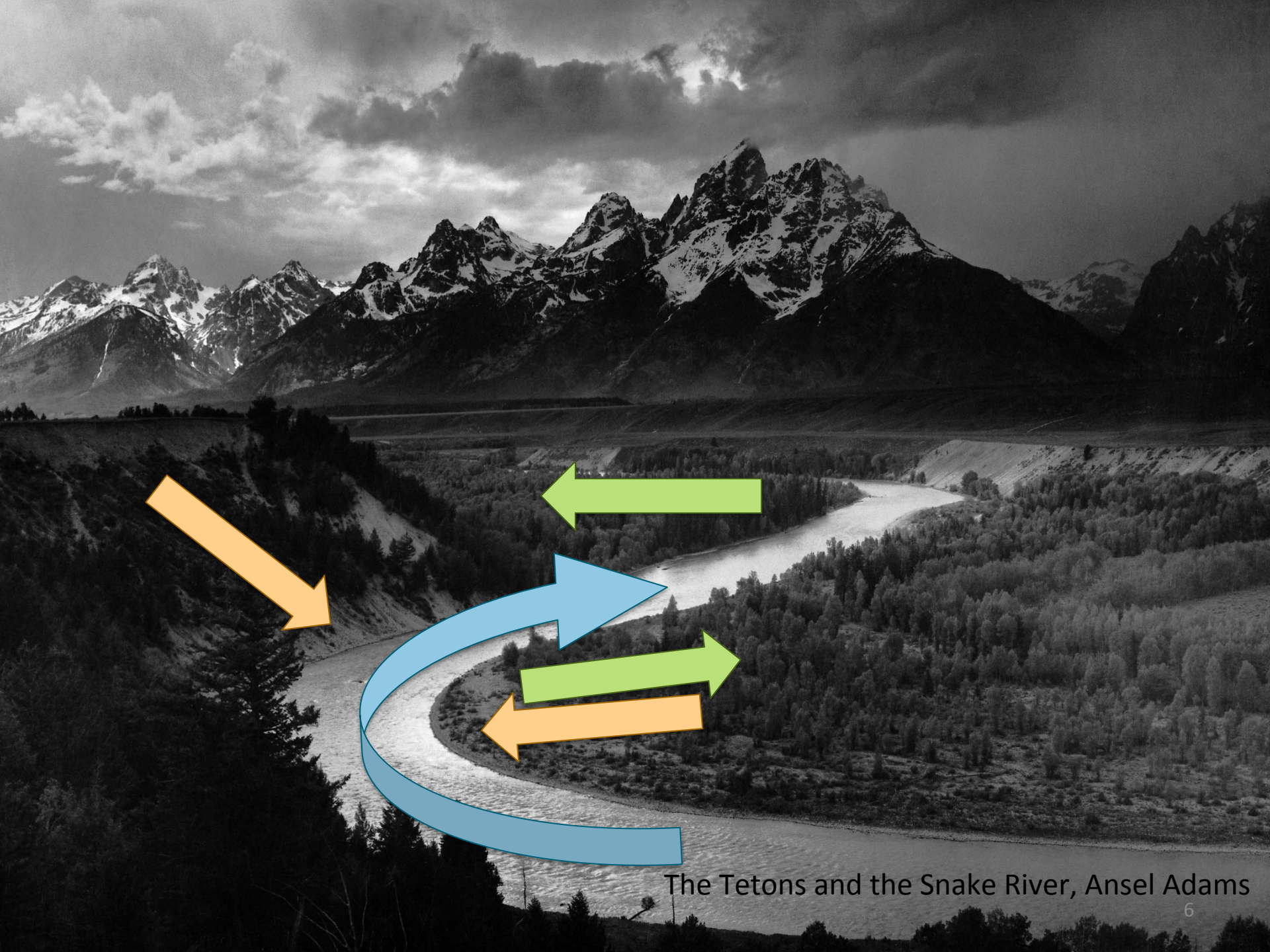
Freshwater social-ecological balance



What does it mean to be human?

… humin?

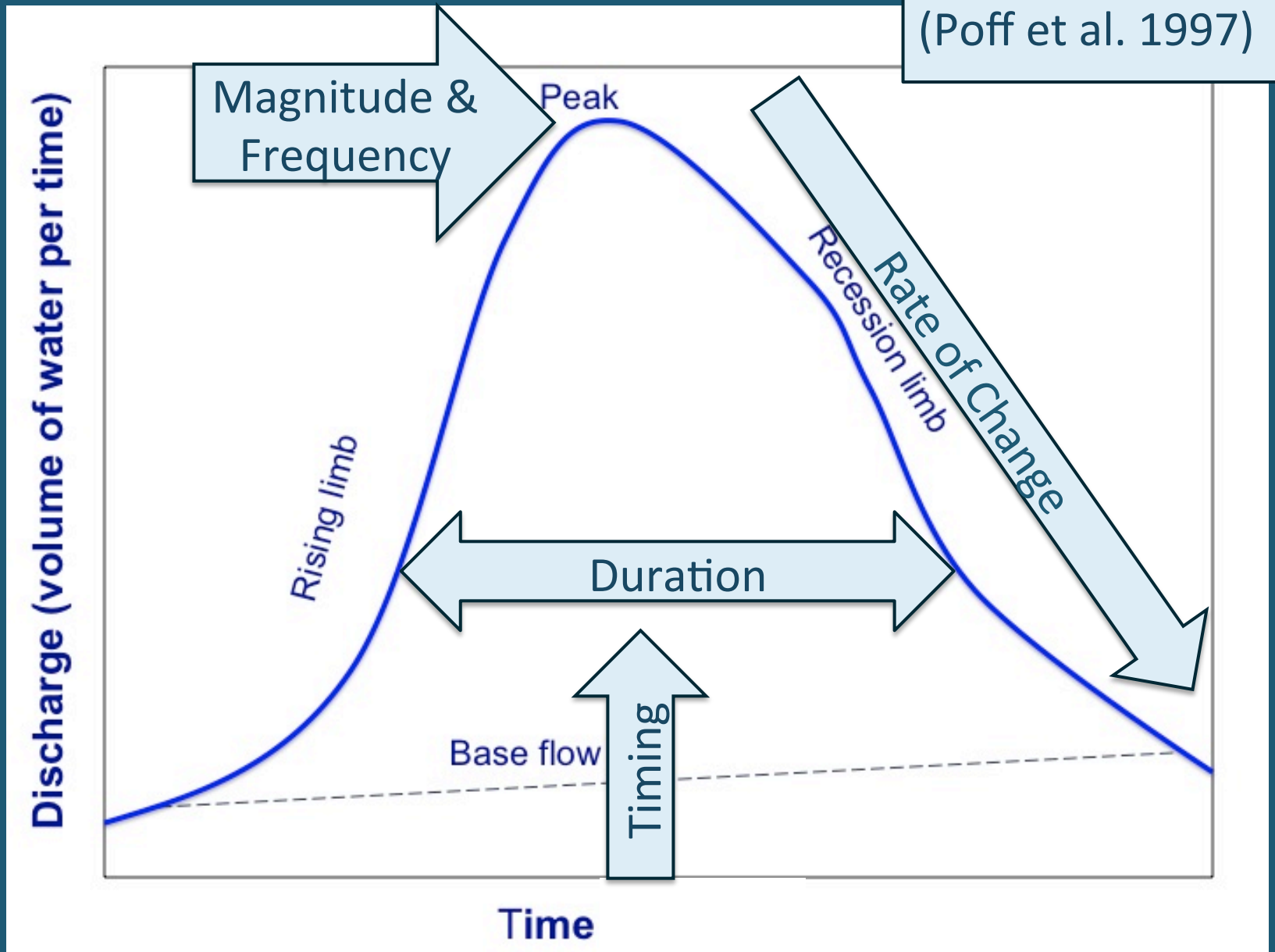
Humin is the fraction of organic matter in soil that is not soluble in water



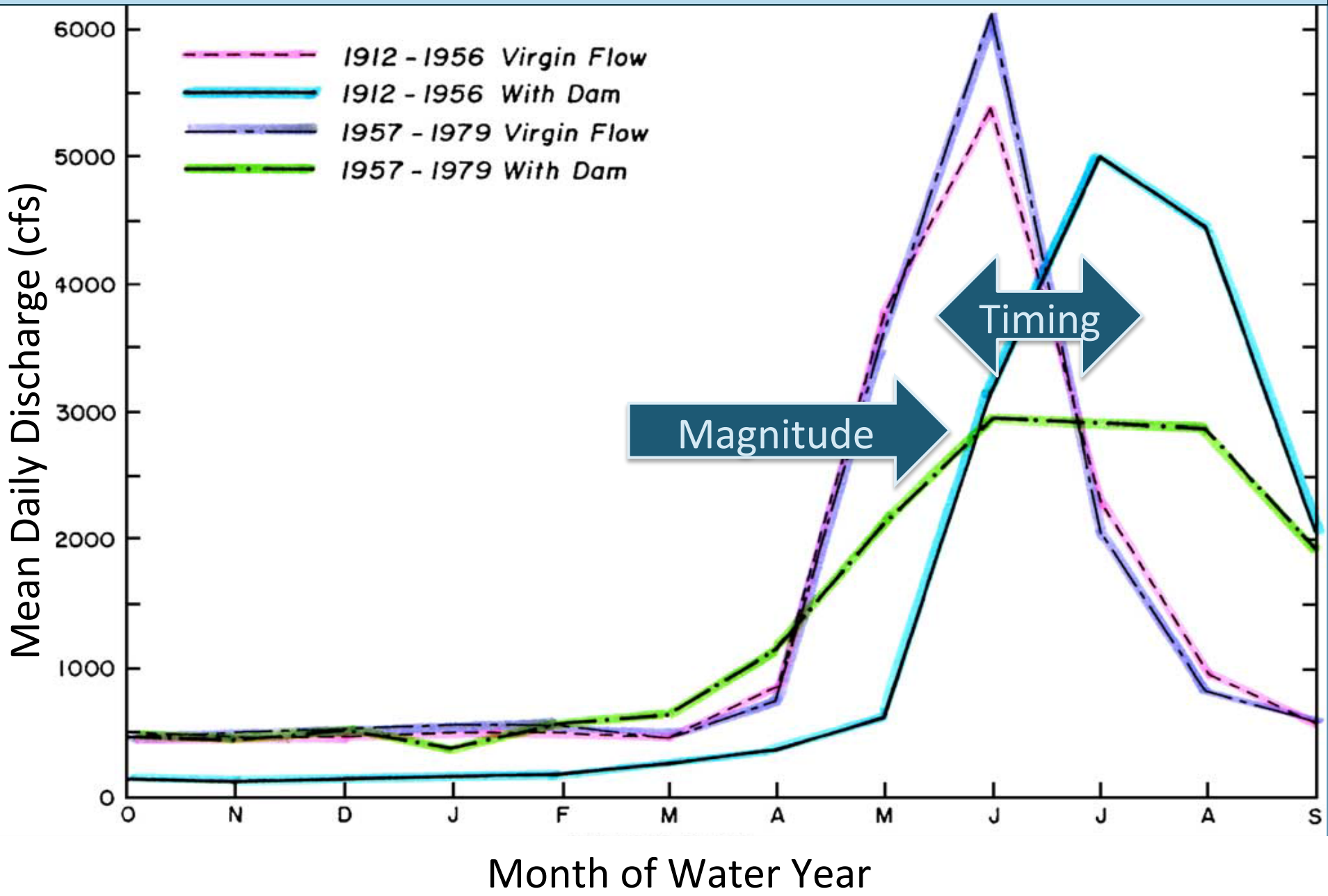
The Tetons and the Snake River, Ansel Adams

River flow and Hydrographs

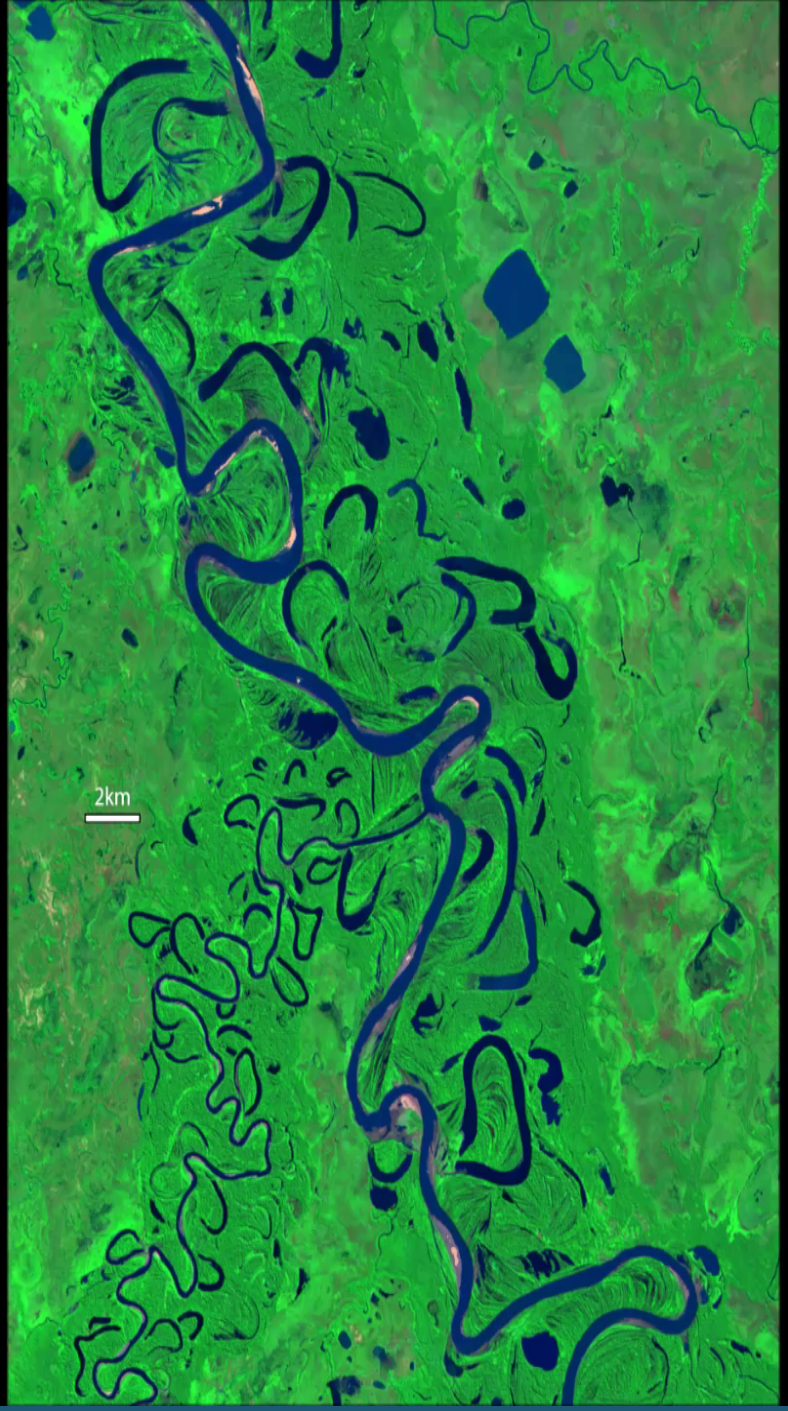
Natural flow regime (Poff et al. 1997)



Snake River altered hydrograph (Marston et al., 2005)

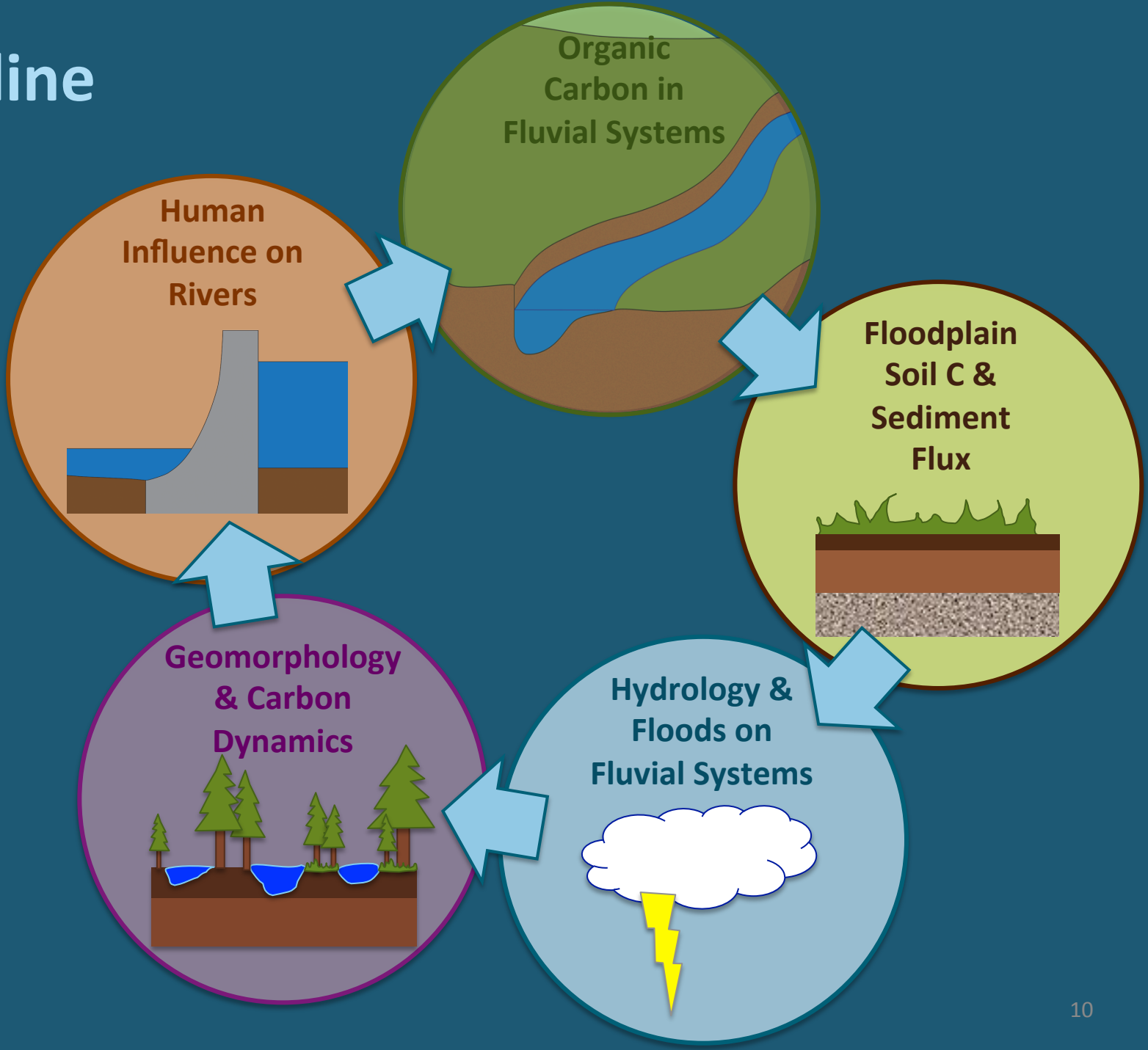


Mamore River, Bolivia 1984 to 2015



Courtesy of Alex Bryk, UC Berkeley. Compiled with Google Earth Engine

Outline


Organic Carbon in Fluvial Systems
Floodplain Soil C & Sediment Flux
Hydrology & Floods on Fluvial Systems
Geomorphology & Carbon Dynamics
Human Influence on Rivers

Carbon dynamics are important in rivers

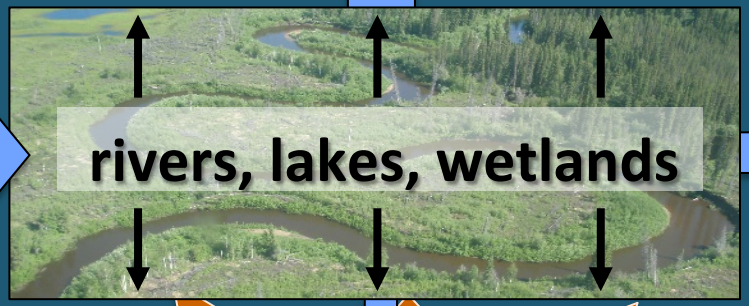
- Ecosystem processing (Vannote, 1980; Allan, 2001)
  - Foodwebs
  - Ecosystem services
- DOC and carcinogenic disinfectant byproducts (Coffin et al., 2000)
- Global carbon cycle
  - Carbon stocks
- Impacted by land use and land-cover changes
- Climate change and hydrologic regime

2015 Flood on the Blanco River

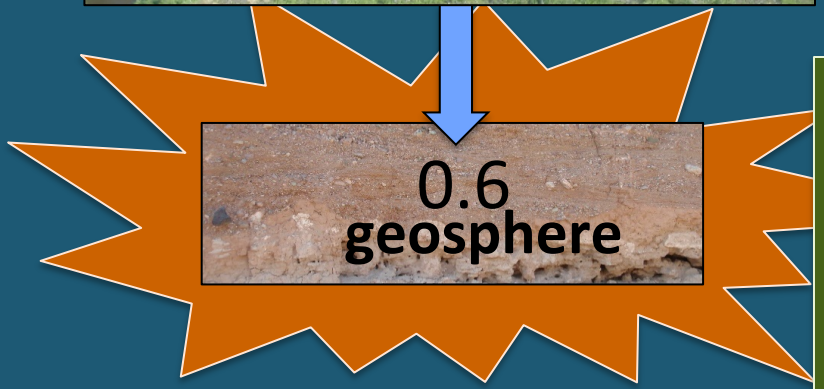
Photo: Stephen Ramirez http://www.ibtimes.com/texas-oklahoma-floods-2015-flooded-properties-central-texas-were-knowingly-built-1943070

Rivers and streams as carbon sink

(Battin et al., 2009; Aufdenkampe et al., 2011, Cole et al., 2011)

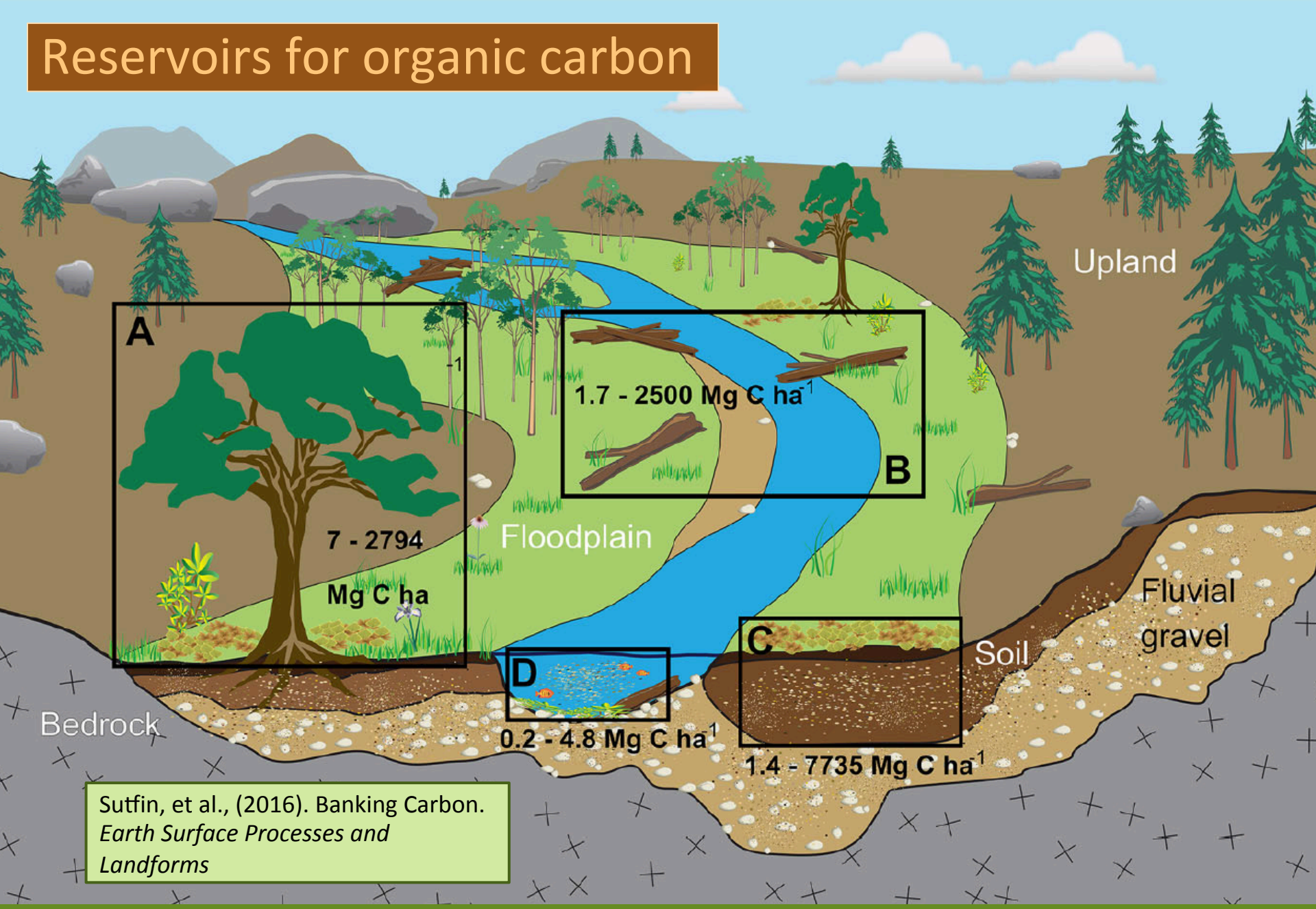


Units in Pg C /yr
(Aufdenkampe et al., 2011)



Floodplains store more C than adjacent uplands (Sutfin et al., 2016)

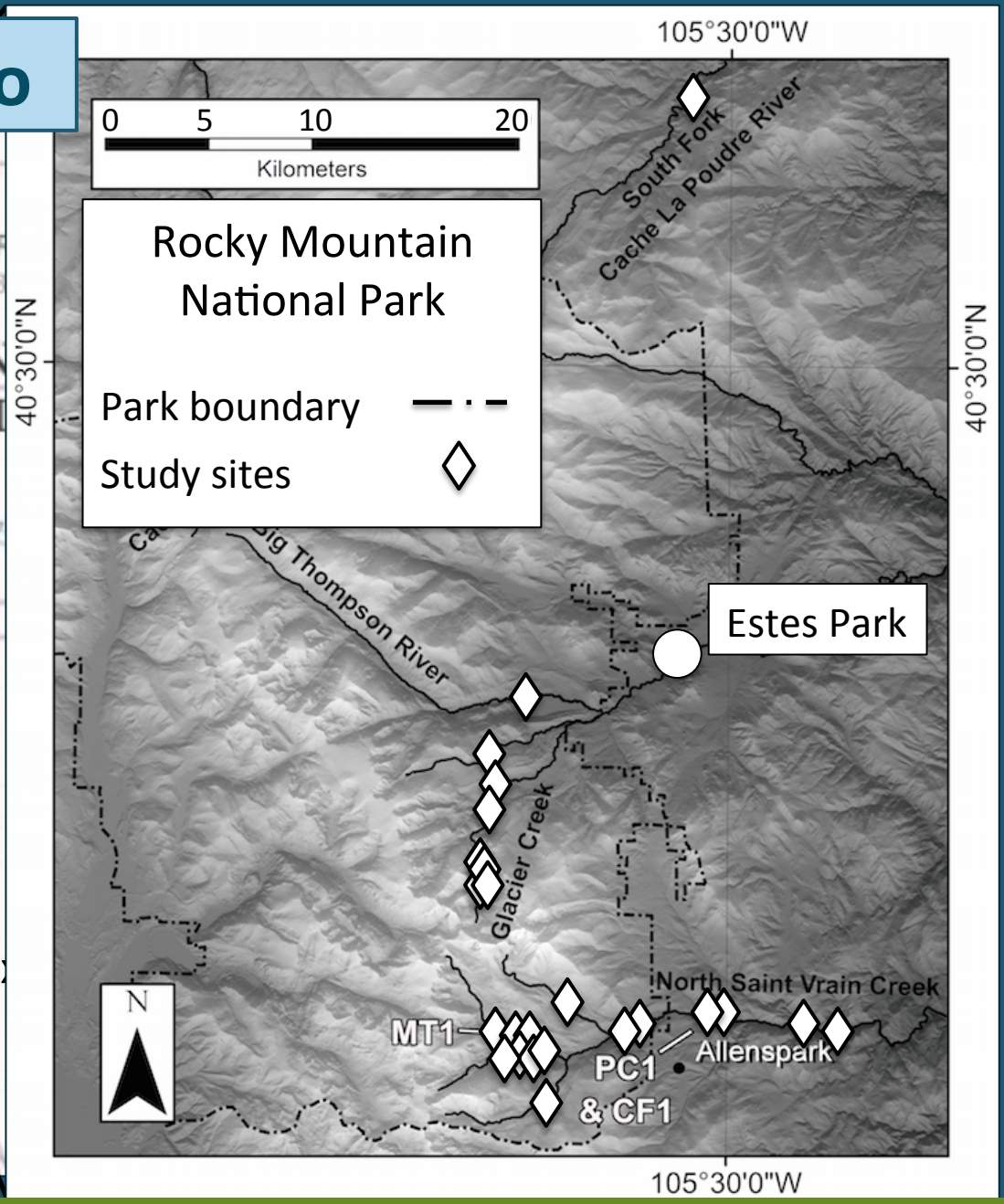
Reservoirs for organic carbon



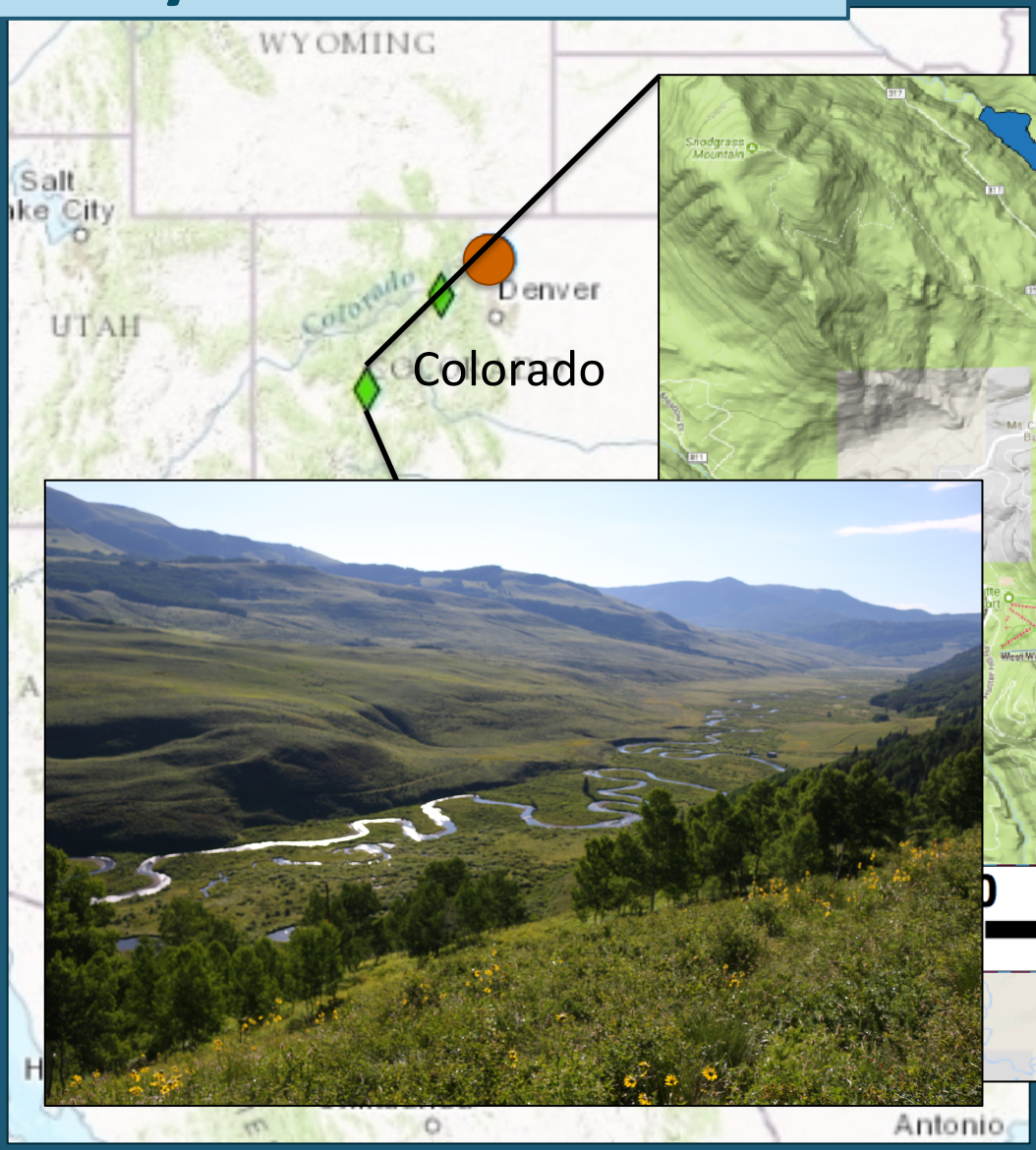
Sutfin, et al., (2016). Banking Carbon. *Earth Surface Processes and Landforms*

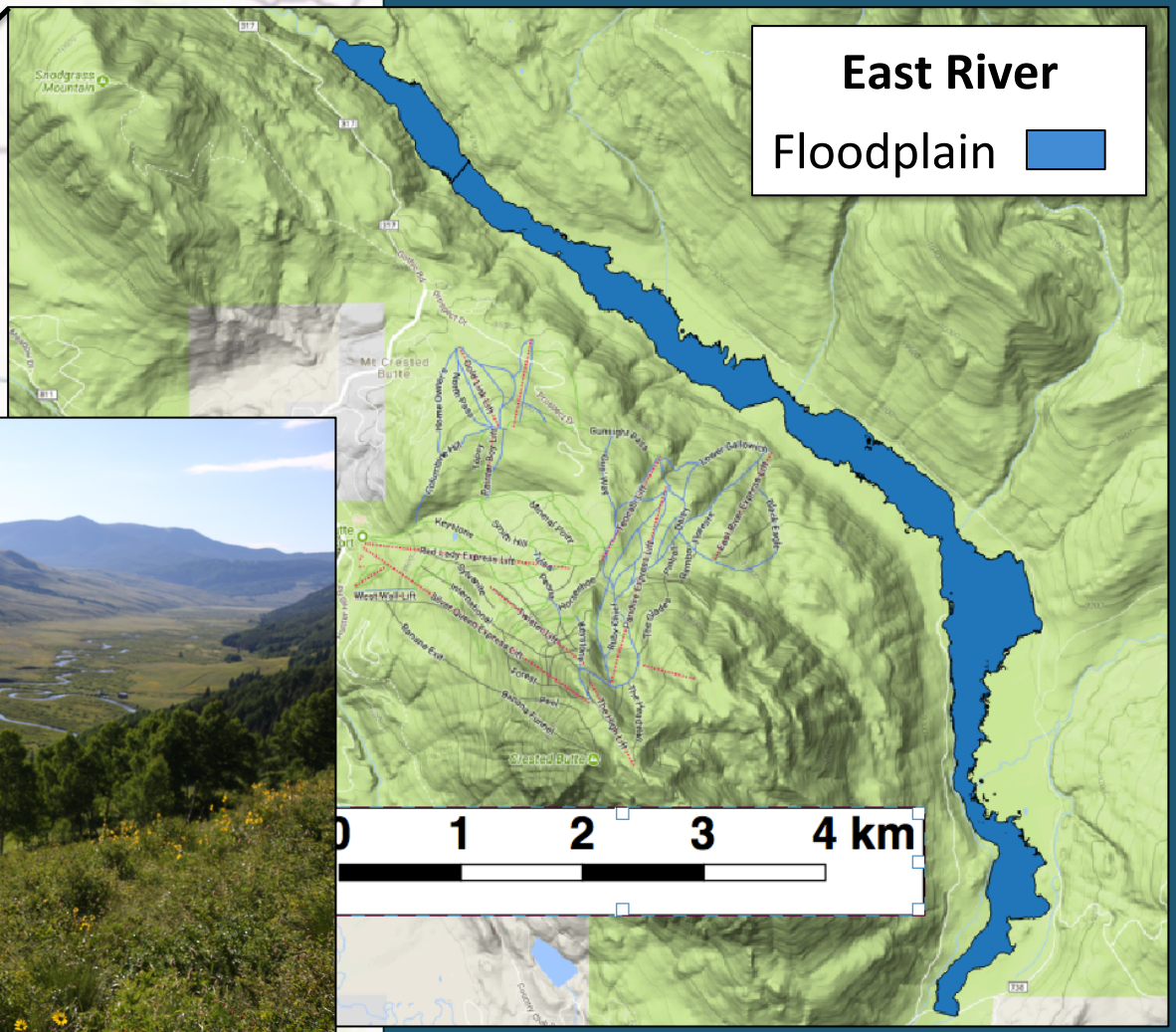
Study Sites in Colorado

Study Sites in Colorado

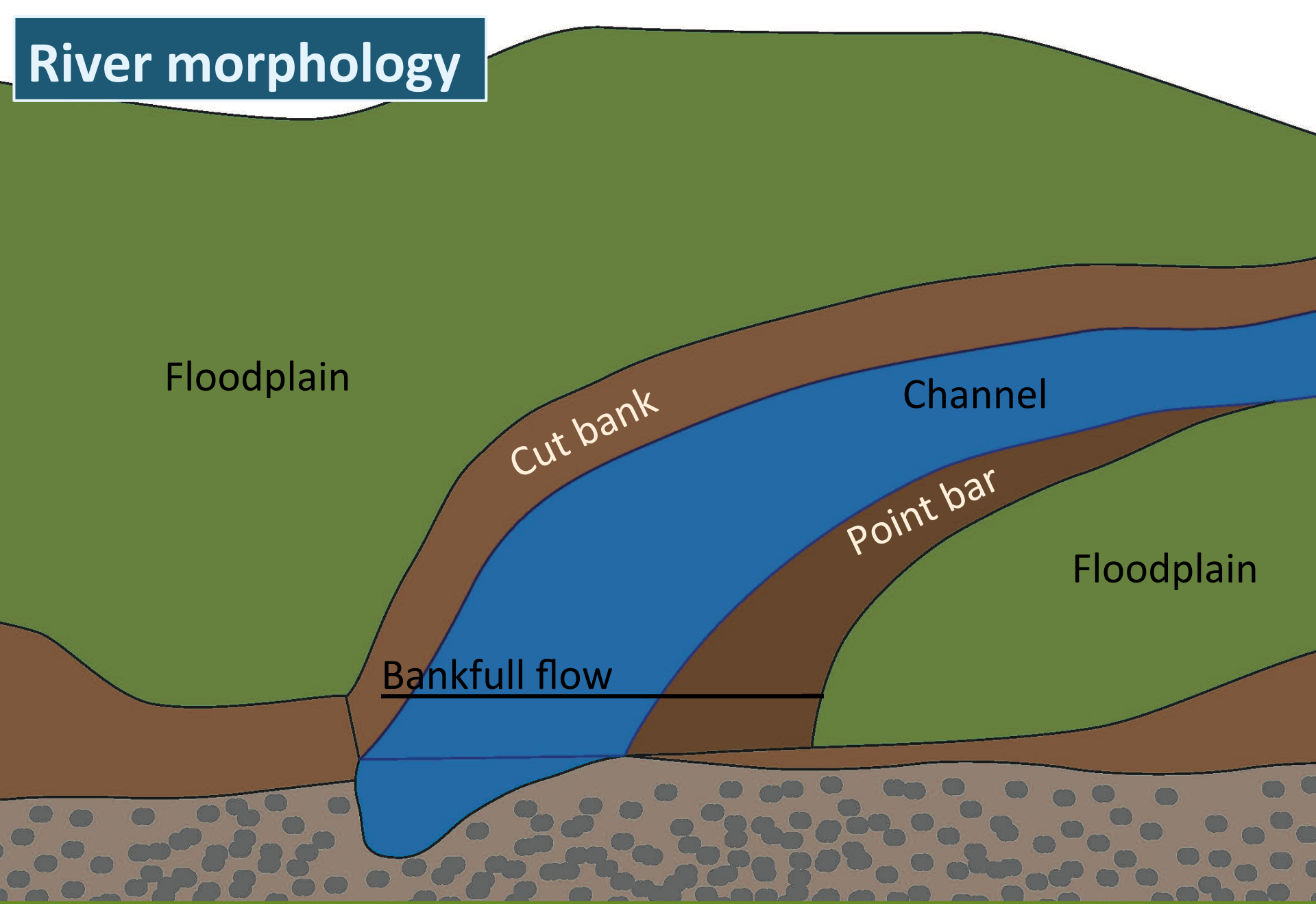


Study Sites in Colorado





River morphology

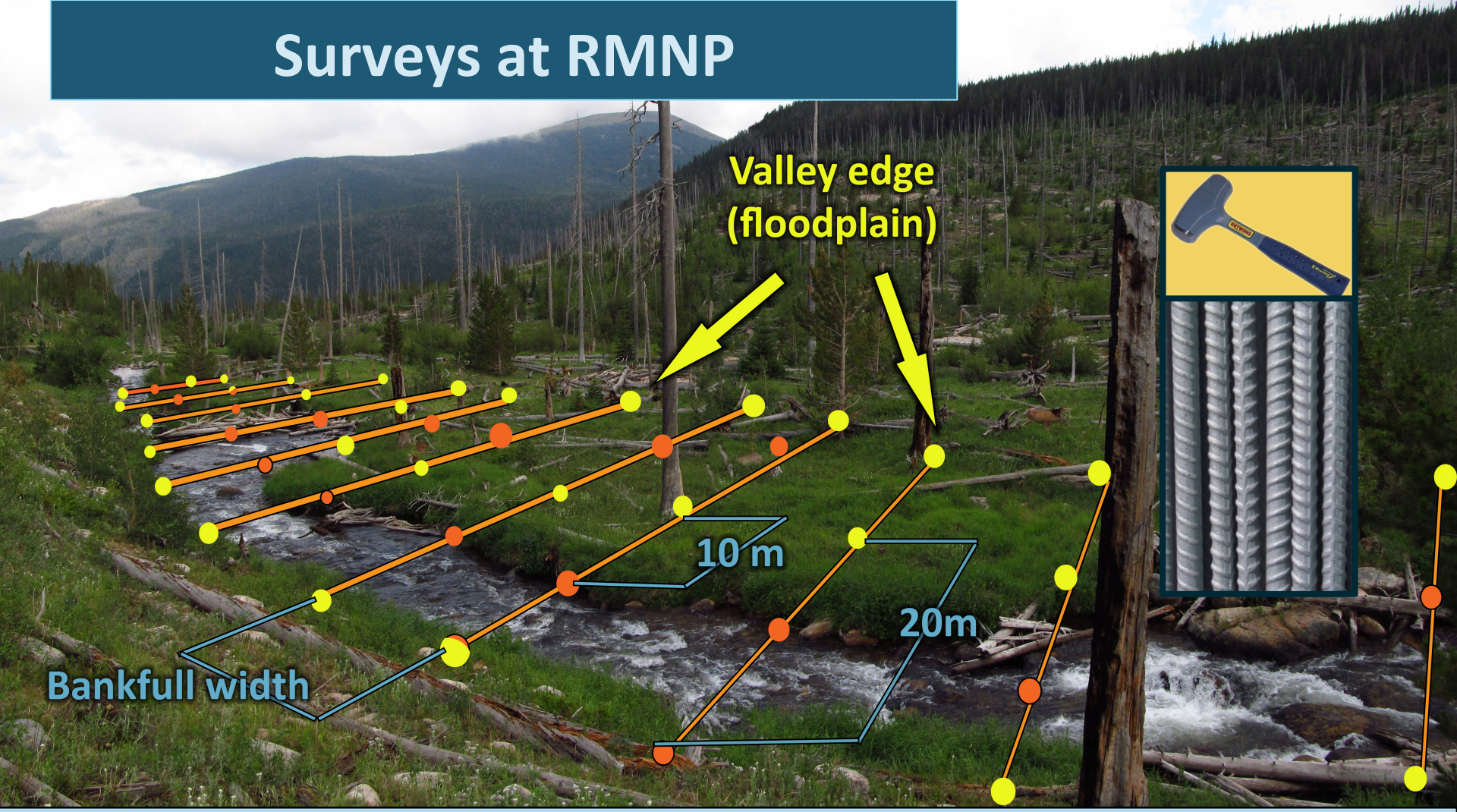


Soil sample collection

660 Soil Samples in RMNP

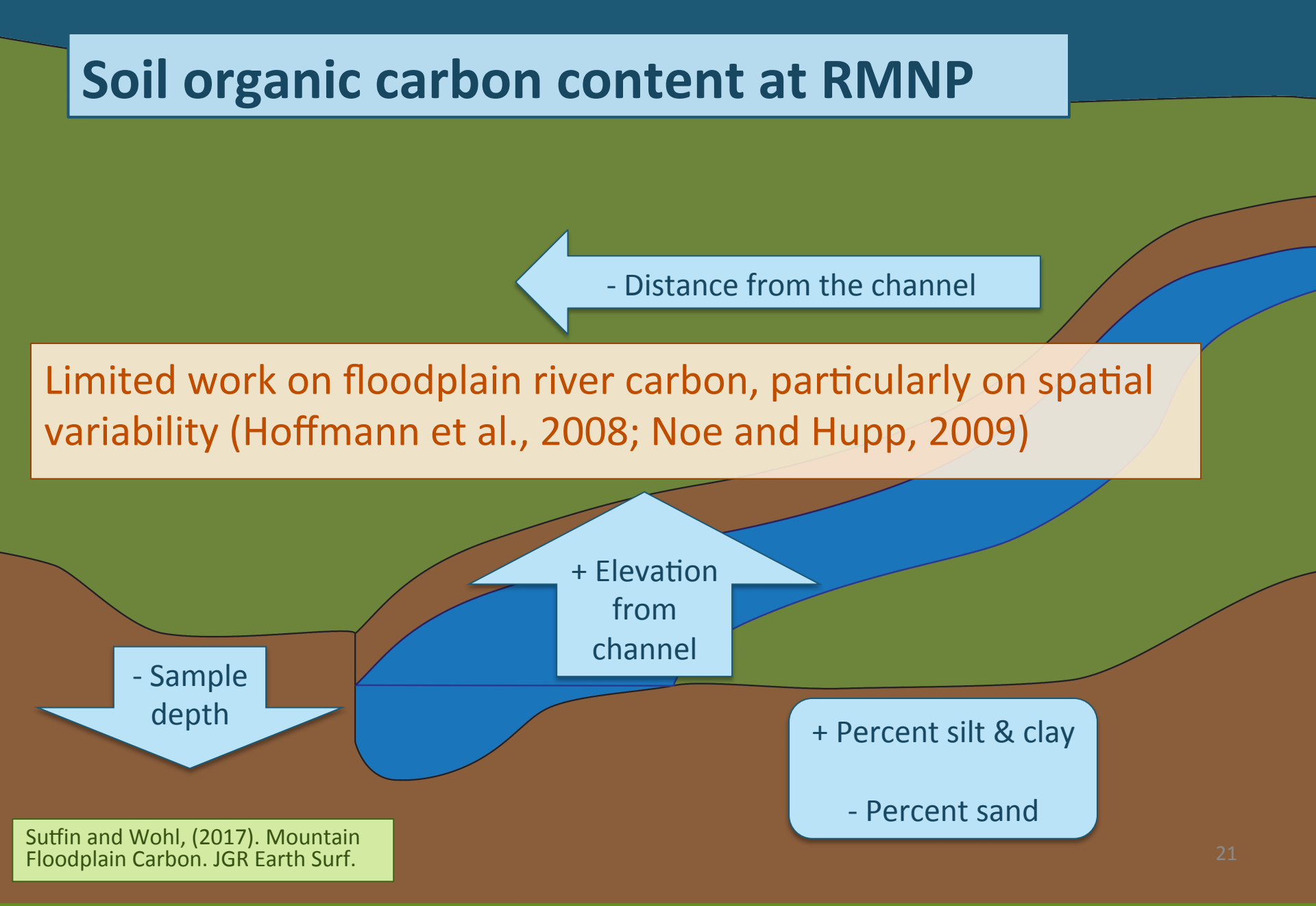
- Systematic random sampling along transect
- 15-cm depth increments (<180 cm)
- LECO TruSpec CN elemental analyzer

Surveys at RMNP



- 11 transects ~ 1 bankfull-width apart
- Topographic surveys at floodplain features <10 m apart
- Depth of sediment using rebar until refusal at survey points

Soil organic carbon content at RMNP



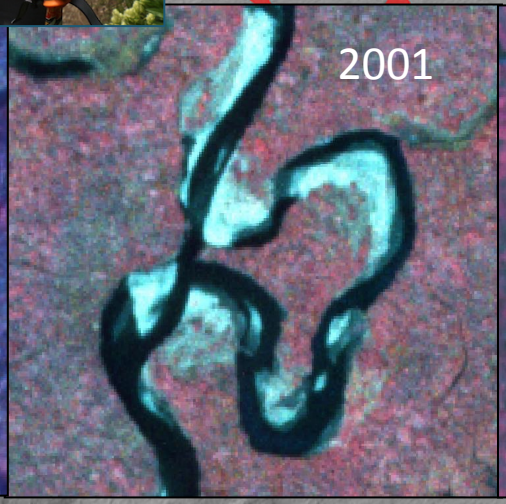
Sutfin and Wohl, (2017). Mountain Floodplain Carbon. JGR Earth Surf.

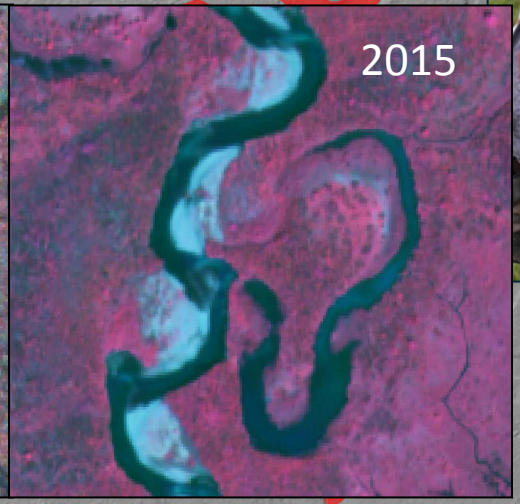
Abandoned channels and Cutoffs

Meghan King

Empirical model for cutoff occurrence

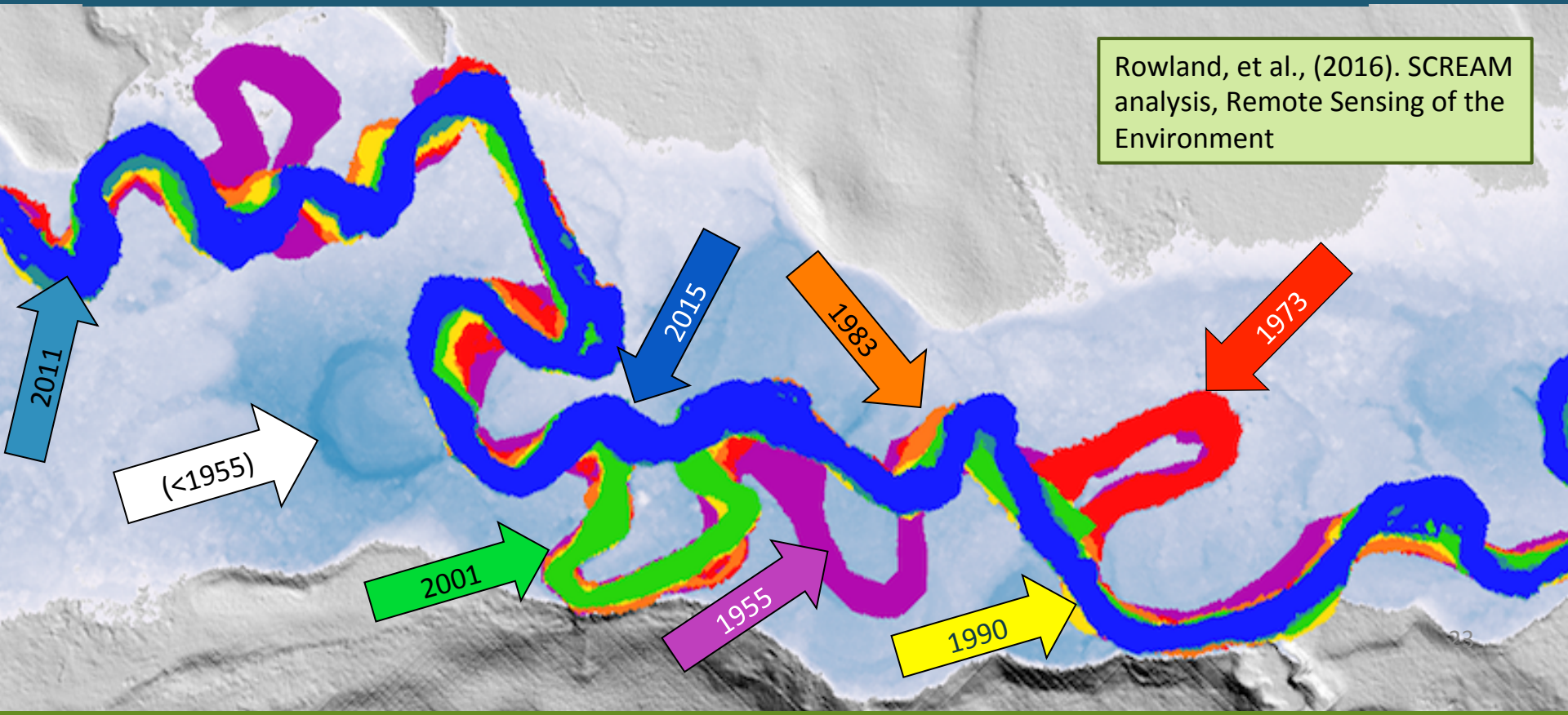
Sophie Stauffe





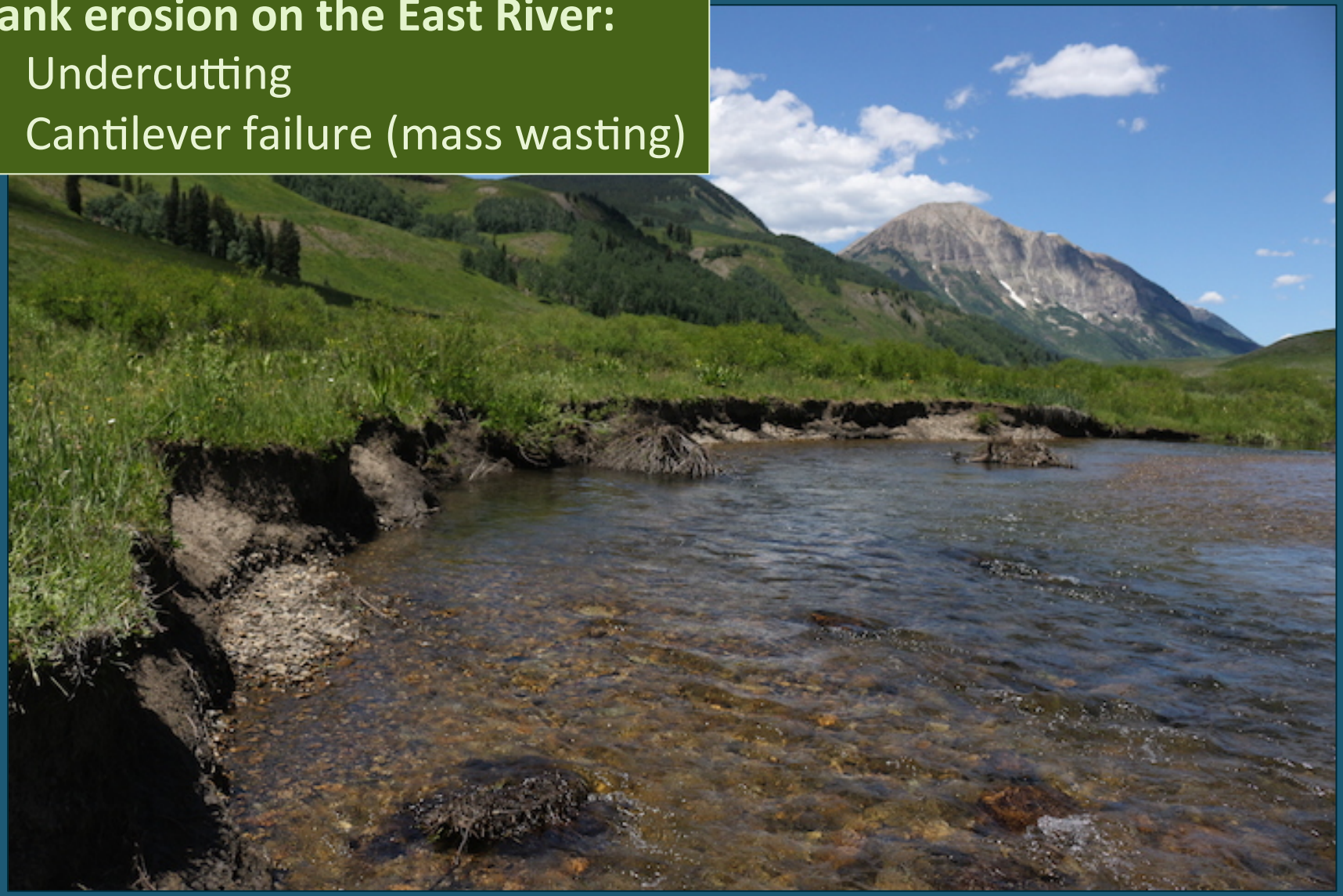
East River channel migration and erosion

- 60 years of remotely sensed imagery
- 0.5-m resolution aerial lidar
- Calculate lateral erosion and sedimentation
- Characterize hydrograph



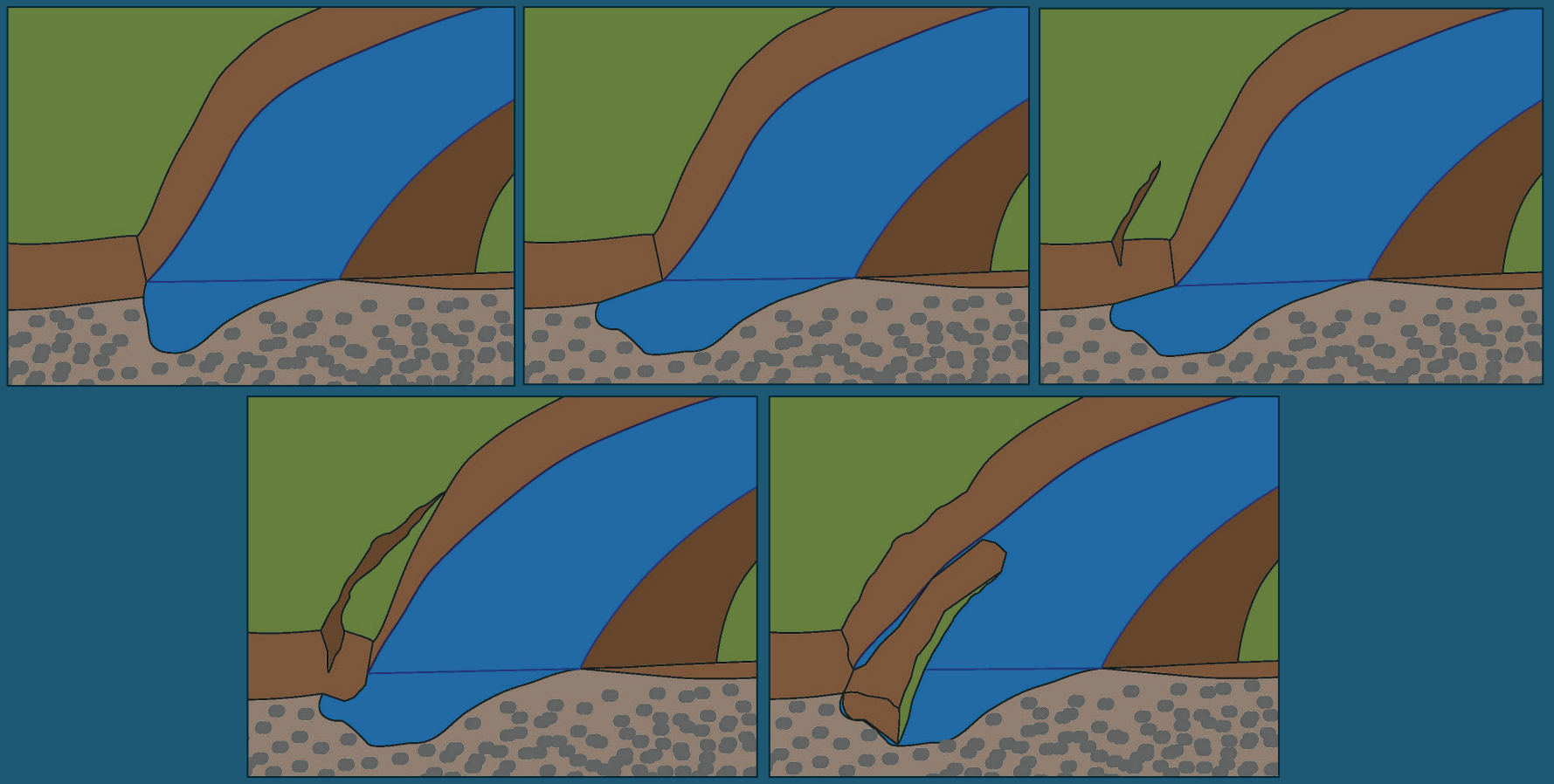
Bank erosion on the East River:

- Undercutting
- Cantilever failure (mass wasting)

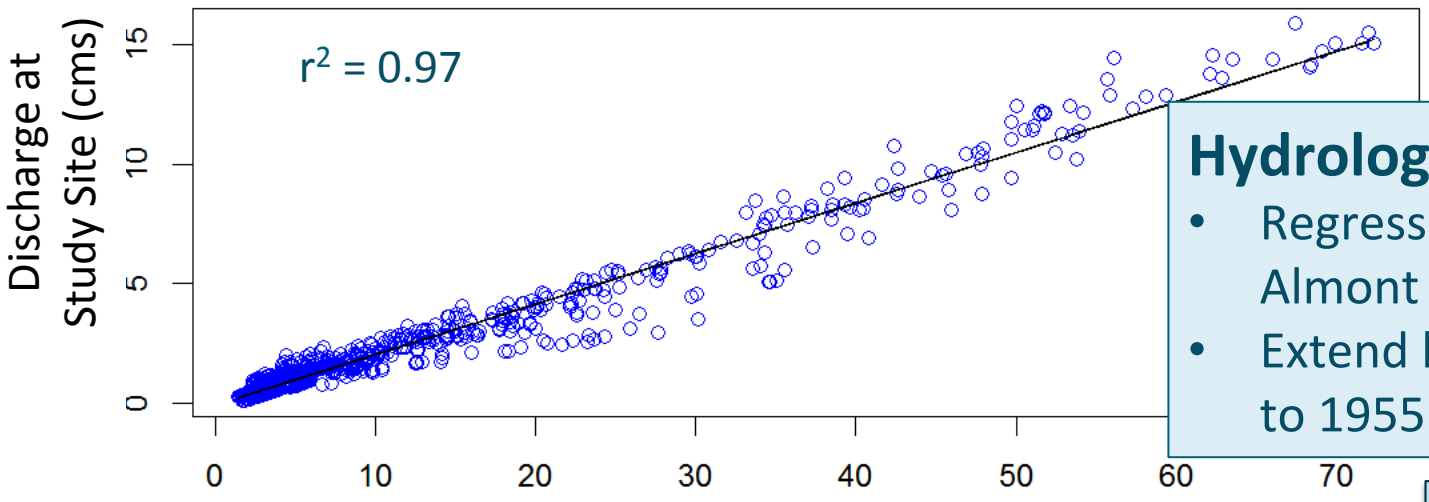


Bank erosion on the East River:

- Undercutting
- Cantilever failure (mass wasting)

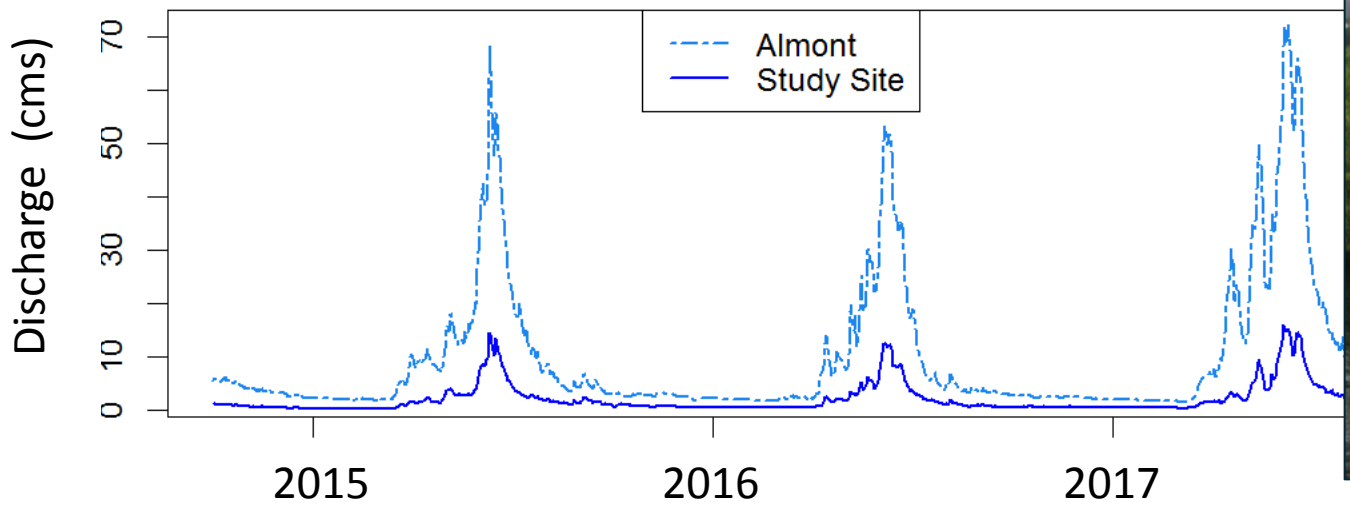


Linking hydrology to floodplain sediment flux



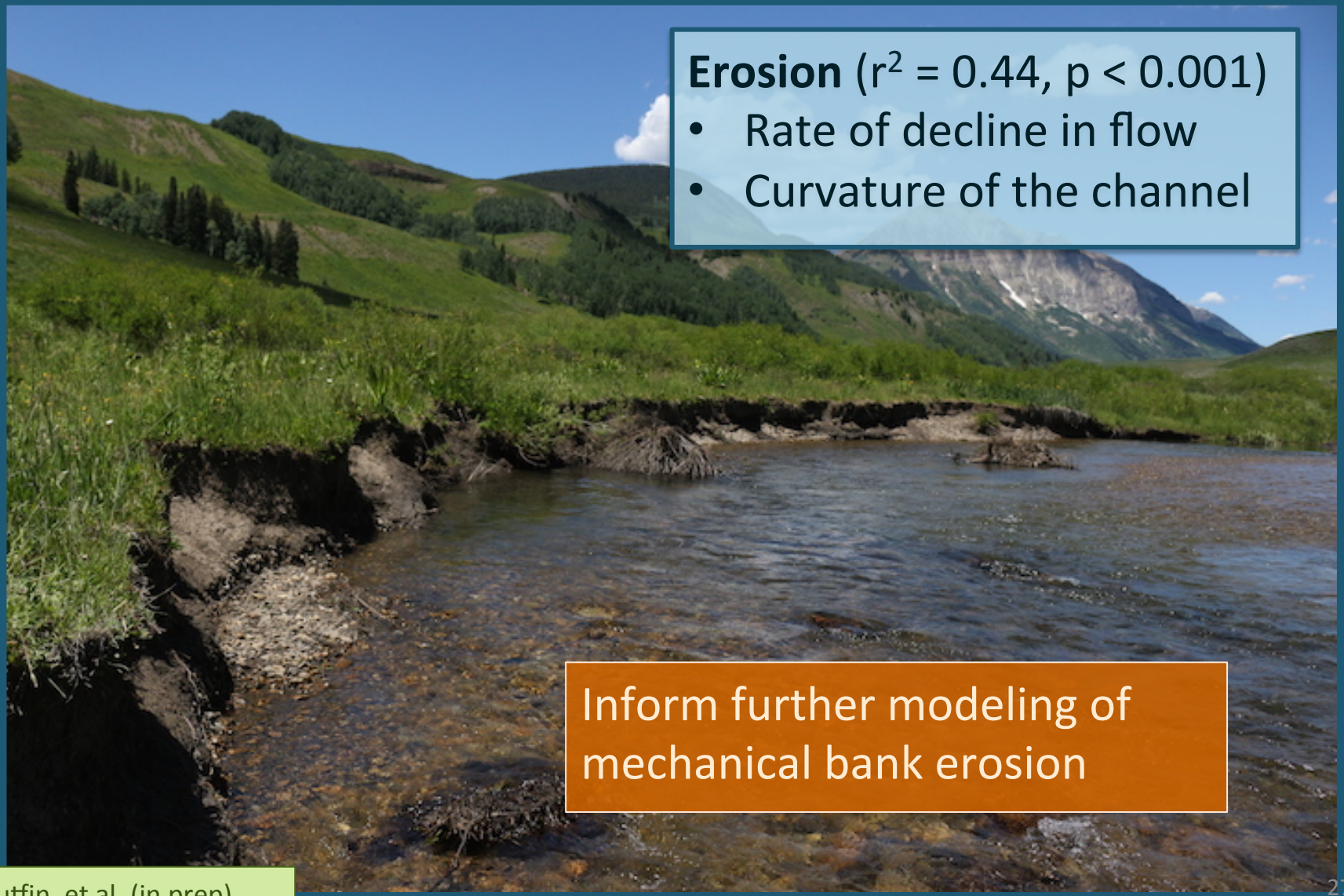
Hydrologic analysis

- Regression with USGS Almont gauge (r^2 = 0.97)
- Extend hydrograph back to 1955



Mulu Fratkin

Linking hydrology to floodplain sediment flux



Erosion ($r^2 = 0.44$, $p < 0.001$)

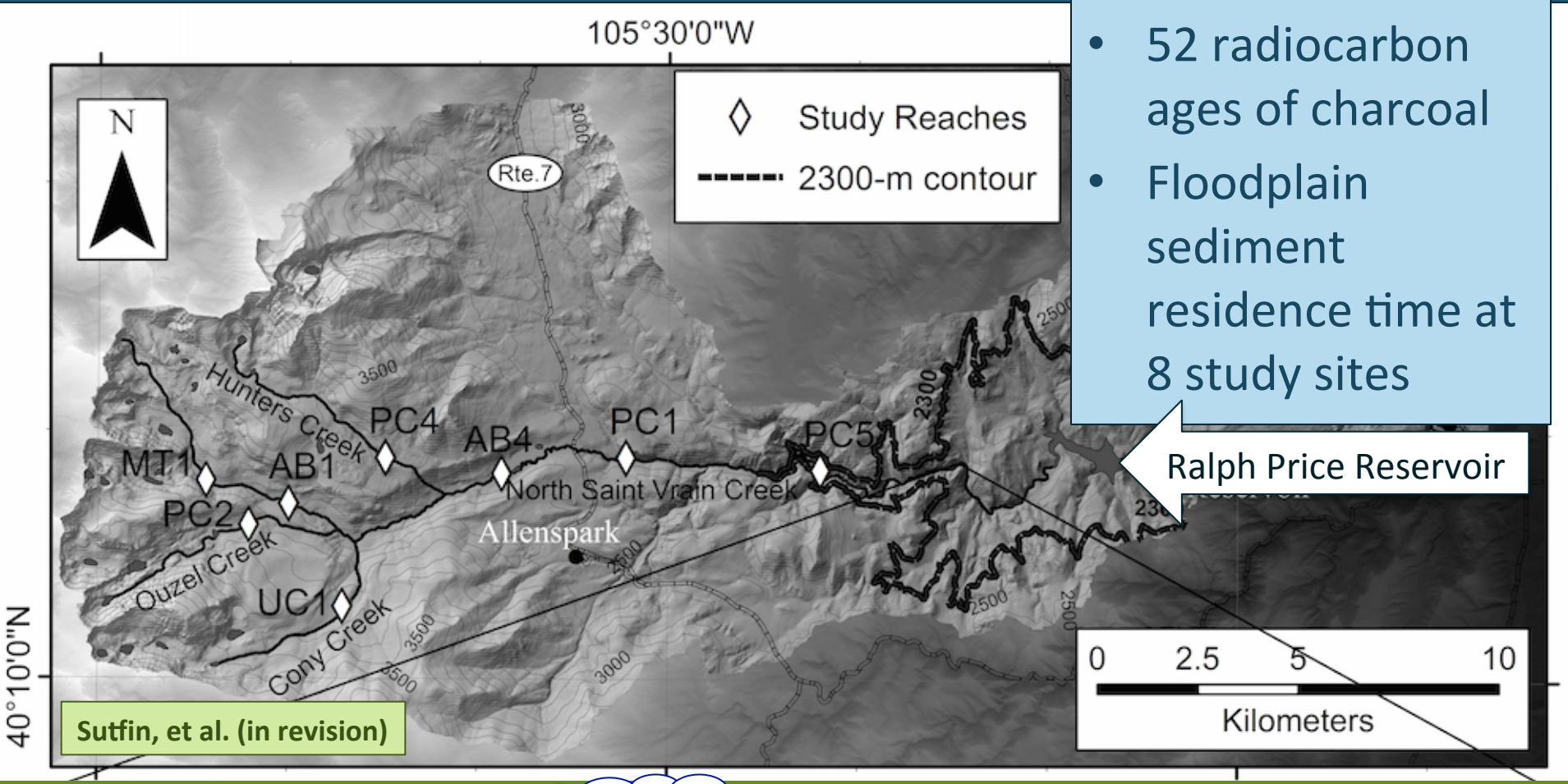
- Rate of decline in flow
- Curvature of the channel

Inform further modeling of mechanical bank erosion

Sutfin, et al. (in prep)

Impact of Extreme Floods on Floodplain Sediment

Rocky Mountain National Park
North St. Vrain Creek watershed

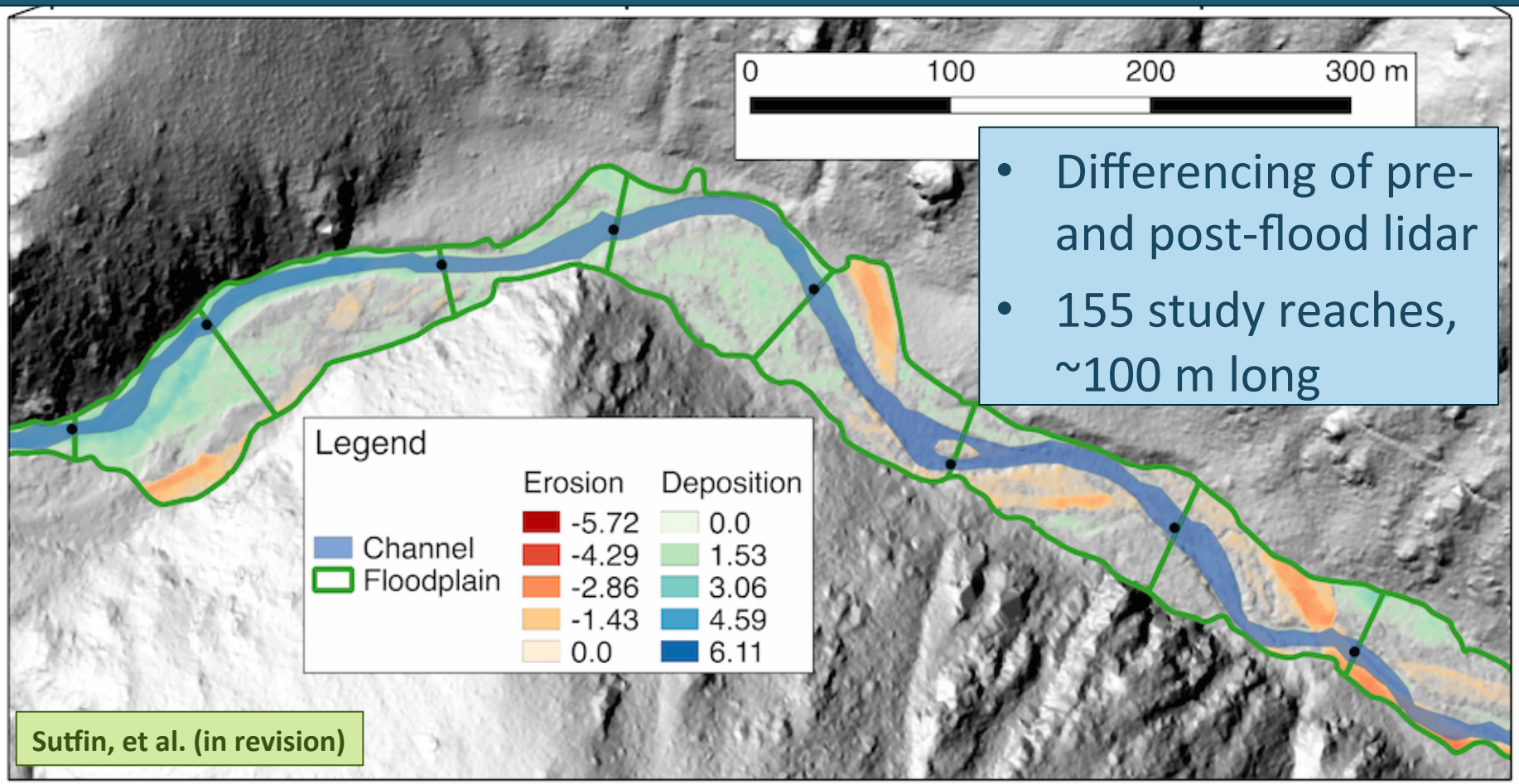


2013 CO floods

- 52 radiocarbon ages of charcoal
- Floodplain sediment residence time at 8 study sites

Impact of Extreme Floods on Floodplain Sediment

Rocky Mountain National Park
North St. Vrain Creek watershed



- Differencing of pre- and post-flood lidar
- 155 study reaches, ~100 m long

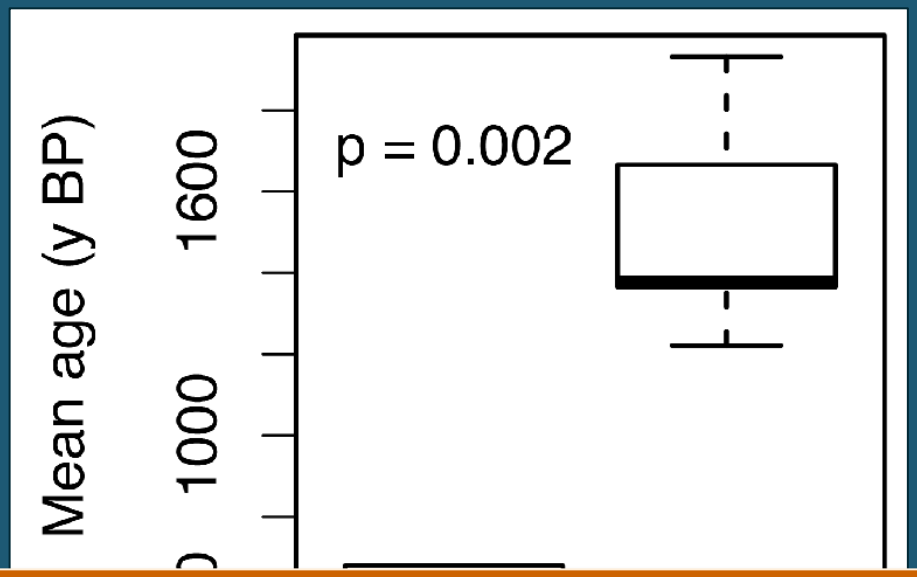
Impact of Extreme Floods on Floodplain Sediment

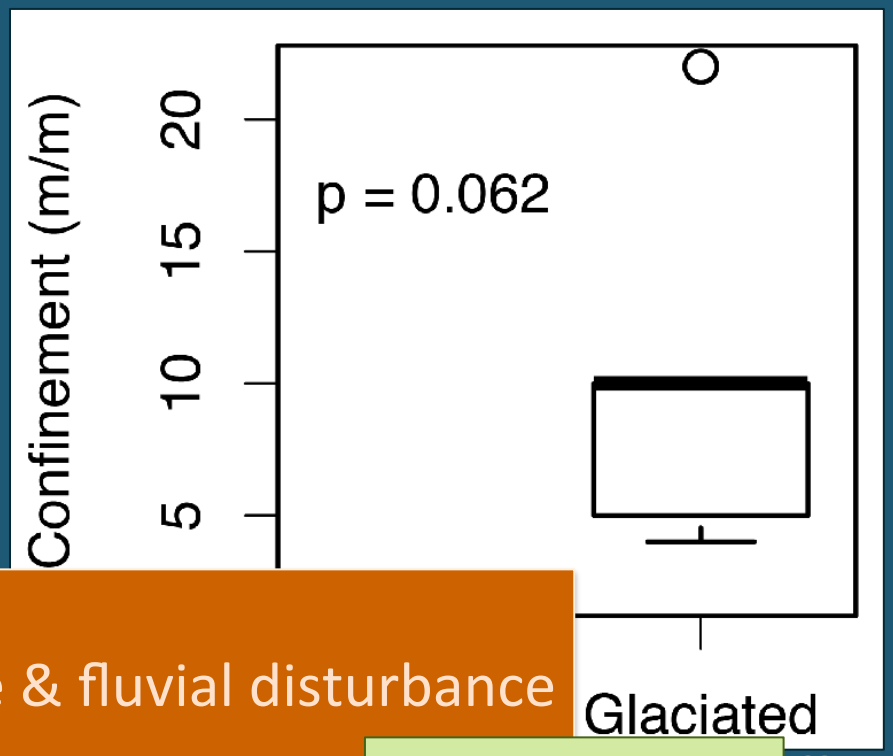
Mean Age (r^2 = 0.96, $p < 0.001$):

- Elevation
- Stream power (function of flow depth and channel slope)

Sediment Transport (adjusted $r^2 = 0.52$, $p < 0.001$)

- Geometry of valley
- Slope of the river





Glaciated sites at high elevation

- Experience less frequent hillslope & fluvial disturbance
- Store sediment for longer

Sutfin, et al. (in revision)

Channel Geometry: RMNP

Beaver meadow

Unconfined multithread

Beavers dams and multithread channels

(Ives, 1942; Butler & Malanson, 2005)

100 ft

North Saint Vrain Creek

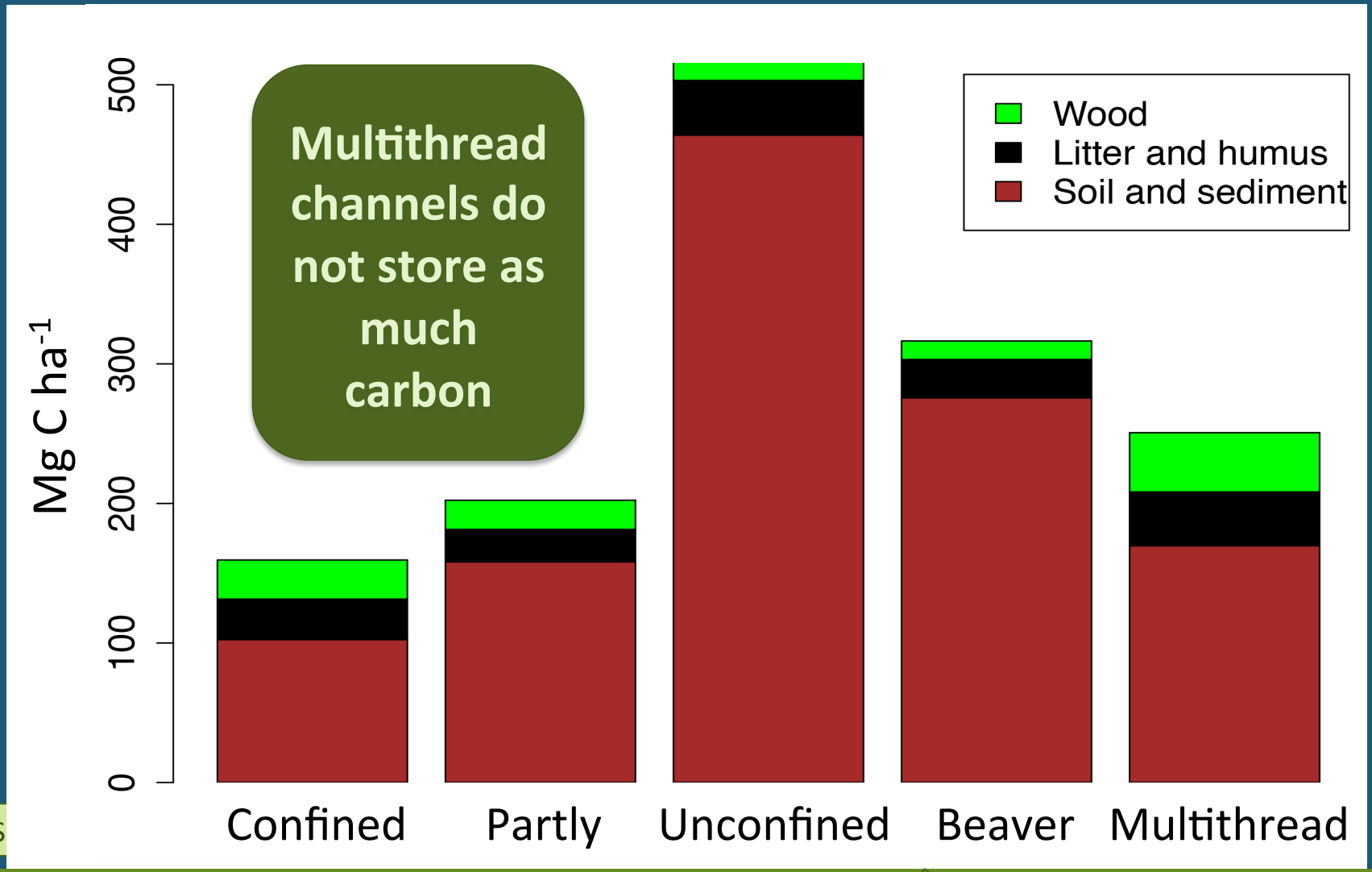
Multithread channels

- ~25% river network
- ~75% of TOC stored within riparian areas

Wohl, 2012. Nat. Commun.

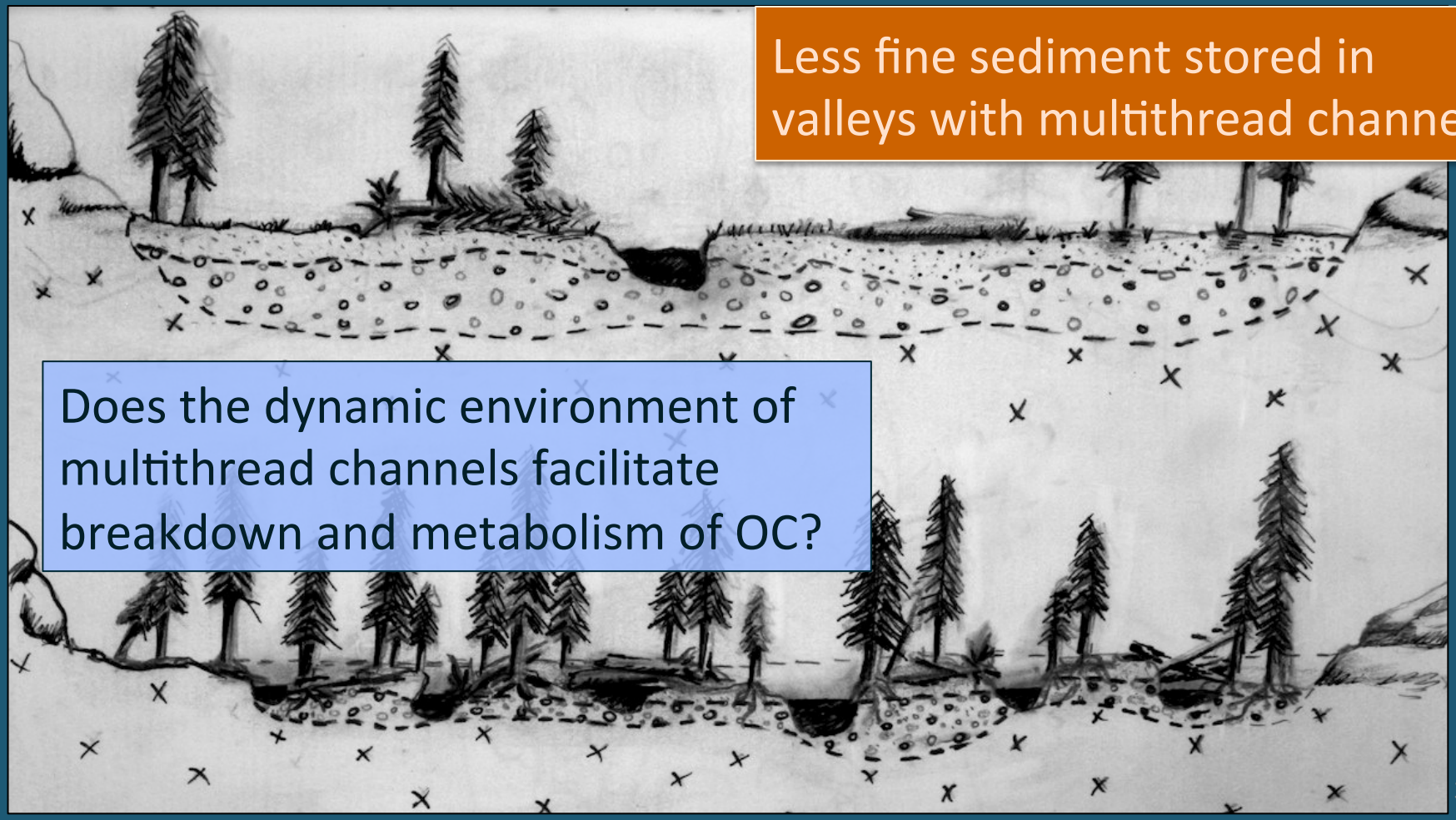
Geomorphology and carbon in N. St. Vrain Creek

660 soil samples at 24 study sites



Geomorphology and carbon in N. St. Vrain Creek

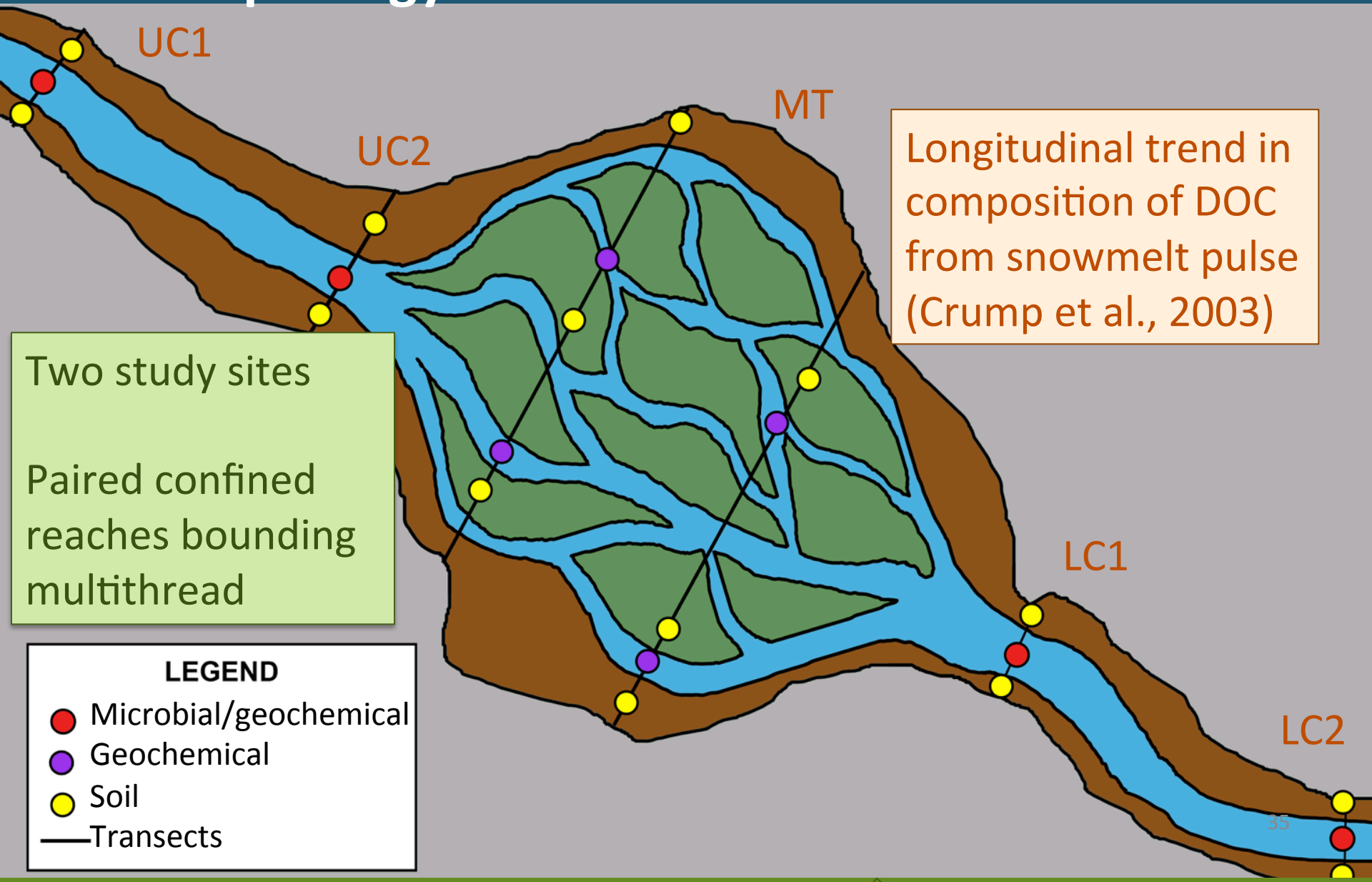
Why is there less carbon in multithread systems?



Less fine sediment stored in valleys with multithread channel

Does the dynamic environment of multithread channels facilitate breakdown and metabolism of OC?

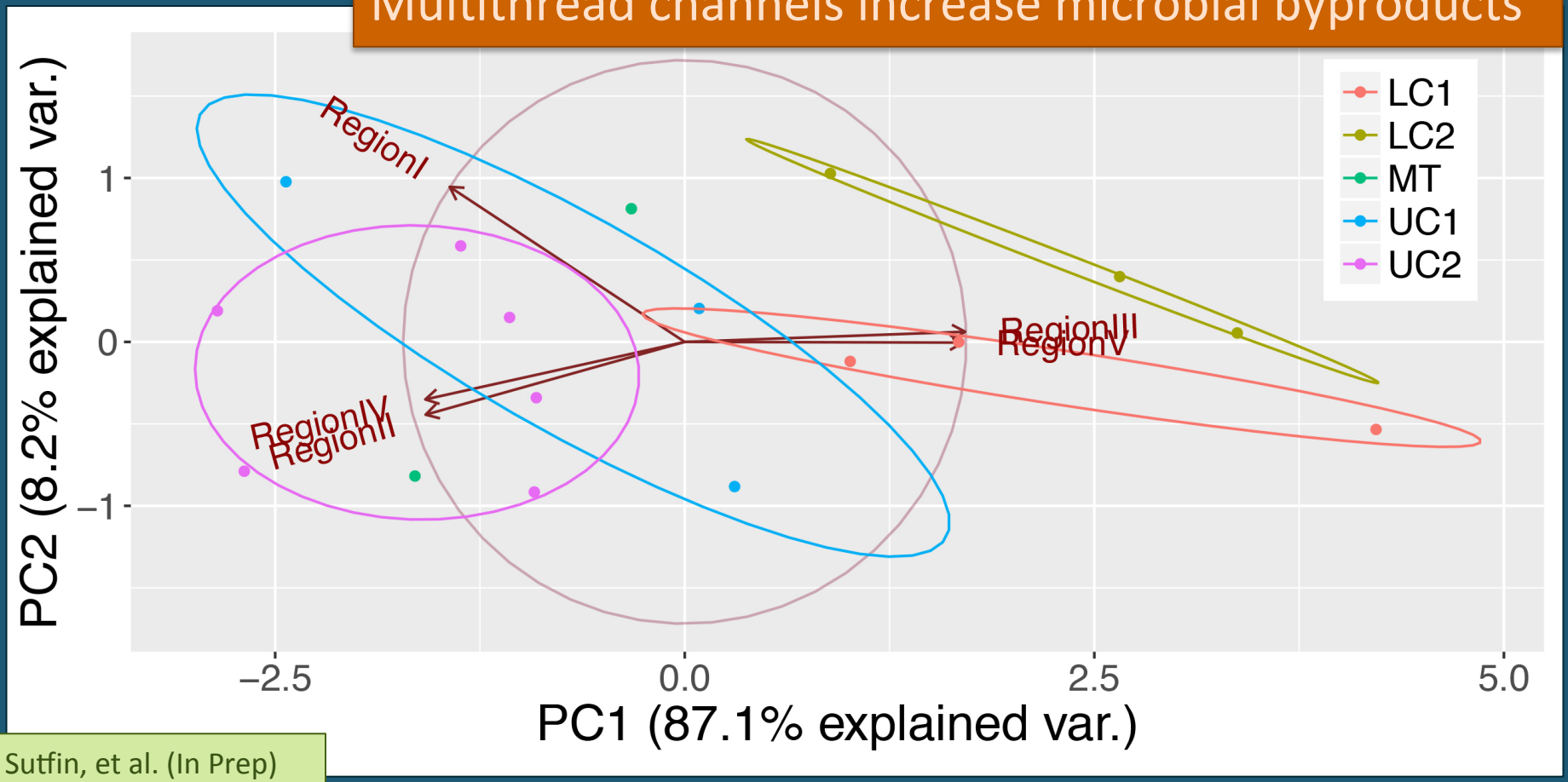
Geomorphology and carbon in N. St. Vrain Creek



Geomorphology and carbon in N. St. Vrain Creek

PCA of Excitation Emissions Matrix Spectroscopy indices

Multithread channels increase microbial byproducts



Sutfin, et al. (In Prep)

Geomorphology and carbon along the East River

Carbon content across the floodplain

- Varies weakly by distance from channel

Characterize carbon decomposition

Soil Samples: 0 - 5 cm, 5 - 15 cm, 15 – 30 cm

Soil water extractions

- H_2O
- MeOH
- $CHCl_3$ (for the humins)

FT-ICR mass spectrometry

Decomposition Ratio = Protein/Lignin or (microbes/terrestrial)

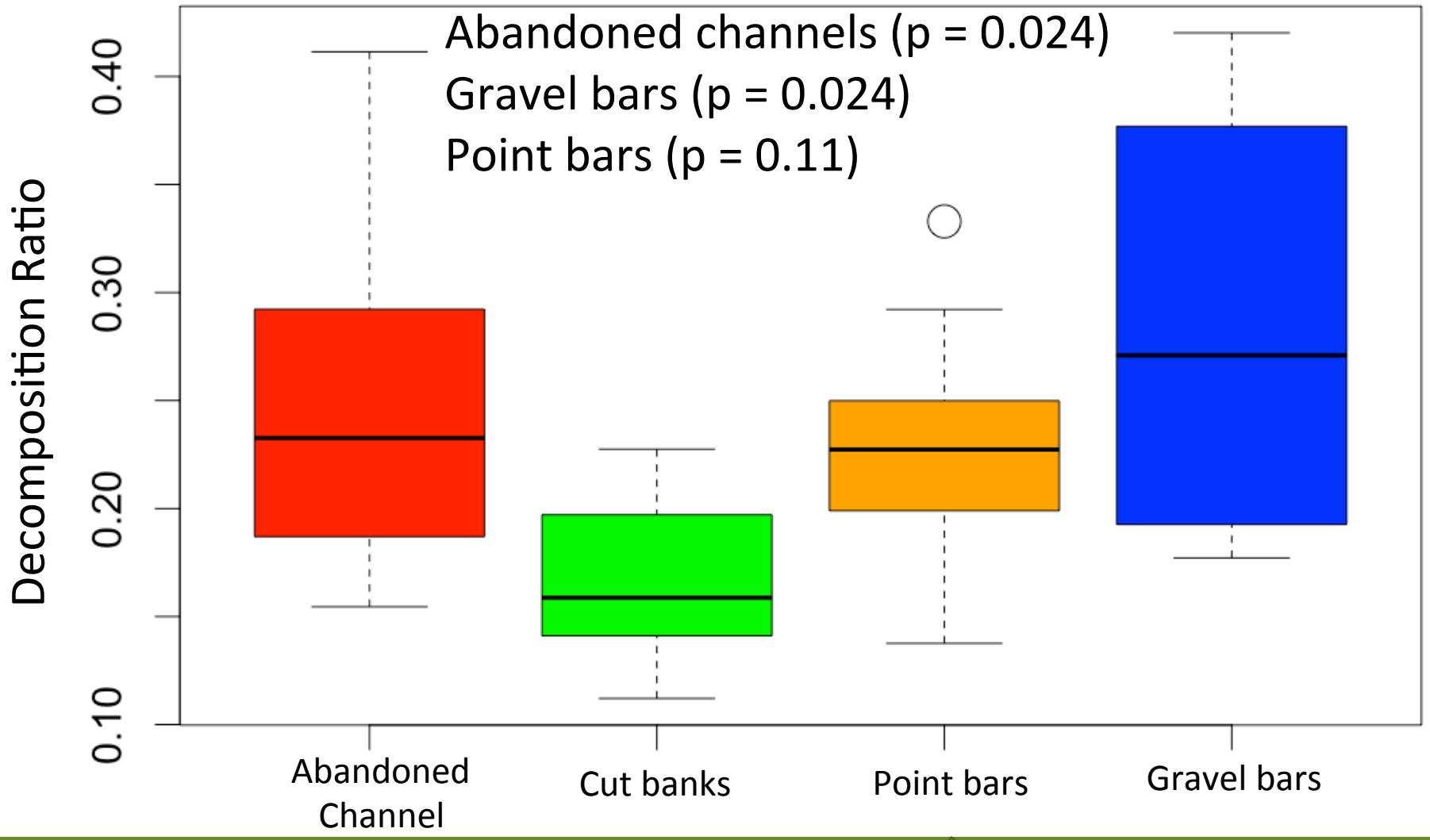
Geomorphology and carbon along the East River

Cut banks differ from:

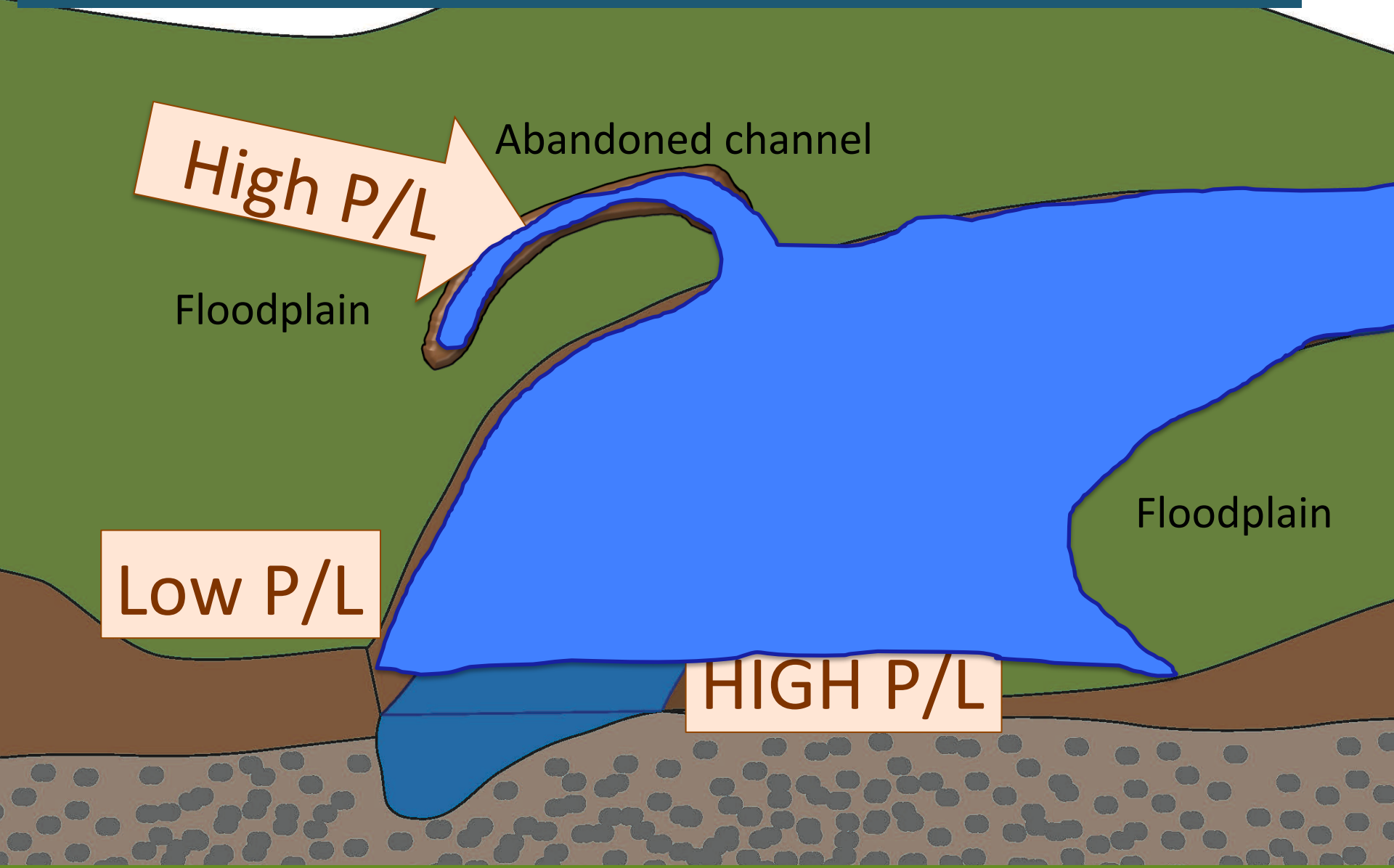
Abandoned channels (p = 0.024)

Gravel bars (p = 0.024)

Point bars (p = 0.11)



Geomorphology and carbon along the East River

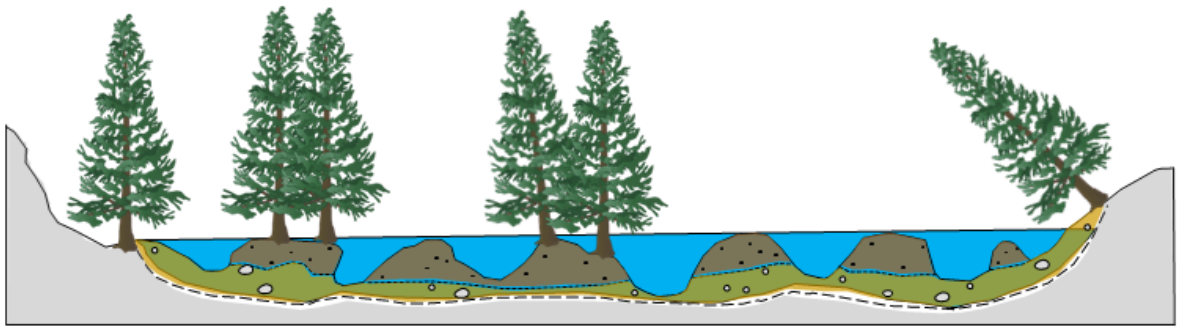


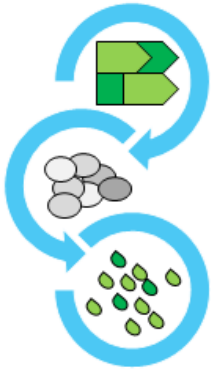
Geomorphology and carbon in N. St. Vrain Creek

Metabolite (GC-MS) in dissolved organic matter

Metabolic pathways for the decomposition of organic carbon vary seasonally in relation to hydrology

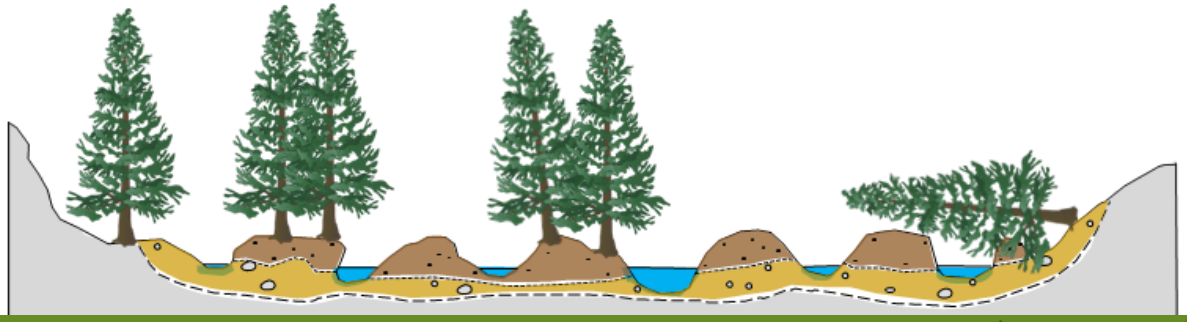
High flow conditions homogenize dissolved organic matter composition

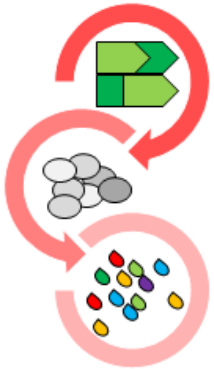




Lynch, Sutfin, et al. (In review)

Low flow conditions increase dissolved organic matter heterogeneity



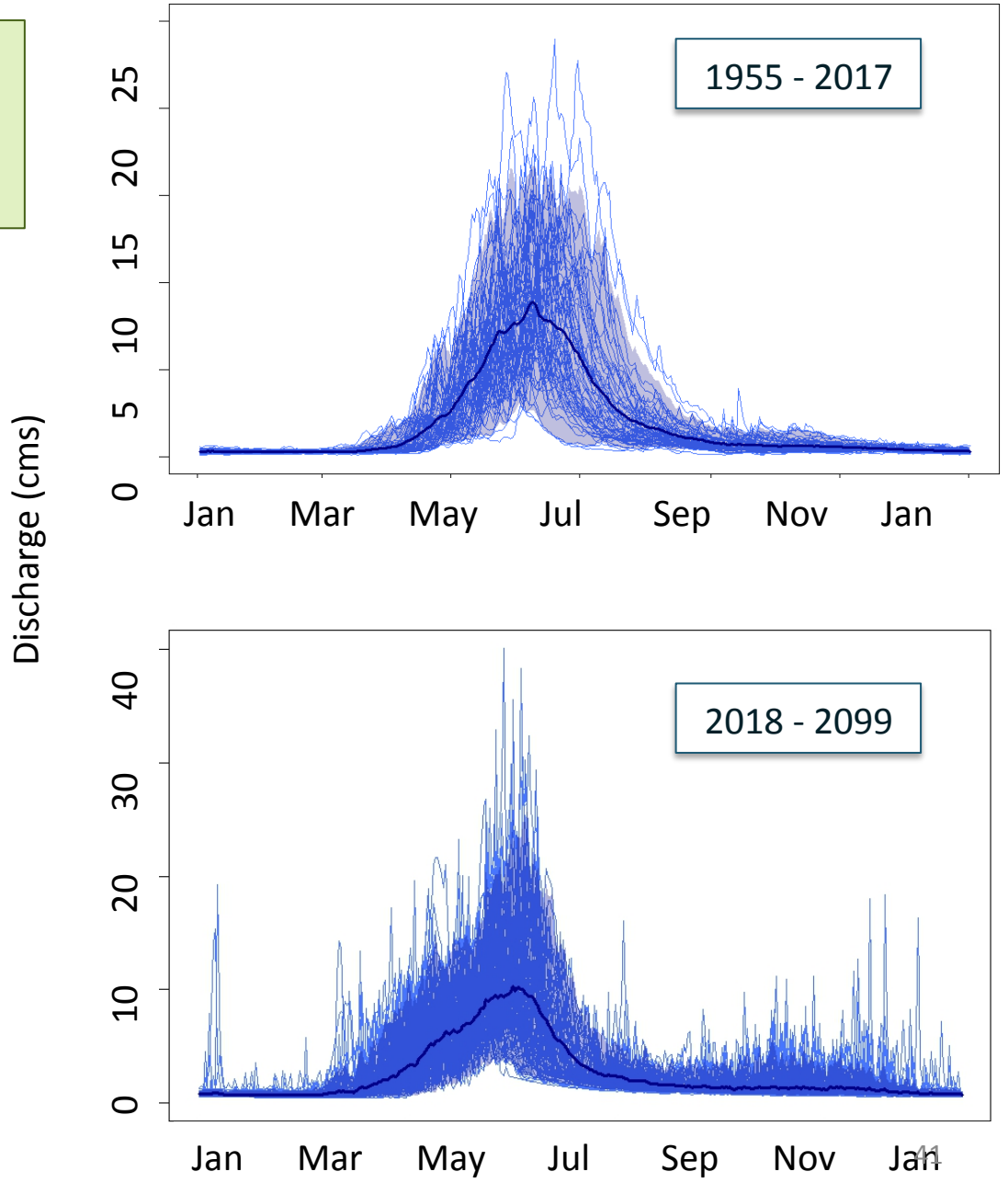


Hydrologic influence on carbon dynamics

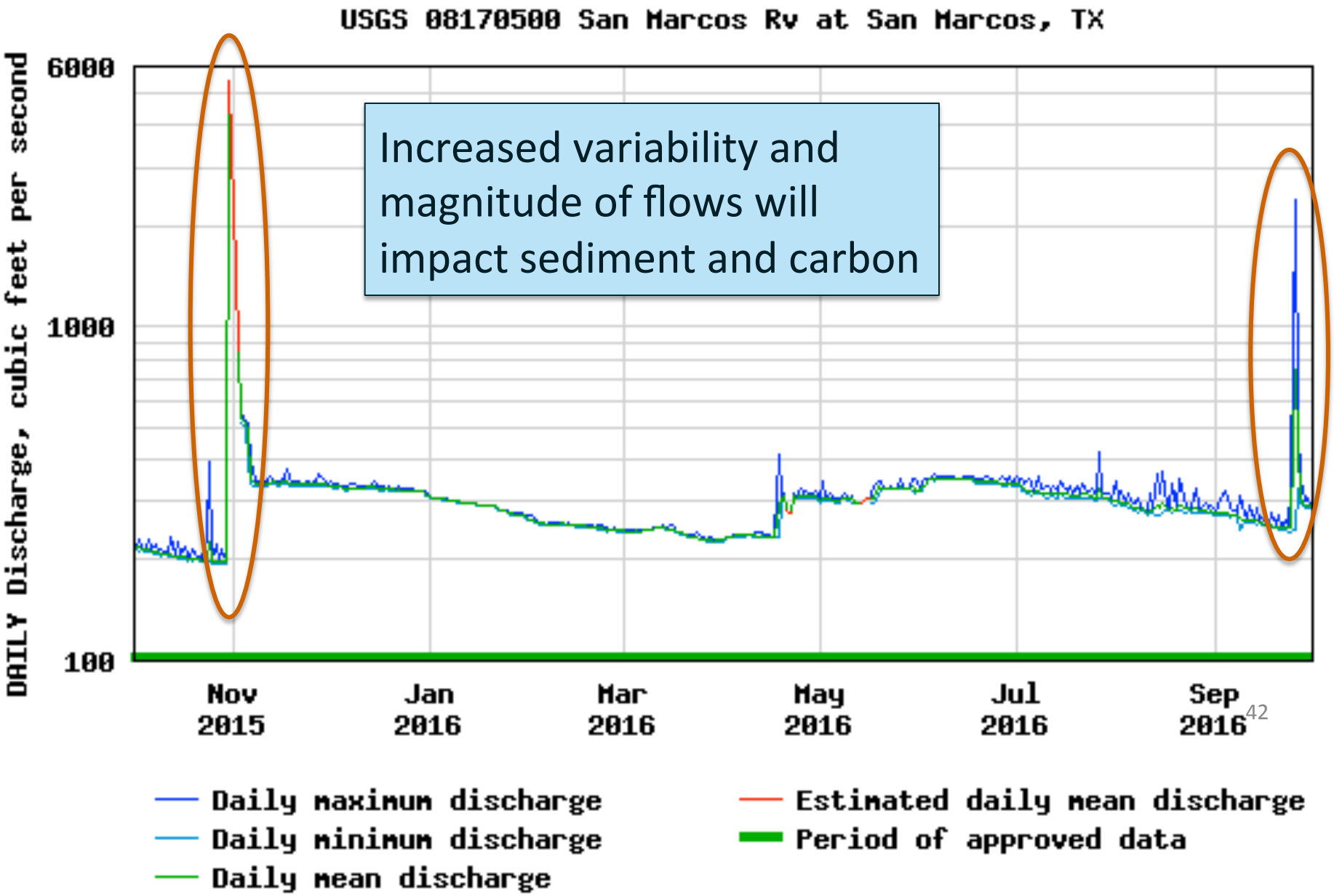
Modeled stream flow:
20 climate scenarios

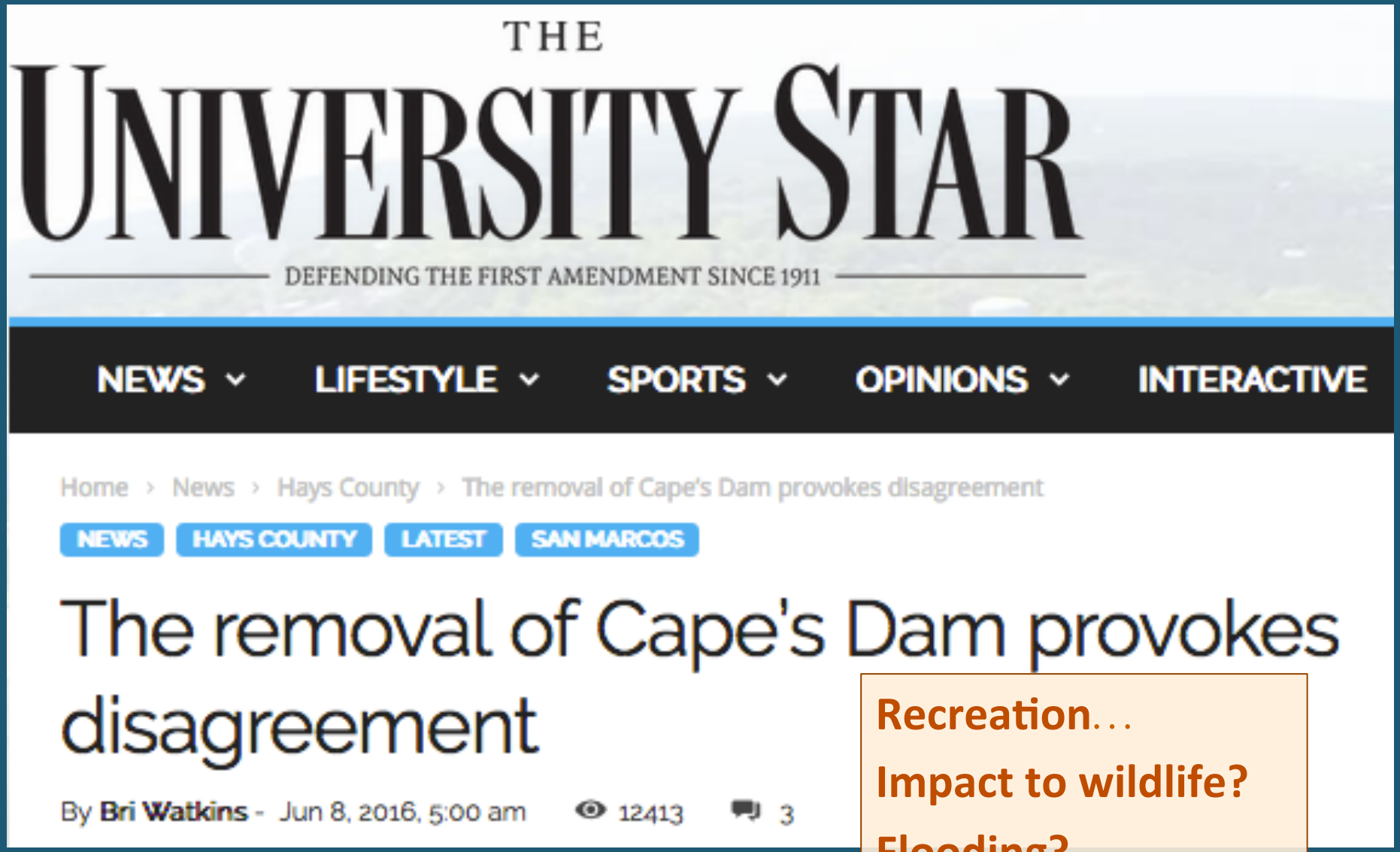
Changes in the flow regime:

- Bank erosion
- Sediment dynamics
- Carbon dynamics



San Marcos River





Recreation…

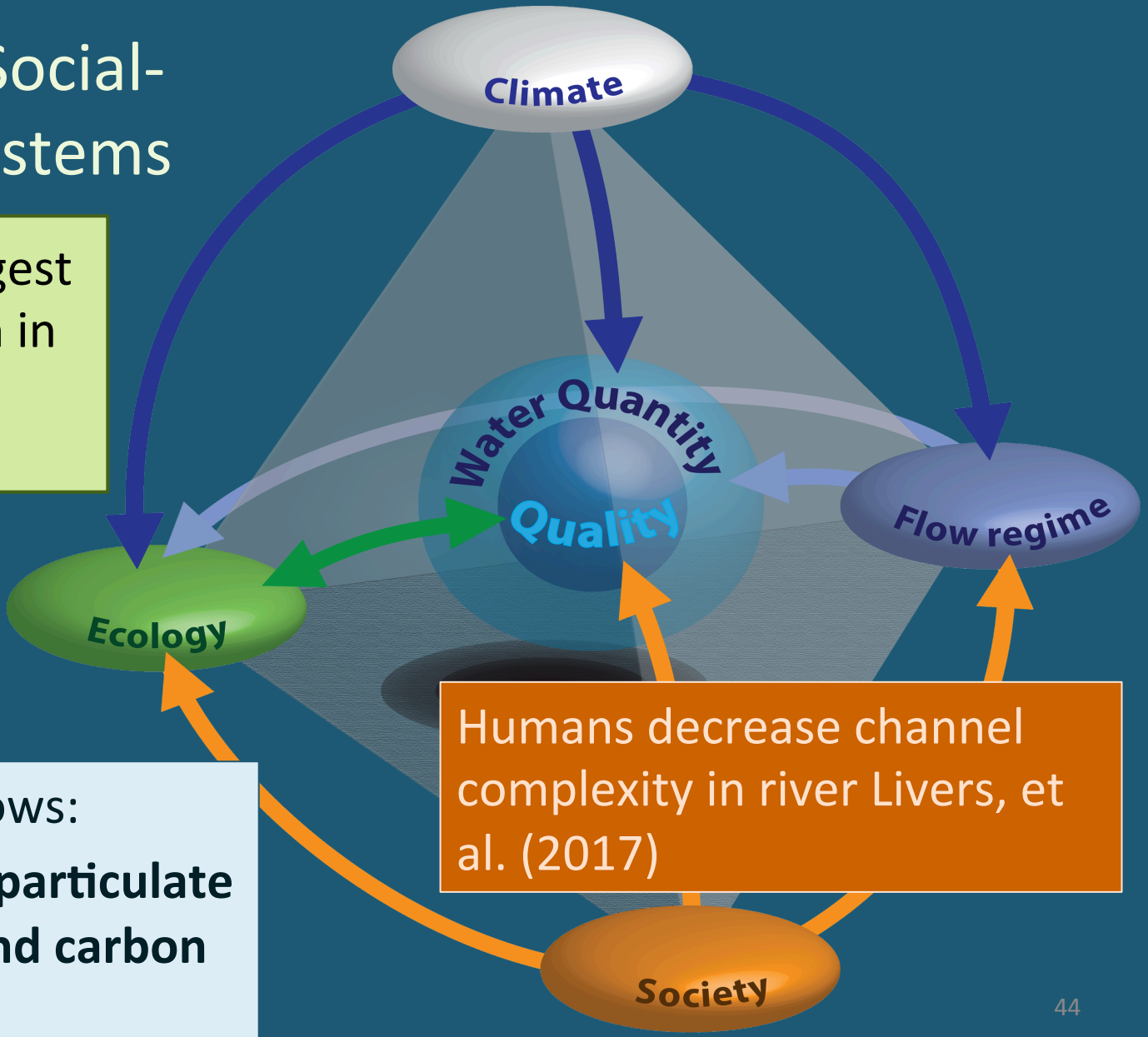
Impact to wildlife?

Flooding?

Organic matter?

Freshwater Social-Ecological Systems

Dams are the largest impact on carbon in river corridors (Wohl et el., 2017)

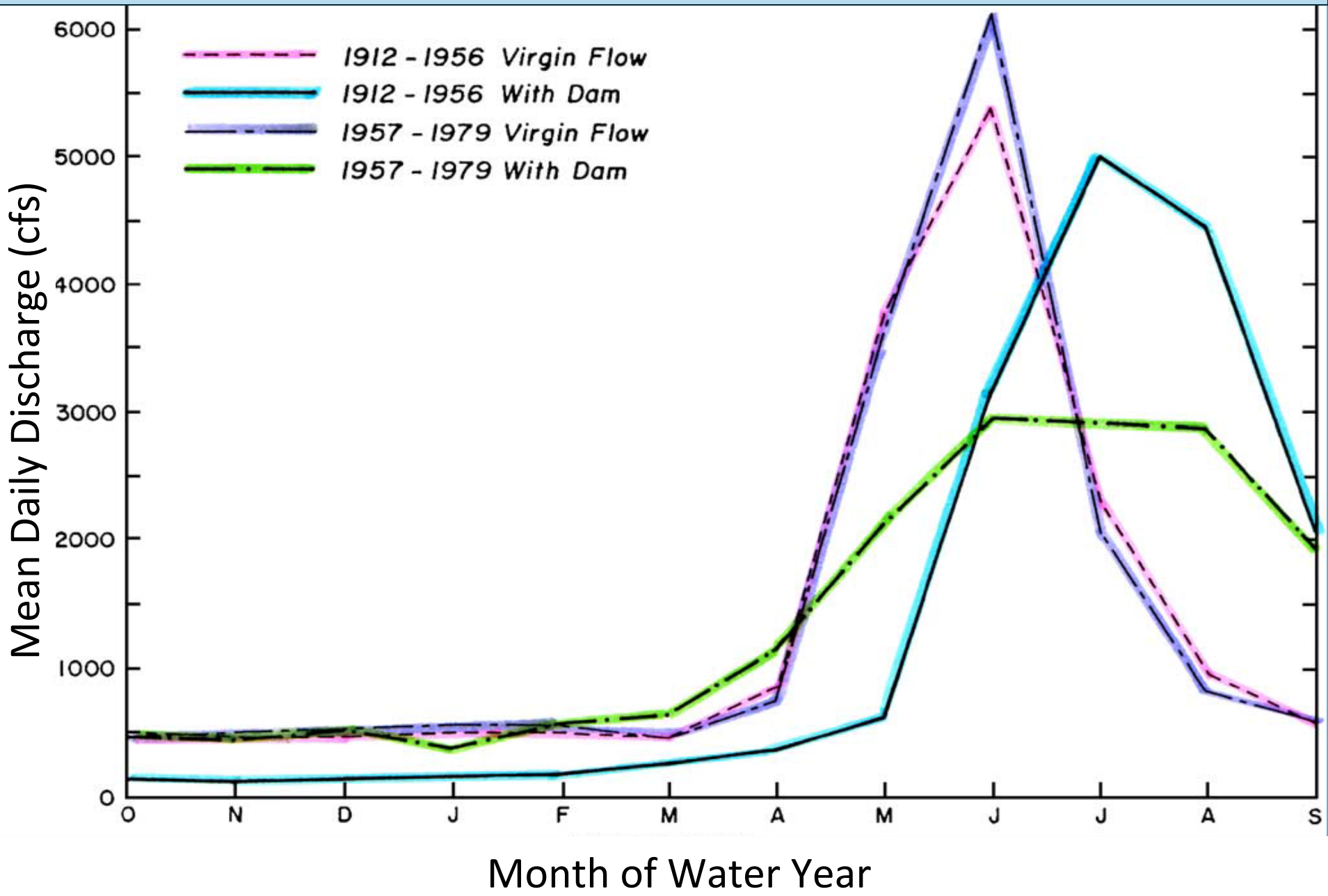


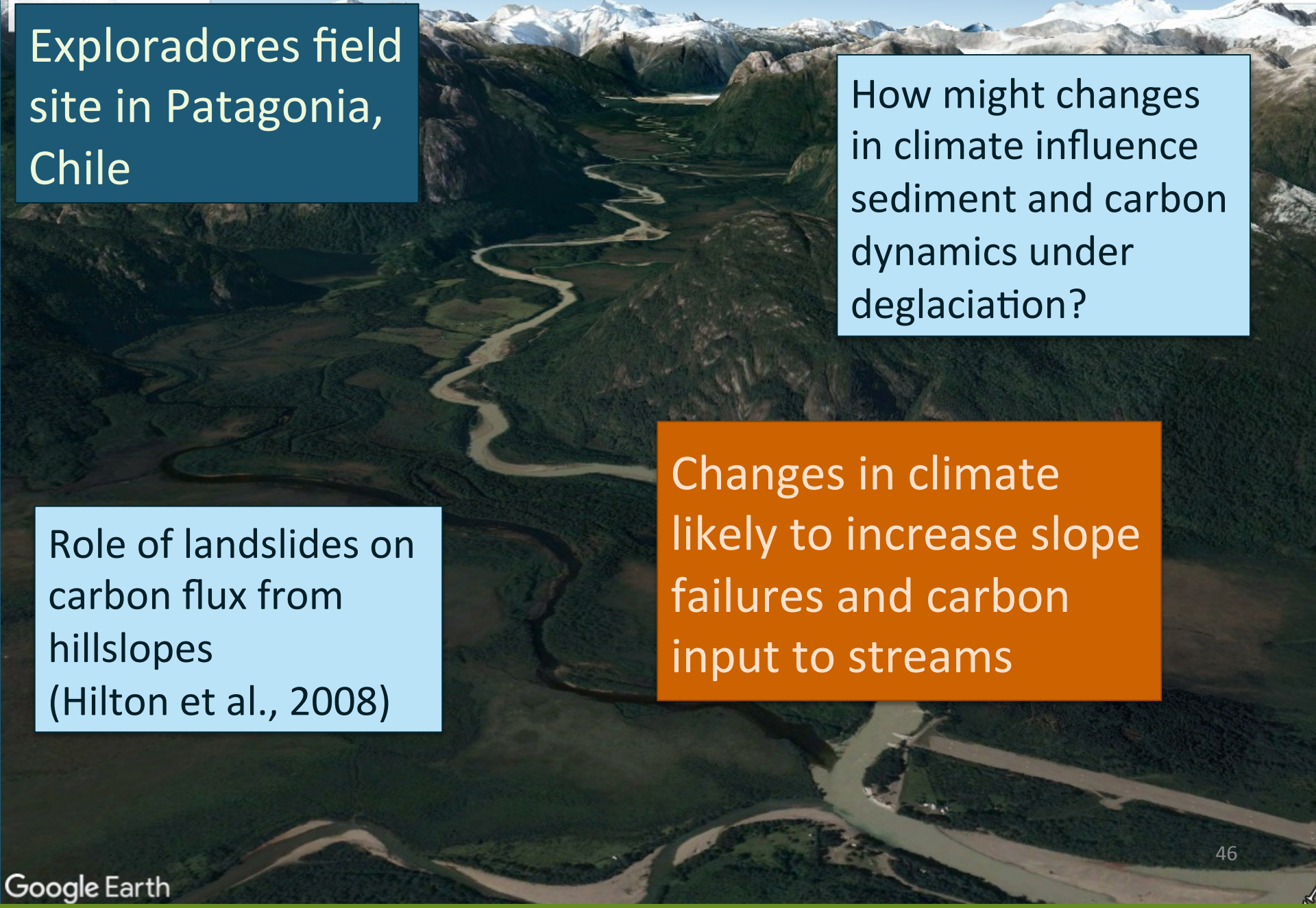
Humans decrease channel complexity in river Livers, et al. (2017)

Environmental flows:

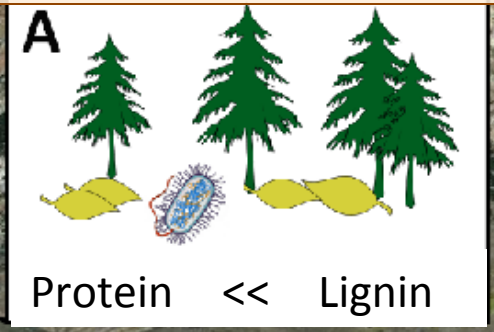
Integrate coarse particulate organic matter and carbon dynamics

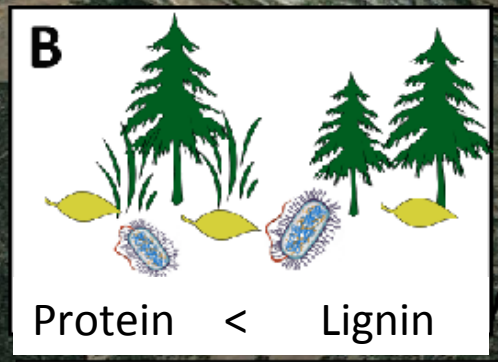
Snake River altered hydrograph (Marston et al., 2005)



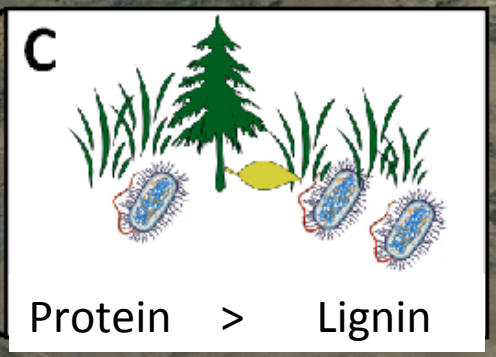

Exploradores field site in Patagonia, Chile
How might changes in climate influence sediment and carbon dynamics under deglaciation?
Changes in climate likely to increase slope failures and carbon input to streams
Role of landslides on carbon flux from hillslopes (Hilton et al., 2008)
Google Earth

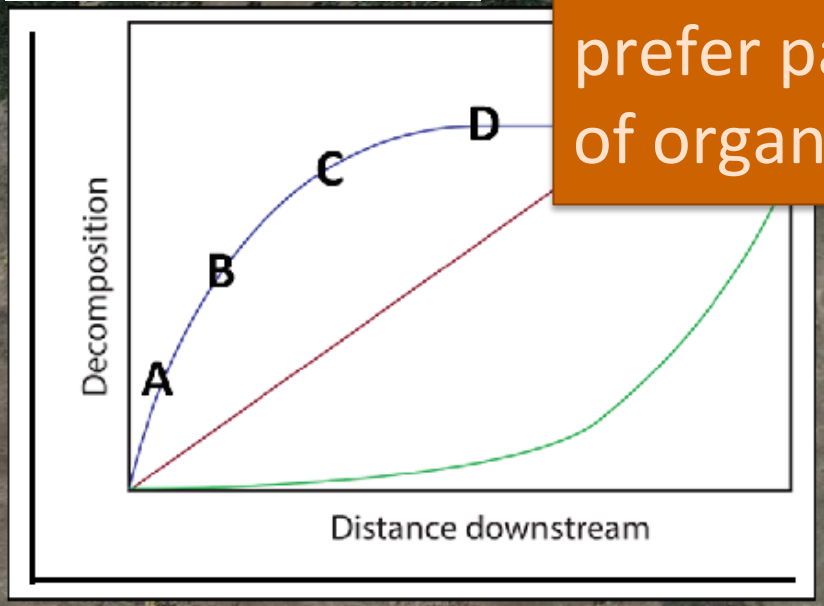
Spatial distribution of carbon in watersheds

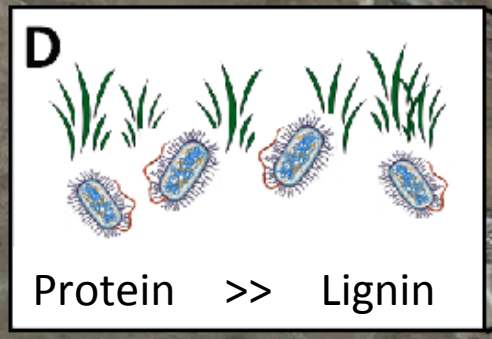




Fate and transport of contaminants likely to prefer particular forms of organic carbon

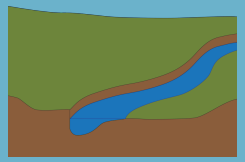






Conclusion

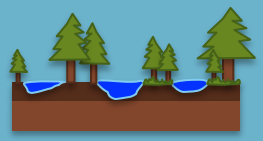
THANK YOU!



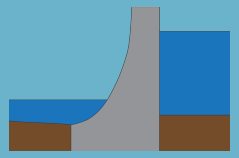
Rivers and floodplains are a significant component of the terrestrial carbon cycle

Erosion is influenced by sensitive components of hydrologic regimes

Anticipated changes in hydrologic regime are likely to alter sediment and carbon regime



River morphology and complexity influence both sediment and carbon dynamics



Changes to channel morphology and hydrologic regimes are likely to influence sediment and carbon