Oregon State University

Myth busting: Effects of sediment pulses on water quality and bed relief in bar-pool channels

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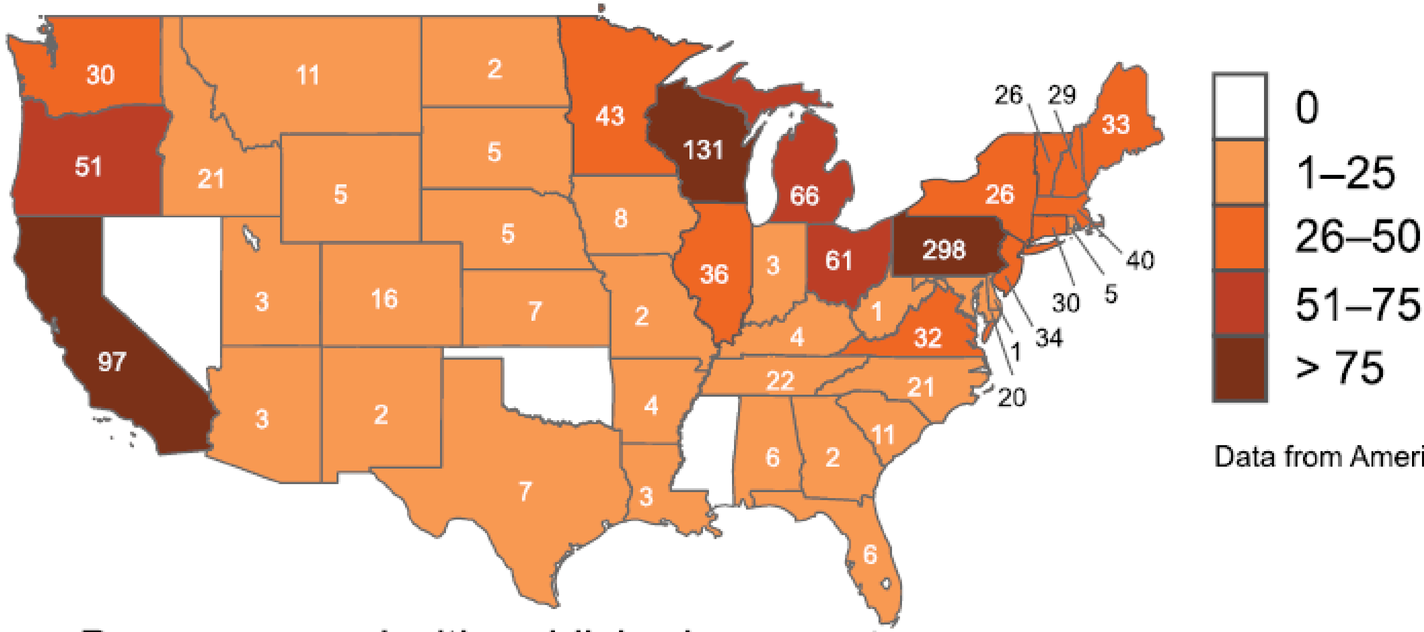
RRNW

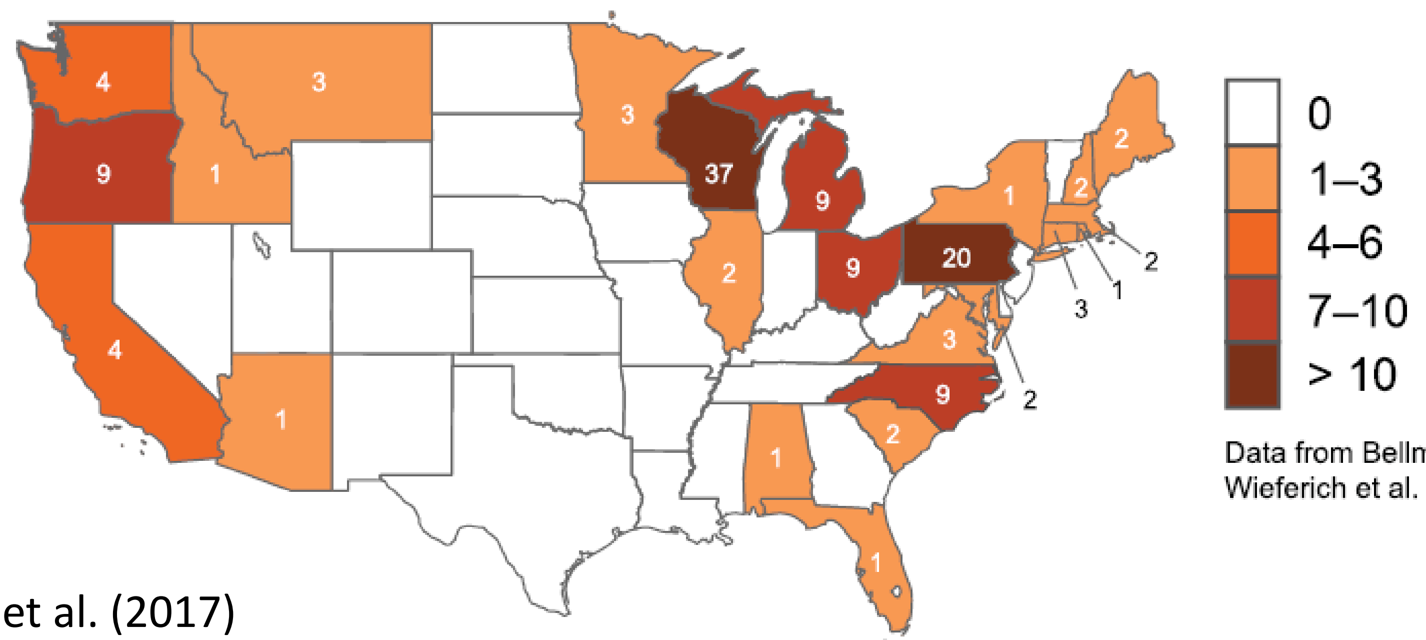
February 08, 2018

Dams removed



Data from American Rivers 1912–2015

Dams removed with published research or monitoring



Data from Bellmore et al. (2015) and Wieferich et al. (2016) through 2015

Foley et al. (2017)

myths of dam removal

- Smothered downstream habitats
- Stinking mudflats
- Runaway knickpoints
- Muddy waters


Source: Don Rvan


9/7/2007, Courtesy of CES

myth busters and policy makers

Powell Center

US Army Corps of Engineers®

Myth busters: what the science says

Study objectives

1. Articulate common management concerns (CMCs) and their potential negative consequences

   What is a CMC?

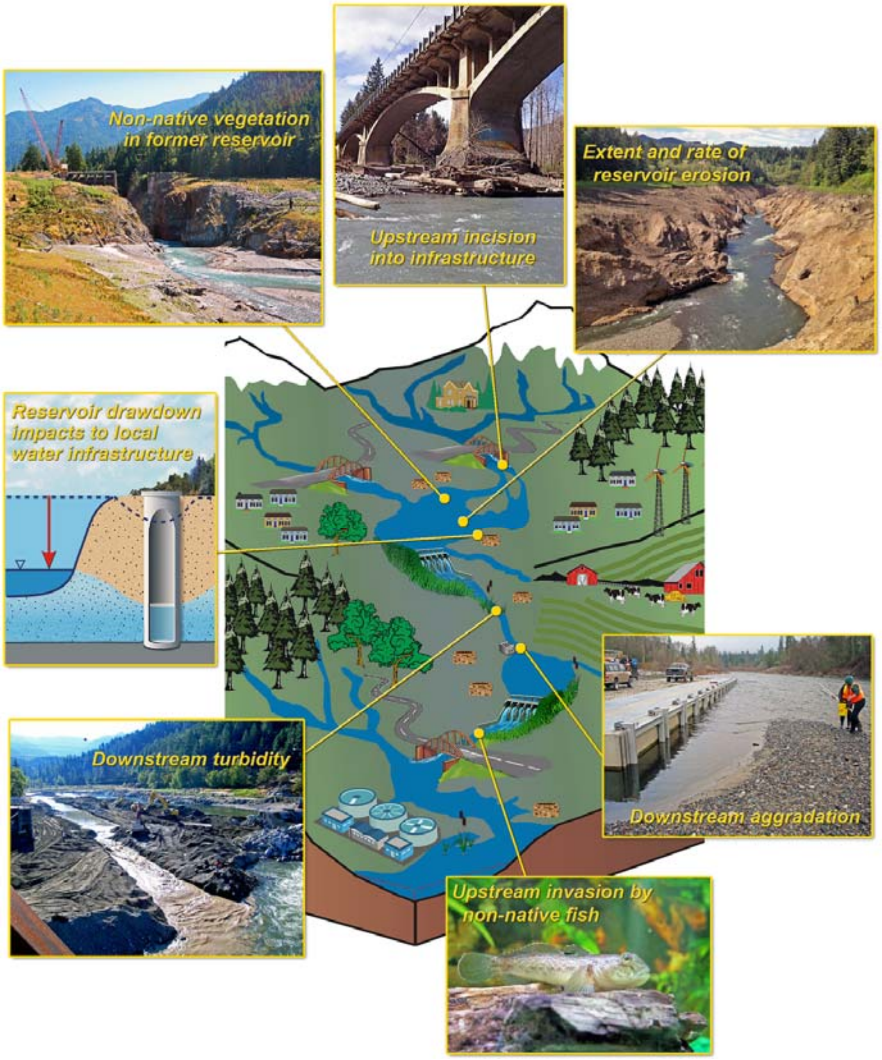
   Dam removal outcomes that may require intervention but are broadly assumed, sometimes incorrectly, to occur at most sites

2. Identify where, and how commonly, CMCs occurred
3. Evaluate what conditions control their occurrence

Tullos et al. 2017. JAWRA

Co-authors: Mathias Collins, Ryan Bellmore, Jennifer Bountry, Patrick Connolly, Patrick Shafroth, and Andrew Wilcox

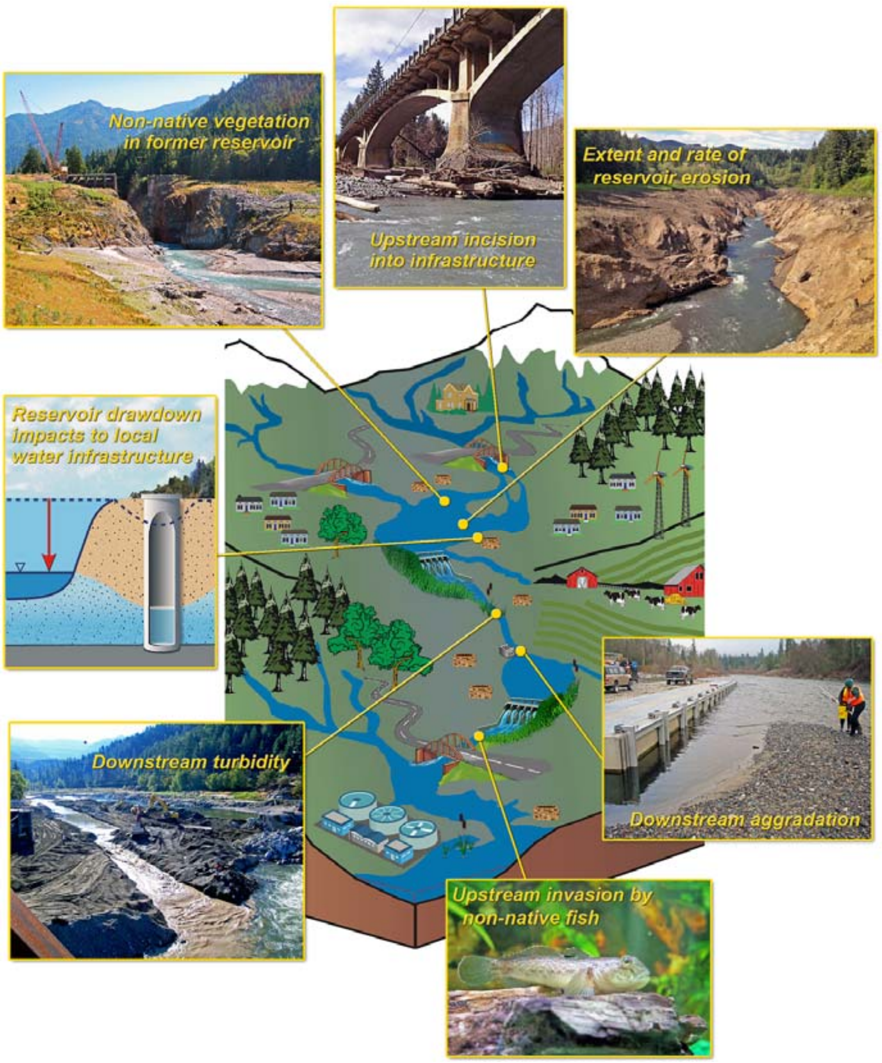
the CMCs



Tullos et al. 2016

1. Upstream incision into infrastructure
2. Non-native vegetation in former reservoir
3. Reservoir drawdown impacts to local water infrastructure
4. Downstream turbidity
5. Upstream invasion by non-native fish
6. Downstream aggradation
7. Extent and rate of reservoir erosion

the CMCs



Tullos et al. 2016

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assessing the risk of CMCs

Evaluate CMC risks by:

- Likelihood: Assessing likelihood of relevant biophysical controls
- Consequence: Investigating intersections of the controls with ecological or human use impacts important to stakeholders

(Image: Tullos)

4/8/2009

(Image: Tullos)

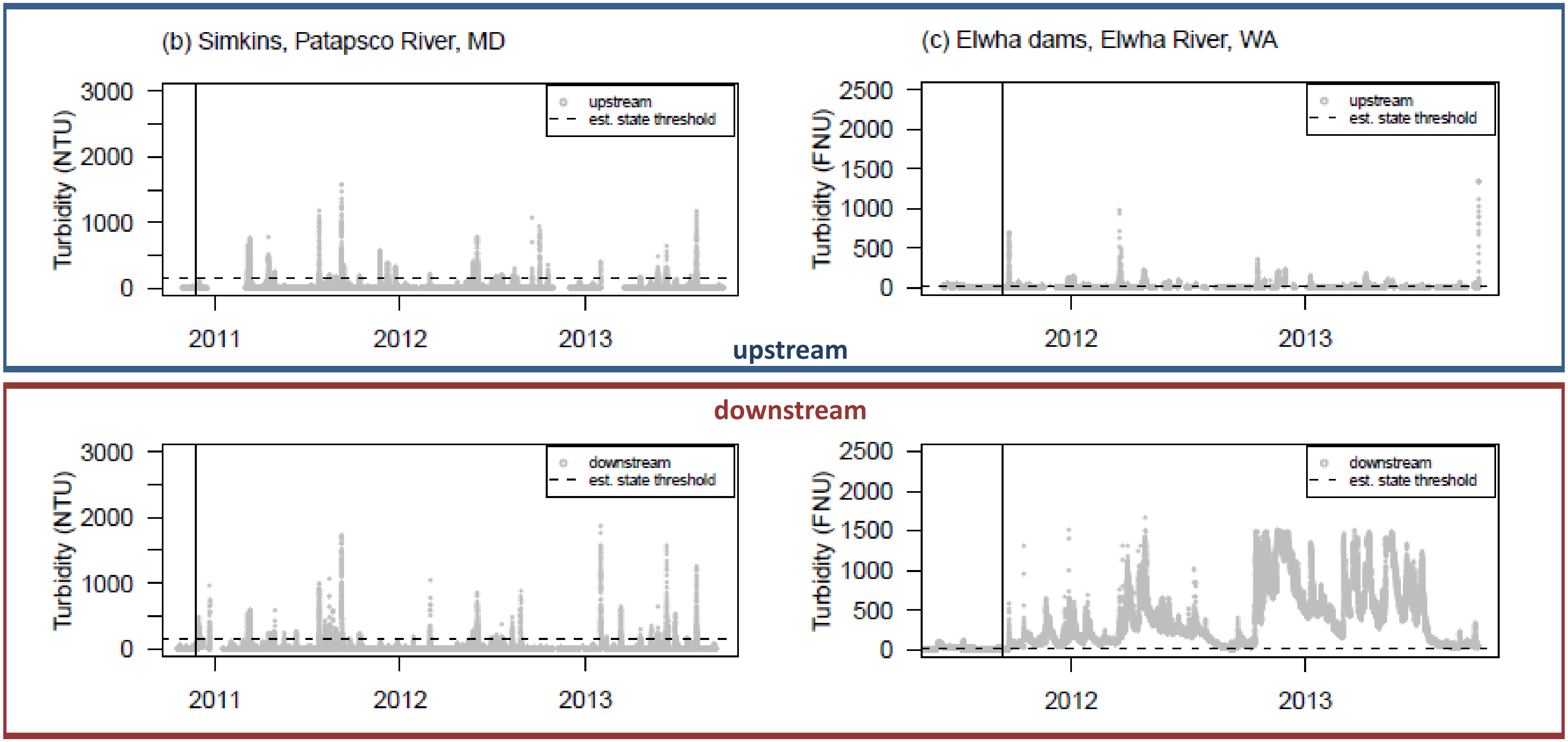
(Image: USGS)

(Image: USBR)

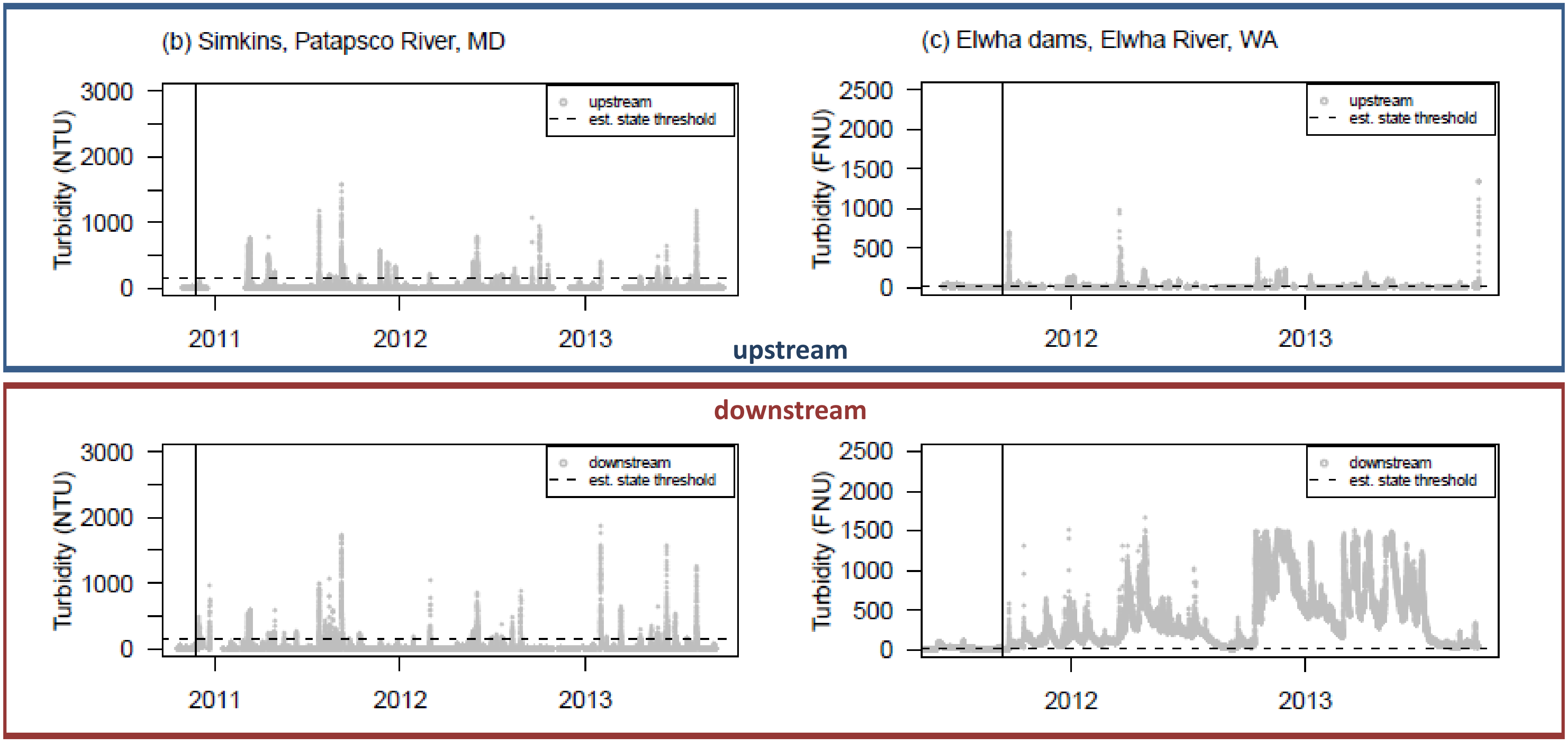
the CMCs

CMC	Case studies	Biophysical process controls	Site conditions suggesting management implications
Degree and rate of reservoir incision	N/A	• high % of stored fine sediments • average sediment deposit width/channel width > ~2.5 • phased removal	stakeholder values; fish passage needs or sensitive habitats
Excessive channel incision upstream of reservoir	38	• reach-scale incision d/s • high % of stored fine sediments • phased removal • coarse delta • ephemeral flow	infrastructure within reservoir deposit or along margins at risk for bank erosion; fish passage needs or sensitive habitats
Downstream aggradation	6	• high V* • proximal to dam • antecedent channel has low slope/unconfined	low-lying properties; transportation infrastructure; pump intakes; fish passage needs or sensitive habitats
Elevated turbidity	7	• high % of stored fine sediments • high V* • rapid reservoir drawdown	sensitive aquatic organisms; human recreational uses; drinking water intakes
infrastructure		river, and groundwater • regionally deep water table	
Non-native plant colonization of reservoirs	23	• proximity to non-native seed sources • high % of stored fine sediments • no planting or weed control	legal requirements for noxious weed and/or invasive species control; stakeholder values
Non-native fish	7	• abundance and proximity of non-native fish • availability of suitable habitat and temperatures for non-natives	state fisheries regulations or management plans; stakeholder values

Muddy waters?



Muddy waters?



Results: Elevated suspended sediment

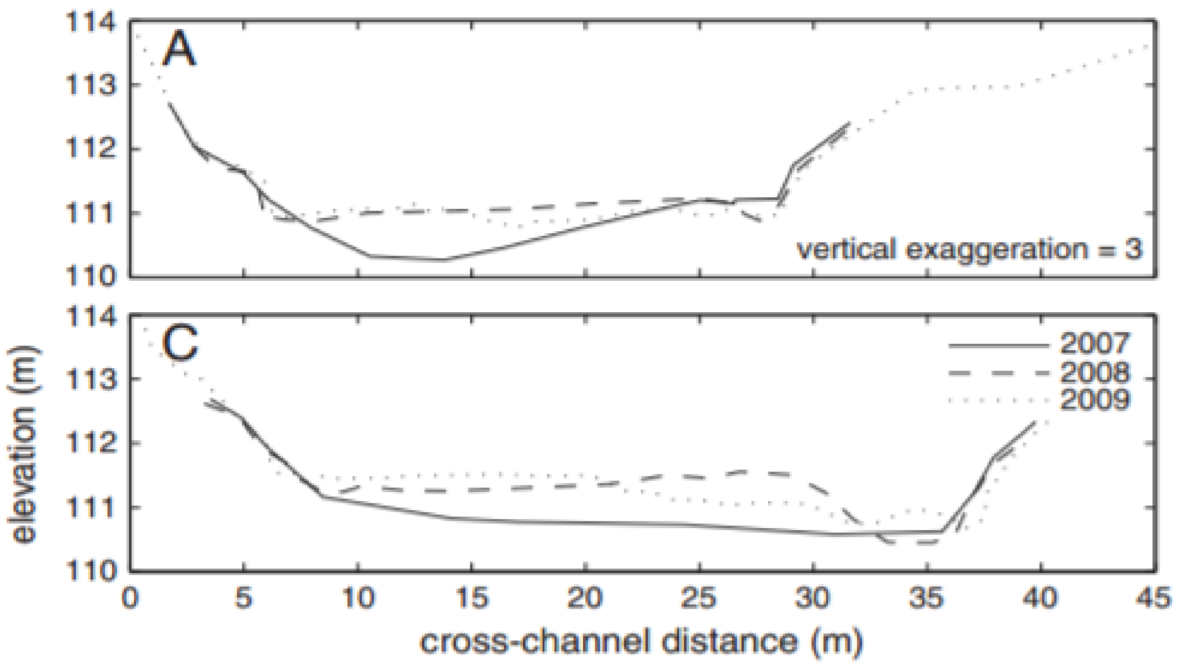
- For the majority of sites
  - turbidity generally within range of natural variability and/or below state standards
  - Impoundments store little sediment relative to average annual load (low V*)
- Exceptional situations:
  - High V* (e.g., Elwha River)
  - Site specific circumstances (e.g., large sediment volumes of fines behind instantaneously removed dams)

(Image: Nat Geo)

Intersection with ecological and human resource?

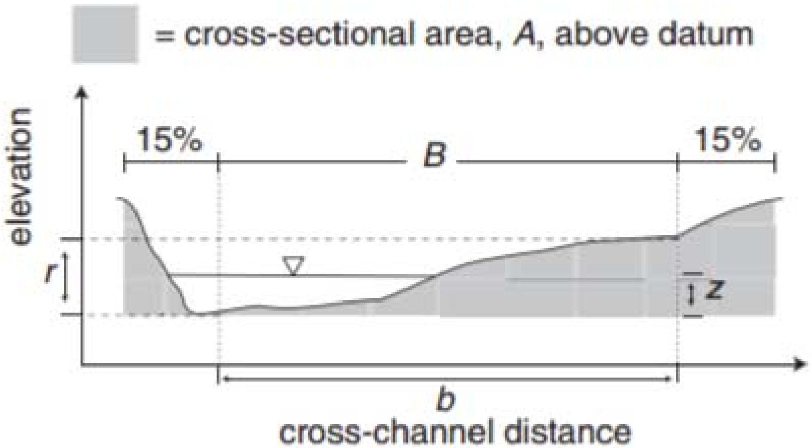
Smothered downstream habitats?

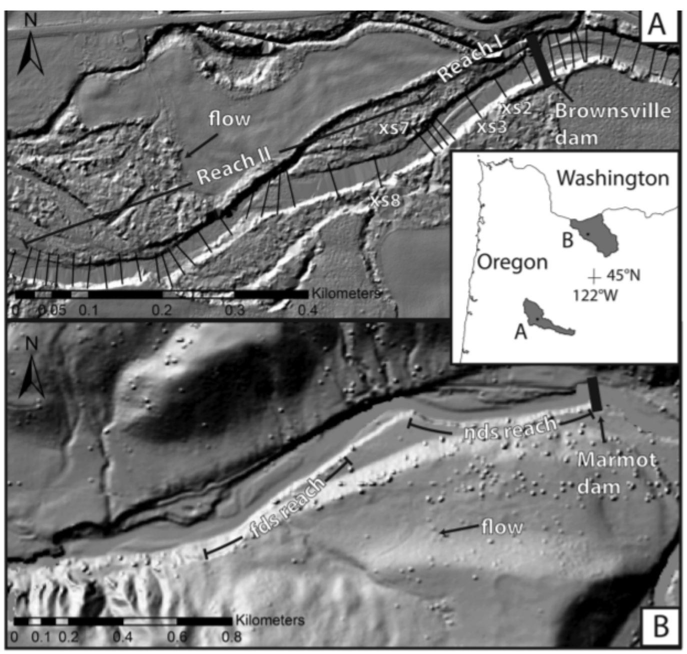
objective: evaluate whether initial relief of a river can be used to predict the response of a bar-pool channel to the release of a pulse of sediment



Zunka J, Tullos D, Lancaster S (2015)

methods: BACI, field-based design





Propose new variables

z* = change in sediment thickness due to pulse

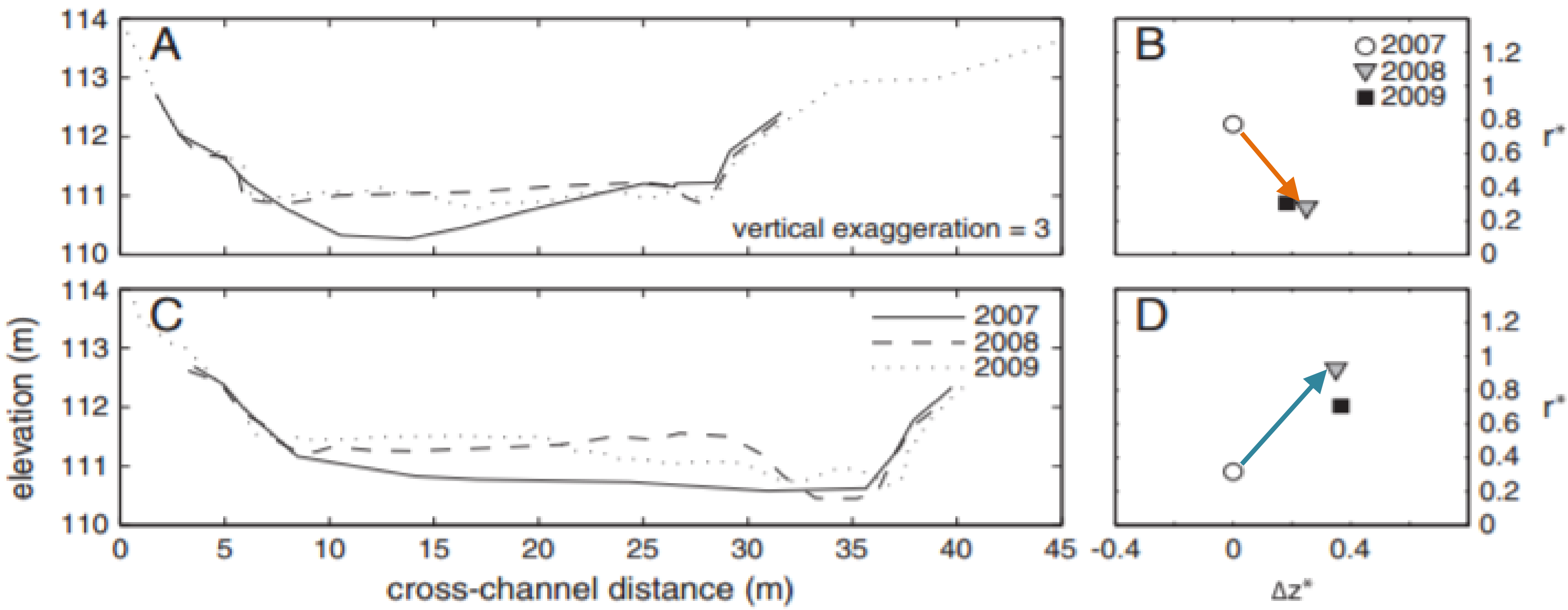
r* = cross-channel relief

Use field data to evaluate hypothesis

*the change in relief due to sediment pulse depends on the initial value of r**

results: Brownsville Dam

- 14,000 m^3 sediment stored
- 29% eroded in year 1

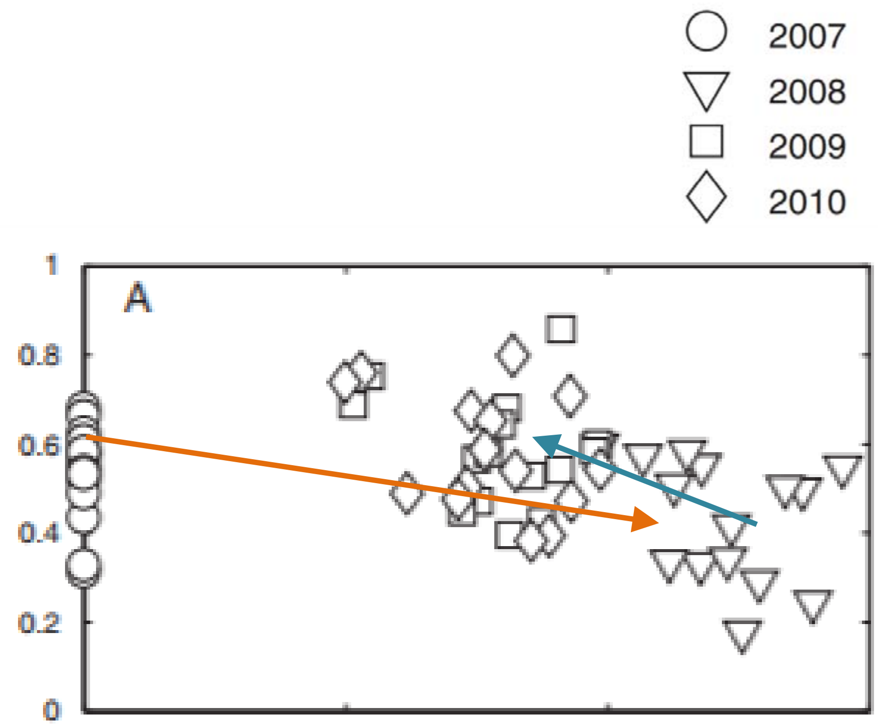


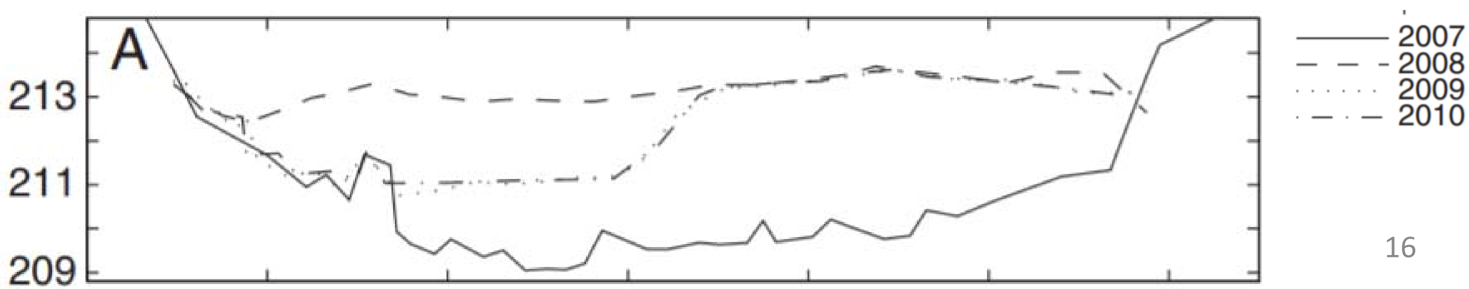
Initially high relief ⟶ pulse reduced relief

Initially low relief ⟶ pulse increased relief

results: Marmot Dam

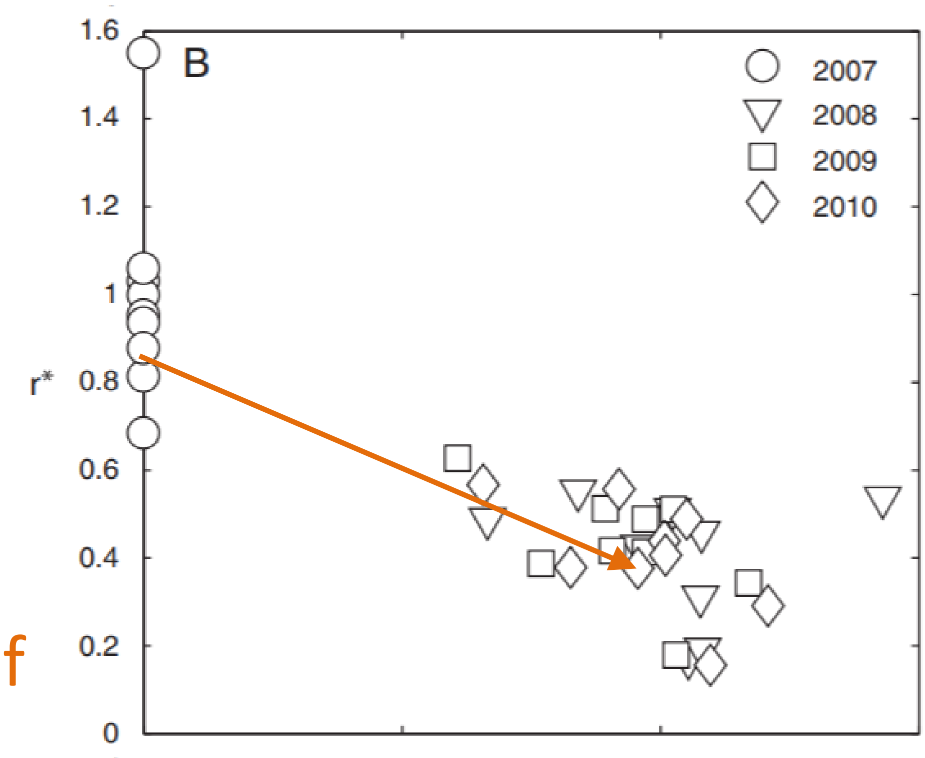
- 730,000 m^3
- 50% eroded in year 1
- Reach 1 (0-250m)
  - High initial r*
  - Large z*
  - Initially decreased relief
  - Subsequent relief increase

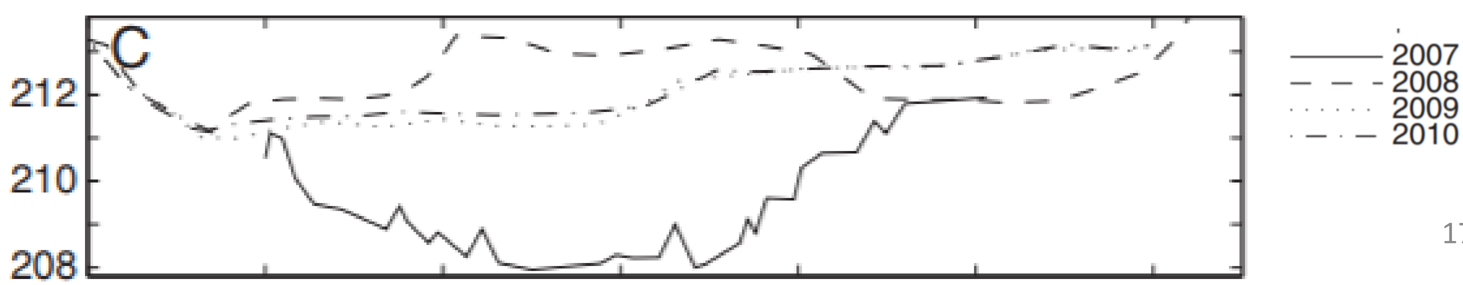




results: Marmot Dam

- 730,000 m^3
- 50% eroded in year 1
- Reach 2 (250-360m)
  - Higher initial r*
  - Large z*
  - Initially decreased relief





key findings

- Habitat “smothering” may be predictable
  - pool filling or bar building appears to depend on the
    - initial relief, and
    - the amount of sediment delivered to individual features
- increase relief at locations with initially low relief
- decrease relief at locations where it was initially high, often following by erosion-based recovery

Further work needed: Addressing remaining CMCs

- Post-pulse pool dynamics
- Impacts to mussels
  - determine if mussels are present
  - Obtaining permits
  - Relocating mussels

thanks!

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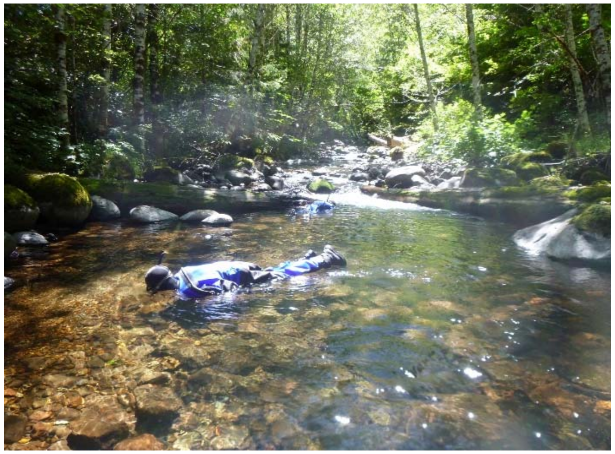
http://blogs.oregonstate.edu/rivers/



The other five CMCs

1. The "stinking mudflat": The percent of reservoir sediment eroded (10%-70% after one year) depends on dam removal style and sediment management.
2. Runaway knickpoint migration: Generally follows conceptual models – rapid erosion then leaking
3. Drawdown impacts to water infrastructure and ecosystem: Depends on connectivity of aquifer to reservoir.
4. Non-native plant colonization of reservoir: At the 25 study sites for which data were available, non-natives represented 13-68% of plants, and mostly commonly it was Reed Canary Grass.
5. Upstream invasion of non-native fish: Very little data, and results appear biased towards documents invasion

and then there's contaminants

- Contaminants
  - most likely in reservoirs with fine sediment and catchment land use histories that lead to contaminant releases