The Rise of the Stage Zero Channel as a Stream Restoration Goal

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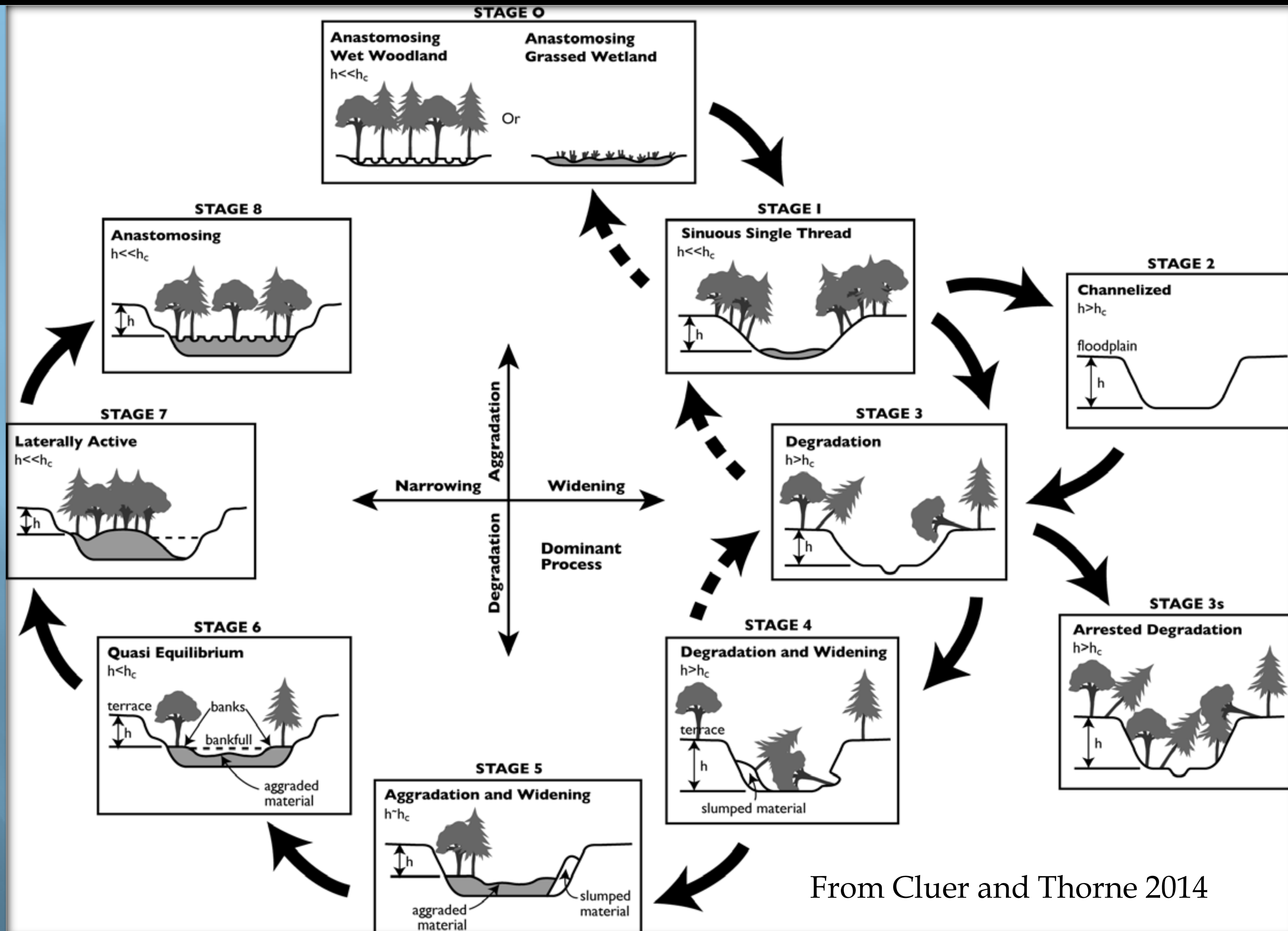
What is a Stage Zero Channel?

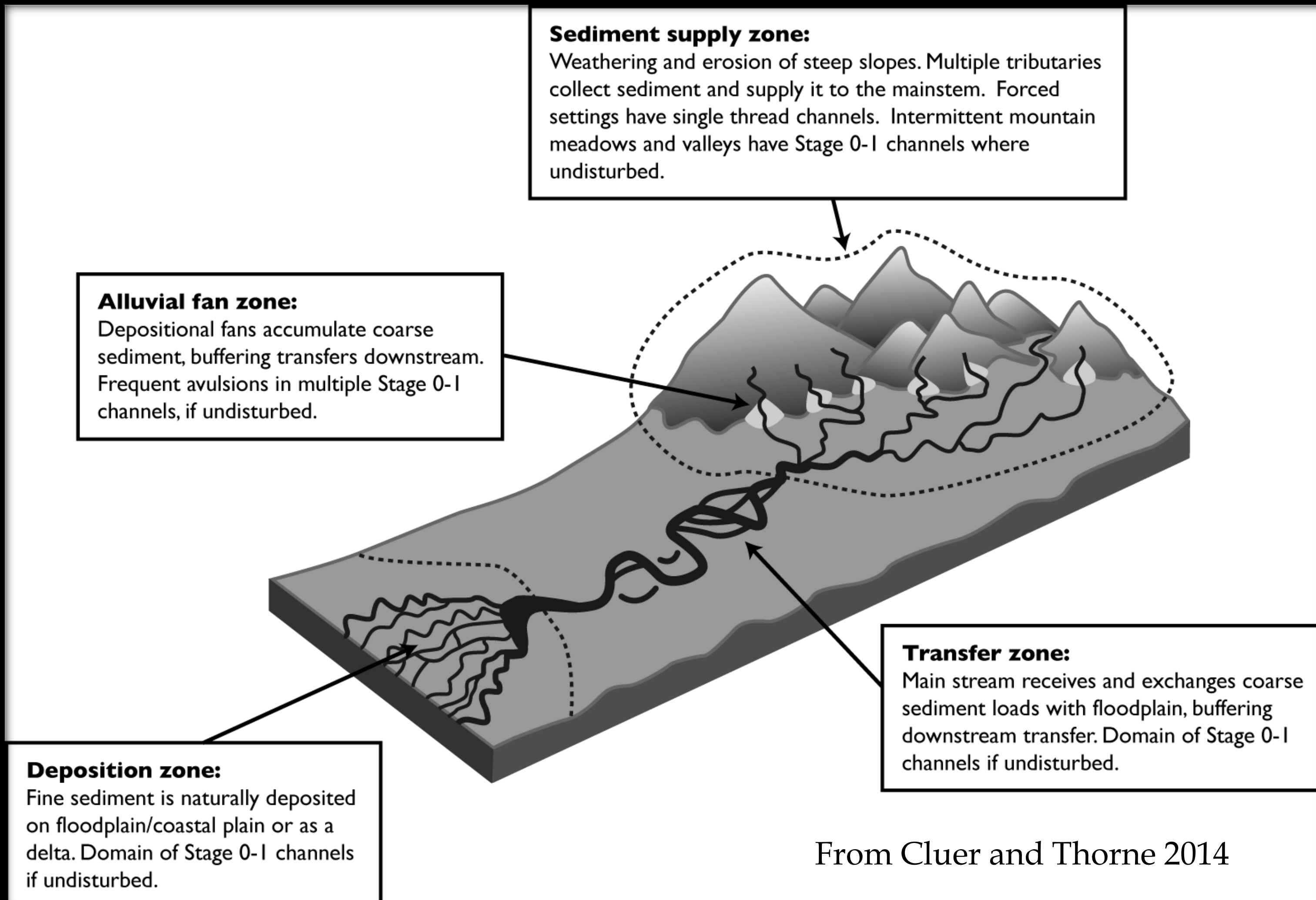


From Cluer and Thorne 2014

Stage Zero Attributes or Tendencies

- Multi-threaded or no definable channels (vegetation)
- Common in unconfined, low-gradient valleys
- Low stream power/unit width
- Wide range of hydrologic conditions
- Abundant off-channel habitat w/long inundation periods
- Elevated water tables
- Wide range of Velocity/Depth combinations
- Blurred line between wetlands and channels
- Biological flow resistance in channels, on banks and on stream adjacent surfaces (e.g. floodplains and mid-channel islands)
  - Aquatic vegetation
  - Emergent vegetation
  - Live and dead tree boles
  - Beaver dams (N. Hemisphere)

Where Do Stage Zero Channels Occur?



From Cluer and Thorne 2014

Lemhi River, Idaho

Taku River (southeast) Alaska

Kuskokwim River, Alaska

Salmon River, Idaho

MacKenzie River, Canada

Yukon River, Alaska

Peel River, Canada

Everglades (River of Grass), Florida

Okavango River, Botswana

Sudd Swamp, South Sudan

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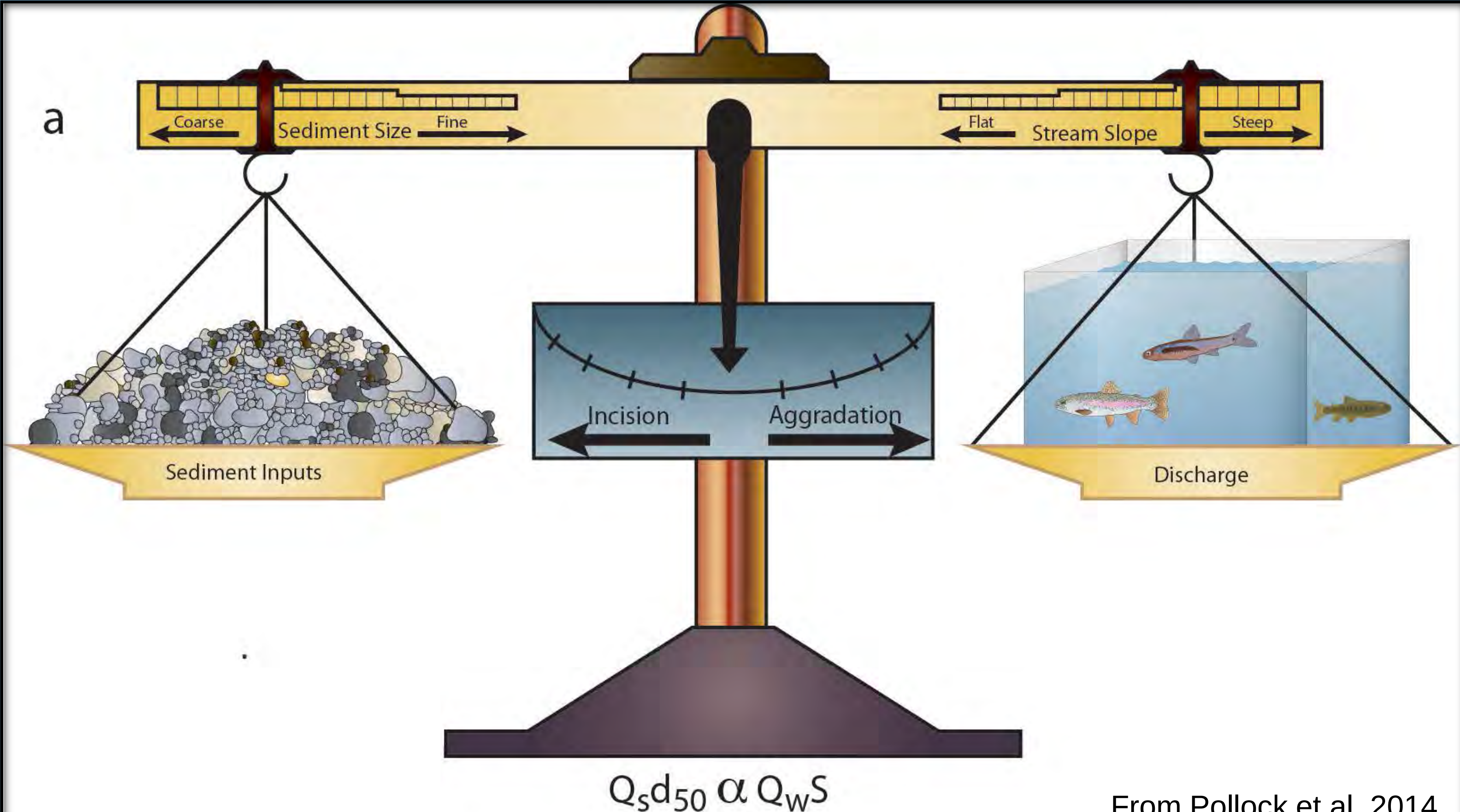
Arguably, 150 years ago the Sacramento and San Joaquin Rivers were Stage Zero systems

150 years ago, 5% of California was "wetlands", mostly in the Central Valley.

What is the best use of this land?

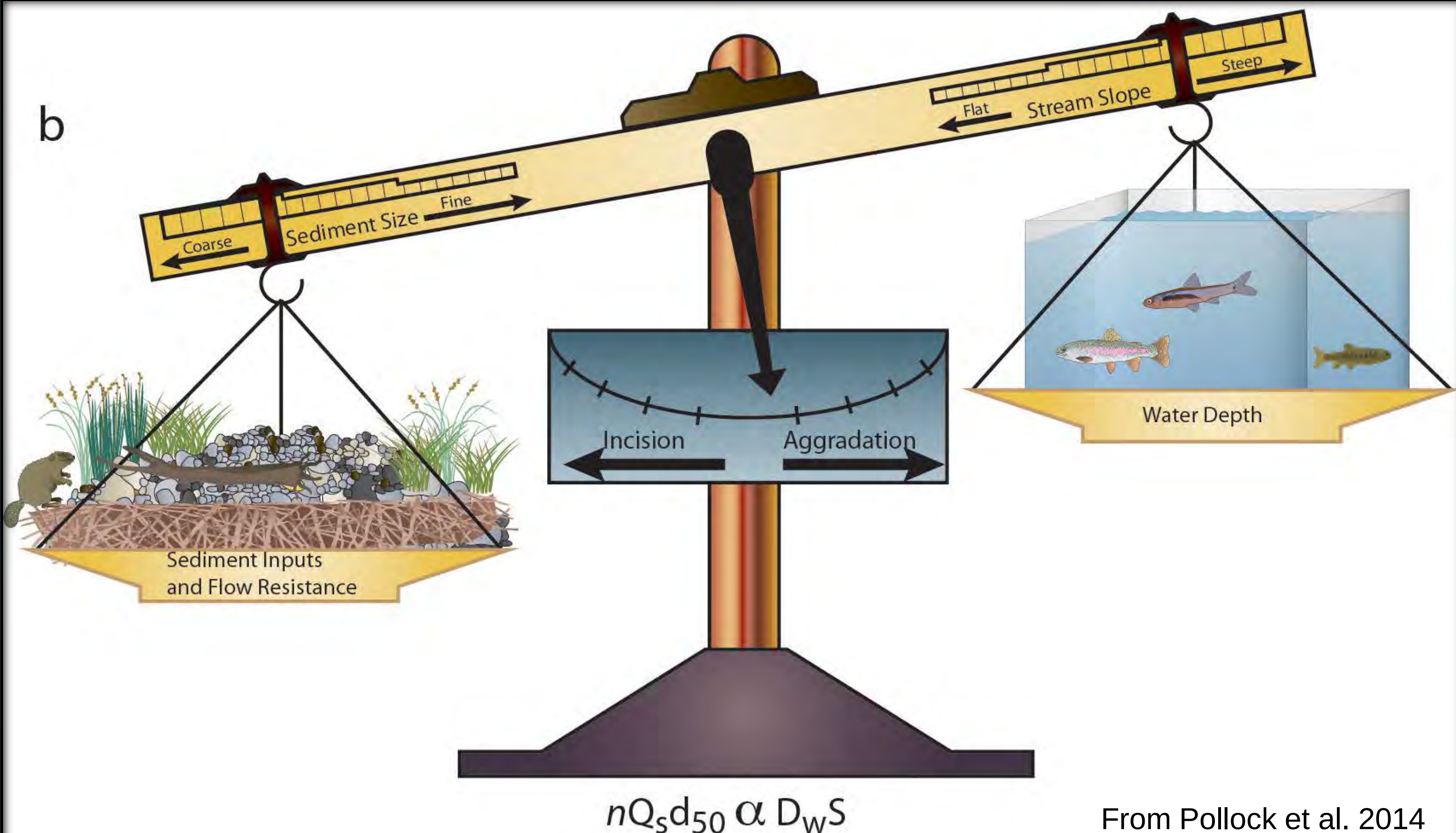
In 150 years, will > 5% of California be wetlands again?

How Do You Build a Stage Zero System?



From Pollock et al. 2014

Increase Flow Resistance

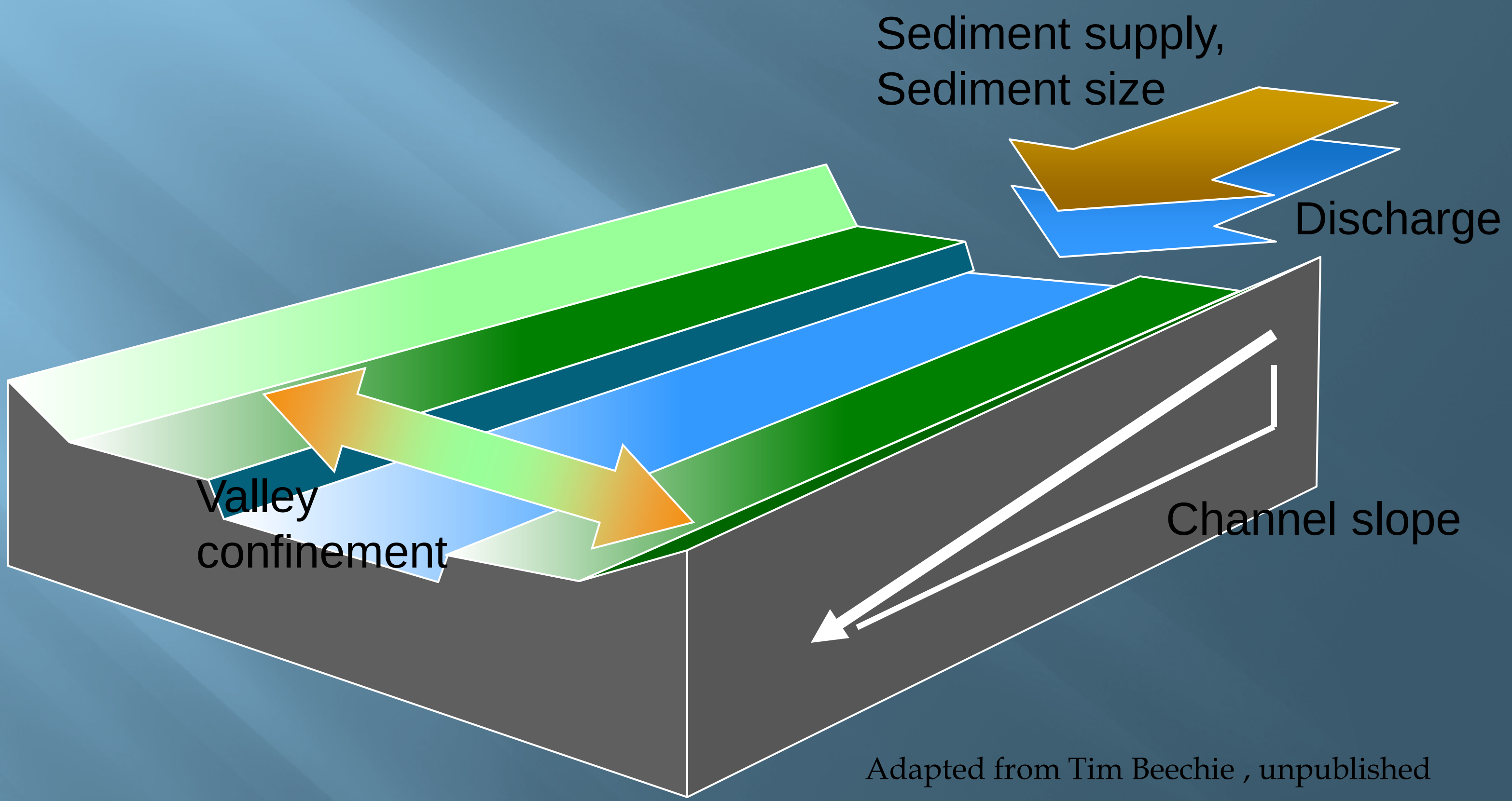


From Pollock et al. 2014

Stage Zero Restoration = Process discontinuity management = reducing transport rates of sediment and water (conveyance v. habitat management)

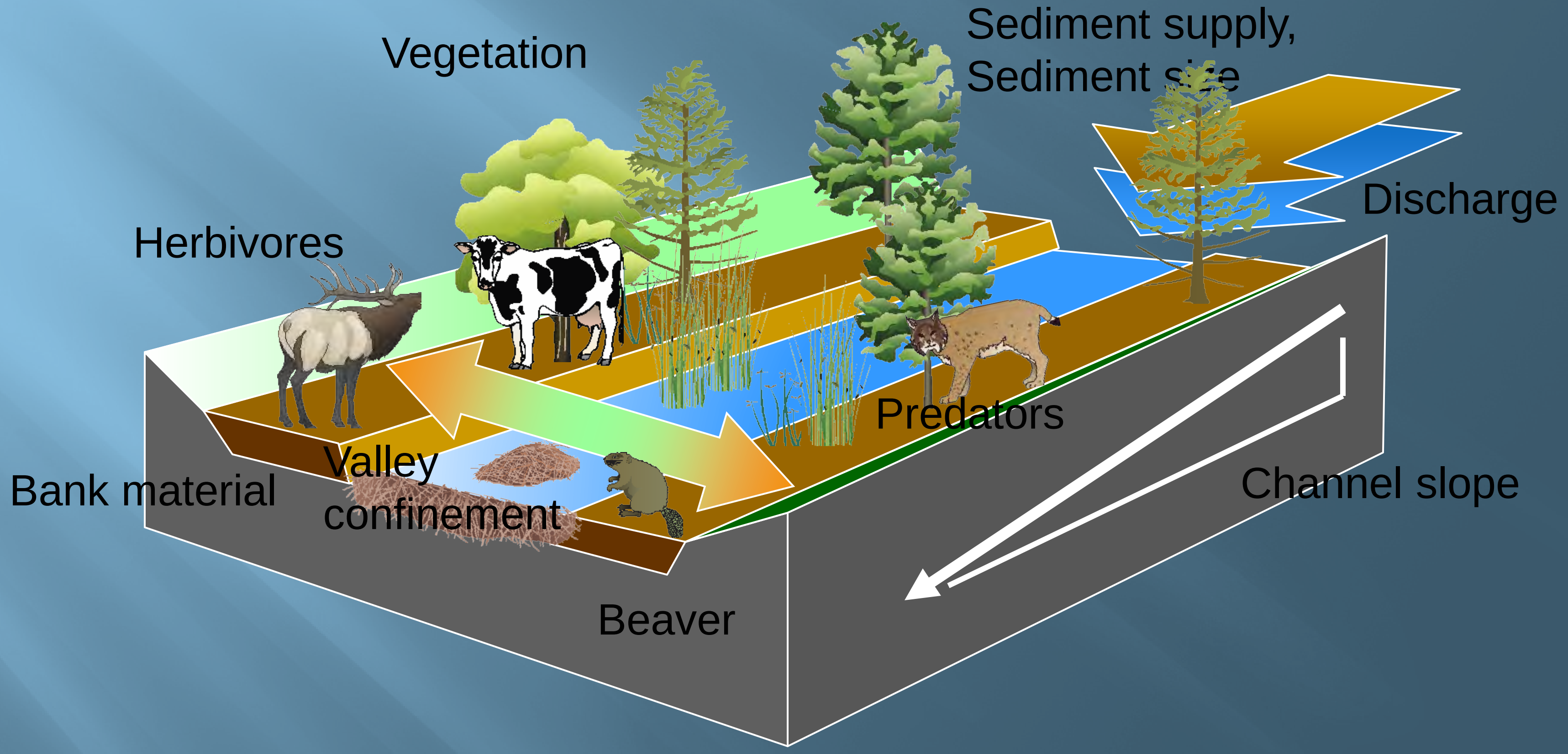
- Sediment = Essential ingredient
  - Deposition and sorting
  - Aggradation
  - Erosion and avulsions
  - Sediment = a resource
  - No Sediment = No Valley floor
- Water
  - Flow diffusion
  - Groundwater recharge
  - Hyporheic exchange
  - Long inundation periods
  - Less distinction between wetlands and channels and floodplains

Factors Controlling Stage Zero Channel Formation



Adapted from Tim Beechie , unpublished

Factors Controlling Stage Zero Channel Formation



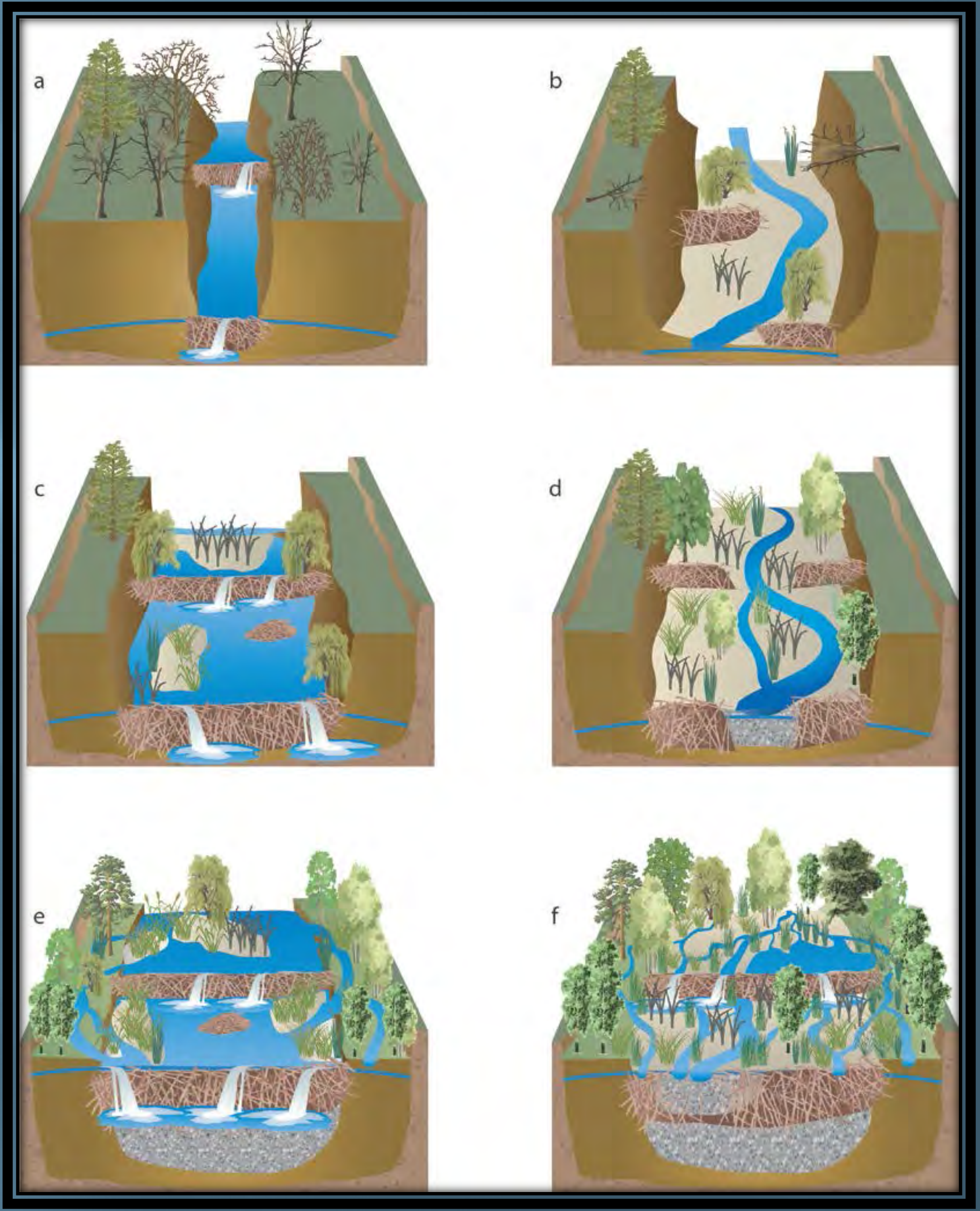
Restoration Tools to Increase Flow Resistance, Change Gradients and Reduce Stream Power/Unit Width

- Beaver Dams
- Live Vegetation
- Large Wood
- Levee Setbacks
- Landslides
- Alluvial Fans
- Sea Level Rise
- Tectonics

Increasing Time Scales

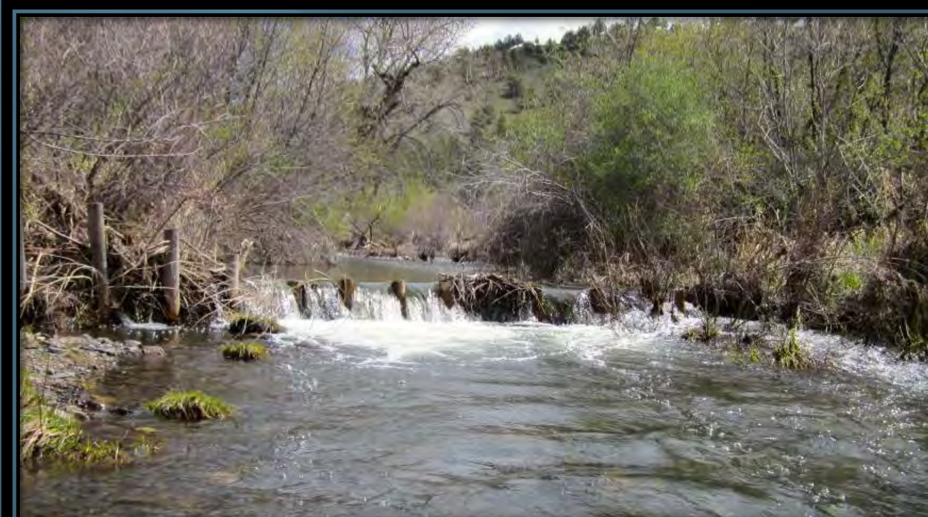
Beaver Dams

-Can reduce recovery times from Stage 1 to Stage 7-8/0 systems by 1-2 orders of magnitude (year to decades instead of decades to centuries)



From Pollock et al. 2014

Beaver Dams and Beaver Dam Analogues



Beaver Dam Analogues-Reach Scale Effects

Carol Volk, Unpublished

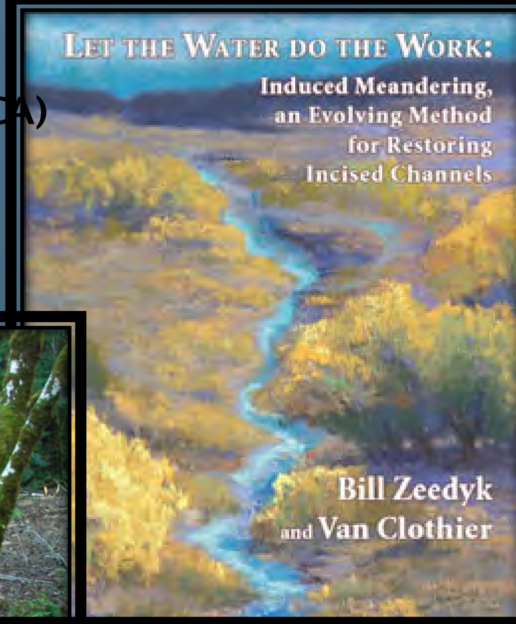
Since 2009, a combination of BDAs and beaver turned a narrow single thread channel with an infrequently inundated floodplain into a multi-threaded channel with water levels close to the floodplain surface most of the year

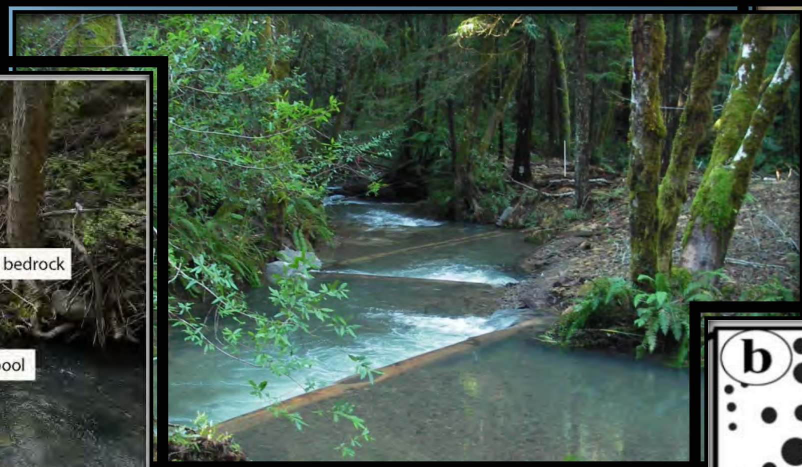
extent

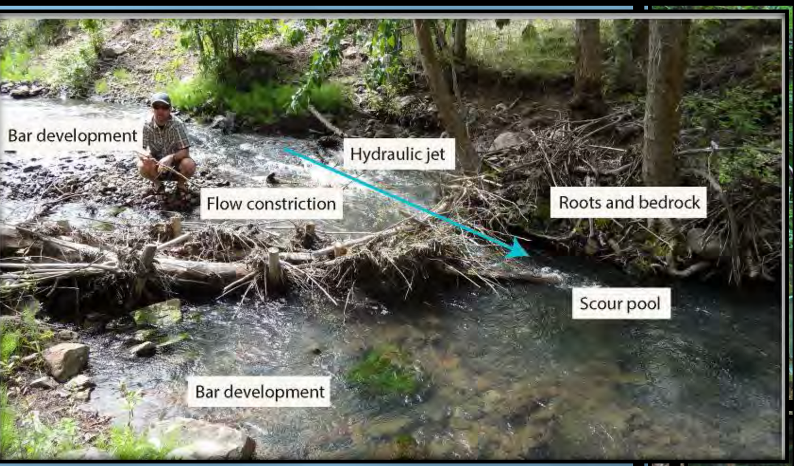
2014 Water extent

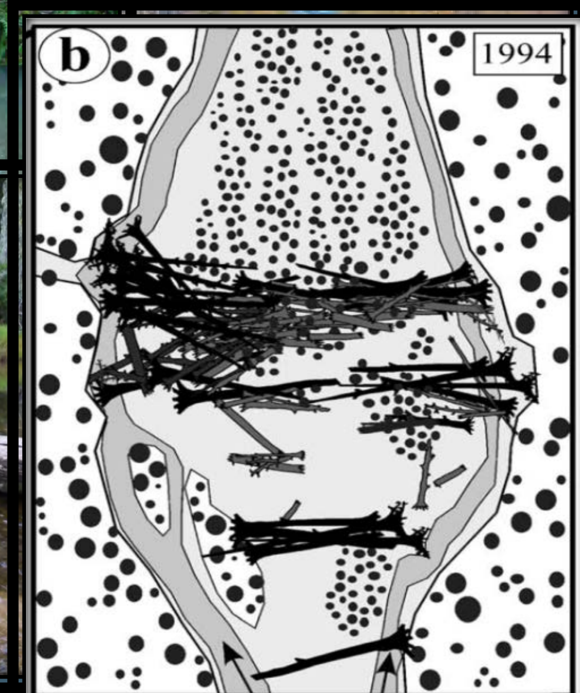
Wood-based Stage Zero Restoration Tools

Log Steps (USFS-many locales, T. McKee-Mattole R., CA)
Wood Jams (Many locales, e.g. Rocco Fiori, Klamath River, CA)
Gravel Dams (Campbell Ranch-Silvies R., OR, CDA Tr., ID)
Meander Dams (Quivira Coalition, NM)
Constriction Dams (N. Bouwes-Asotin R., WA)
Choke Dams (P. Devries-Idaho)









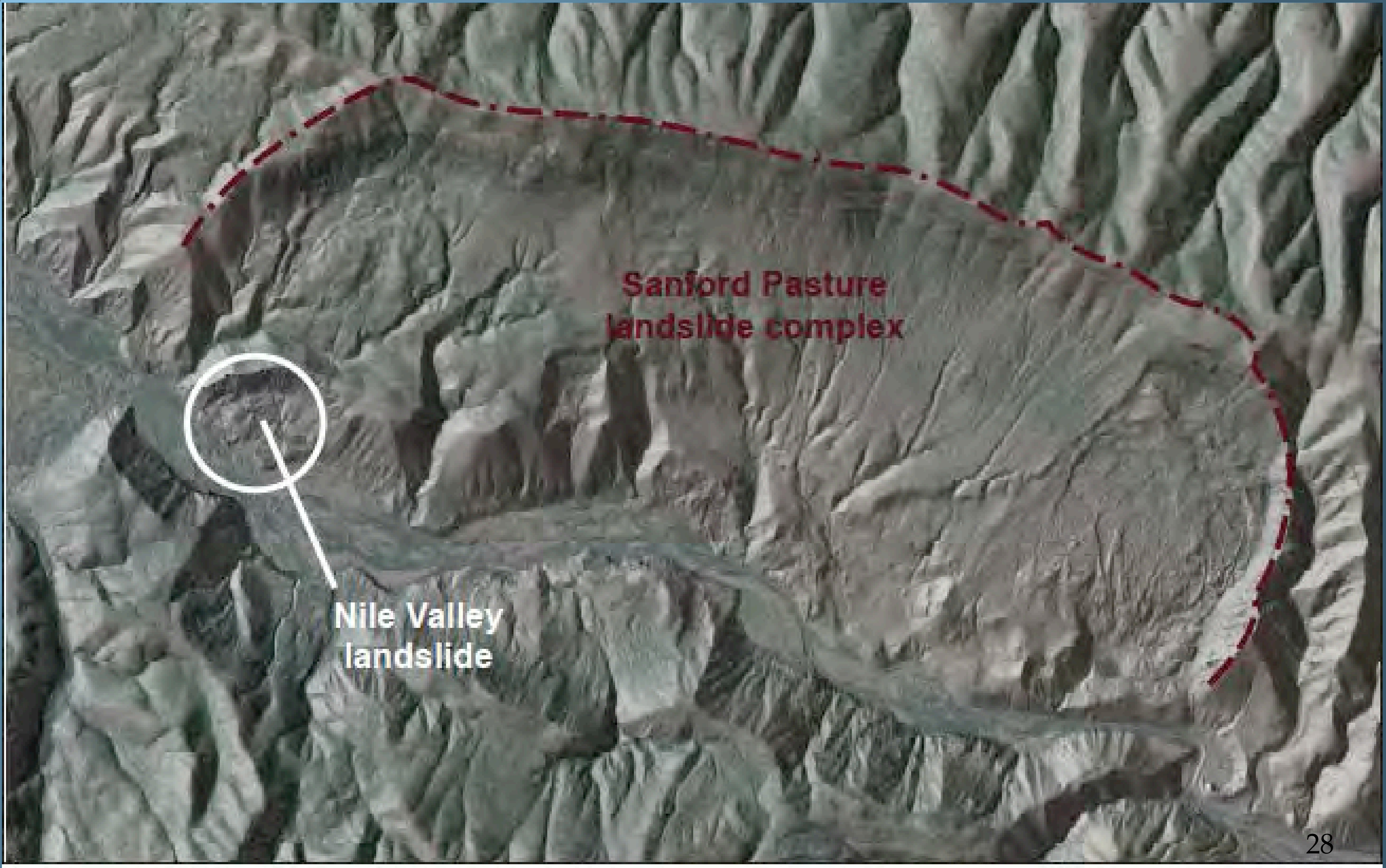
State-of-the-art wood jams in the Klamath

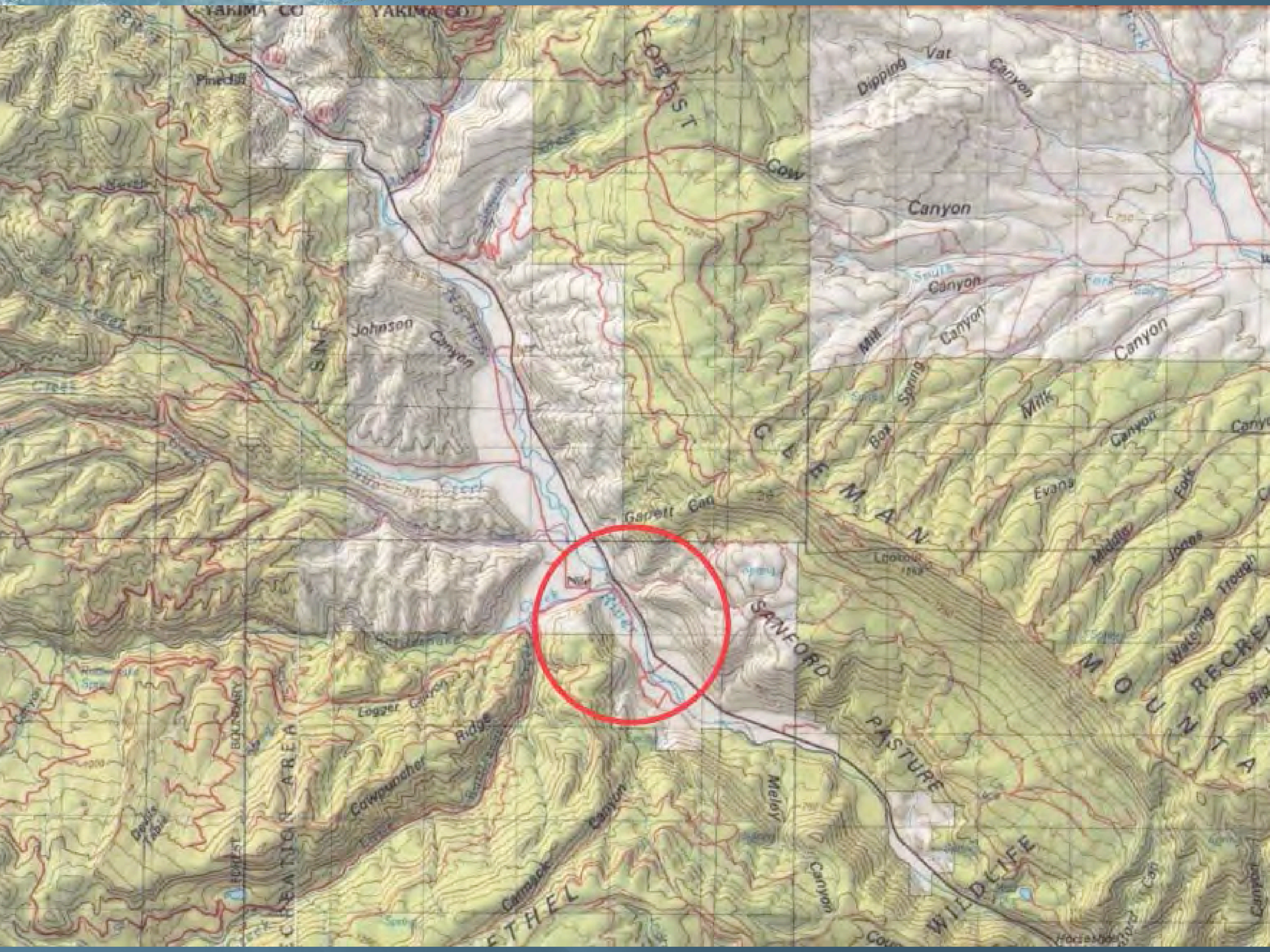
Levee Removal

- In and of itself can (re)create stage zero systems
- Flow/sediment obstructions should accelerate habitat recovery

Eel River, CA

Naches River, WA (Nile Valley) Landslide





YAKIMA CO
Pinedale
Dipping Vat Canyon
FOREST
Cow Canyon
South Fork
Canyon
Mill Canyon
Canyon
Johnson Canyon
Box Spring
Milk Canyon
Evans
Middle Fork
Jones
Watering Trough
CLEMAN
MOUNTAIN
RECREA
Lookout
SANFORD PASTURE
Garrett Gap
River
Logger Canyon
Cowpuncher Ridge
Cormack Canyon
Meloy Canyon
WILDLIFE
RECREATION AREA
BOUNDARY
ETHEL

Landslides Can Create Good Salmon Habitat

Controls on valley width in mountainous landscapes: The role of landsliding and implications for salmonid habitat

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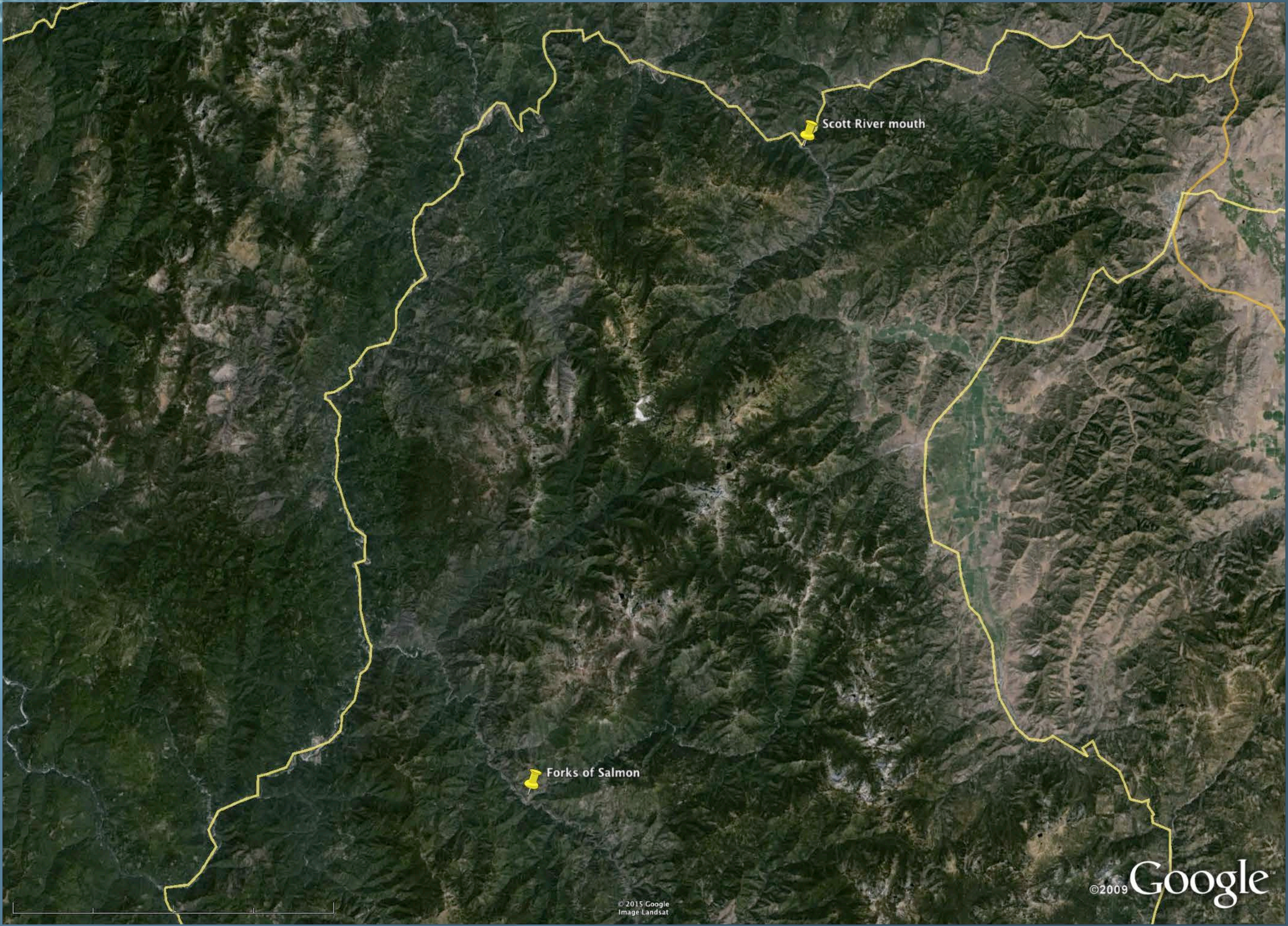
ABSTRACT

A fundamental yet unresolved question in fluvial geomorphology is what controls the width of valleys in mountainous terrain. Establishing a predictive relation for valley floor width is critical for realizing links between aquatic ecology and geomorphology because the most productive riverine habitats often occur in low-gradient streams with broad floodplains. Working in the Oregon Coast Range (western United States), we used airborne lidar to explore controls on valley width, and couple these findings with models of salmon habitat potential. We defined how valley floor width varies with drainage area in a catchment that exhibits relatively uniform ridge-and-valley topography sculpted by shallow landslides and debris flows. In drainage areas >0.1 km^2, valley width increases as a power law function of drainage area with an exponent of ~0.6. Consequently, valley width increases more rapidly downstream than channel width (exponent of ~0.4), as derived by local hydraulic geometry. We used this baseline valley width–drainage area function to determine how ancient deep-seated landslides in a nearby catchment influence valley width. Anomalously wide valleys tend to occur upstream of, and adjacent to, large landslides, while downstream valley segments are narrower than predicted from our baseline relation. According to coho salmon habitat-potential models, broad valley segments associated with deep-seated landsliding resulted in a greater proportion of the channel network hosting productive habitat. Because large landslides in this area are structurally controlled, our findings indicate a strong link between geologic properties and aquatic habitat.

sediment by providing space for the formation of debris flow fans. In addition, low-gradient broad valleys with old-growth forest store the great majority of above-ground and below-ground carbon in mountain streams (Wohl et al., 2012). Understanding the links between hillslope processes and riverine habitat is particularly important for Pacific salmon (*Oncorhynchus* spp.) because these fish are intricately tied to Pacific Rim topography (Montgomery, 2000; Waples et al., 2008).

The goals of this paper are twofold. First, we seek to define an empirical relation between valley width and drainage area (akin to hydraulic geometry for river channels) in a setting with negligible influence from variable rock properties and deep-seated landslide activity. Our approach uses high-resolution topography generated from airborne lidar to define this baseline


Scott River mouth
Forks of Salmon
© 2015 Google
Image Landsat
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Sea Level Rise Lowers Stream Gradients

If all the ice melts, >200 ft sea level rise

- 1-4 foot rise predicted in next 85 yr, but predicted rates keep increasing.
- Circa 5000 yrs for 200 foot rise (big error bars), but on the scale of the rise and fall of civilizations
- Sacramento = 30 feet above sea level.
- Need sediment to counteract rising seas.

National Geographic 2014

Is this a map of the past or a blueprint for the future? Is this the Central Valley 150 Year Restoration Plan?

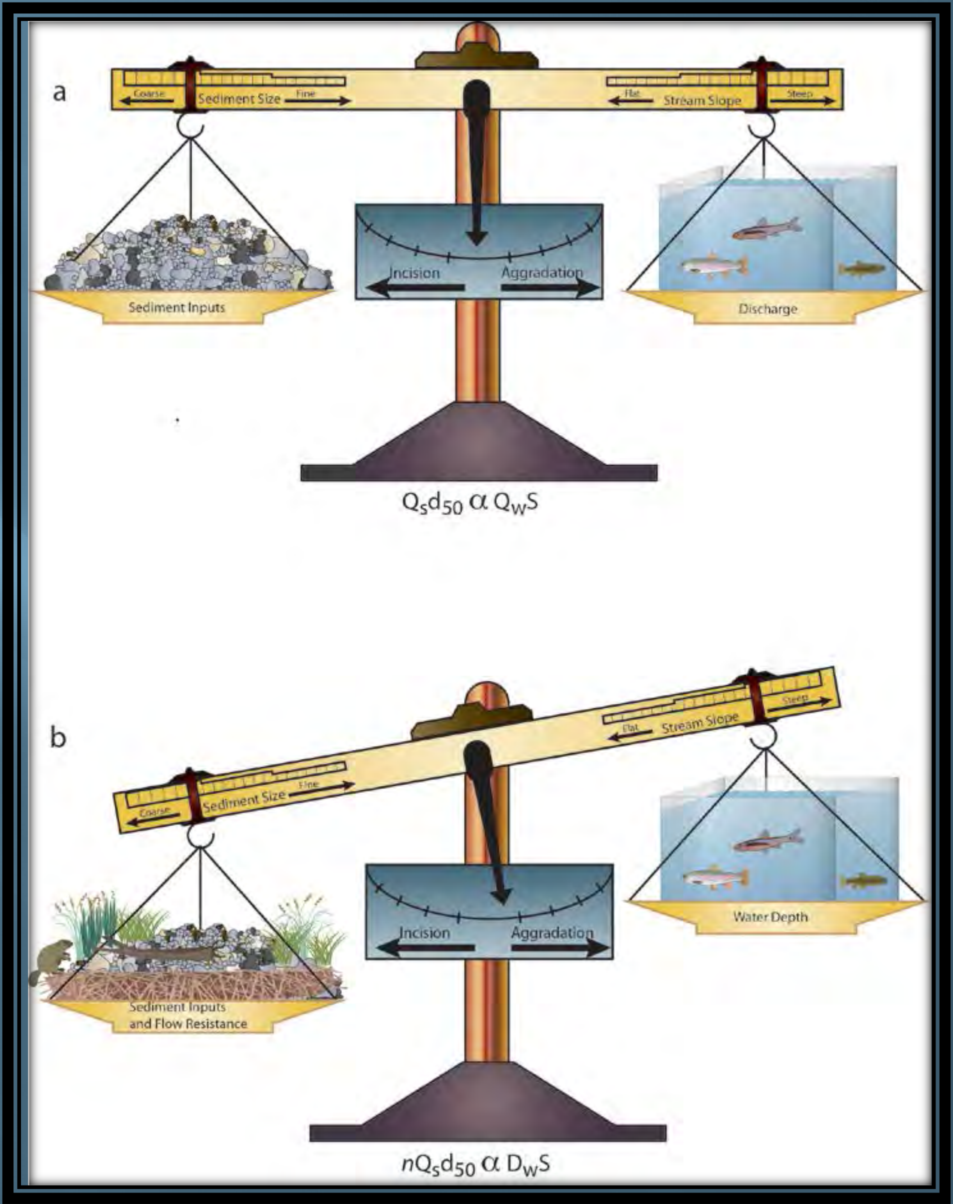
No farms, no food, but…
No water no farms,
No sediment, no farmland

Floods are inconvenient but droughts destroy civilizations

Conclusions

- No sediment = no alluvial valleys
- Three components to stream restoration
  - Sediment, Water and Biota
- Base flow water elevation is key
- Numerous physical and biological processes act at multiple spatial and temporal scales to effectively lower stream and valley slopes and stream power per unit width—This increases retention rates of both sediment and water, and this is a good thing for salmon (and farmers)
- The dawning of the age of aggradation?

Continuity or Habitat, the choice is yours



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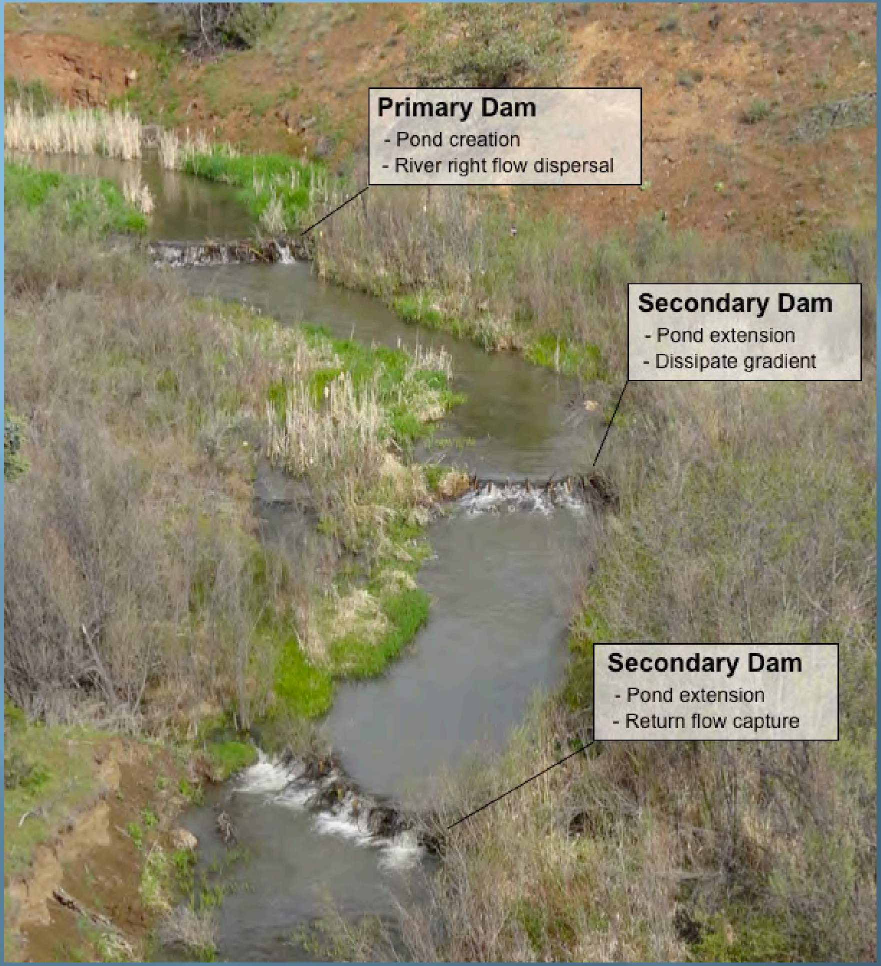
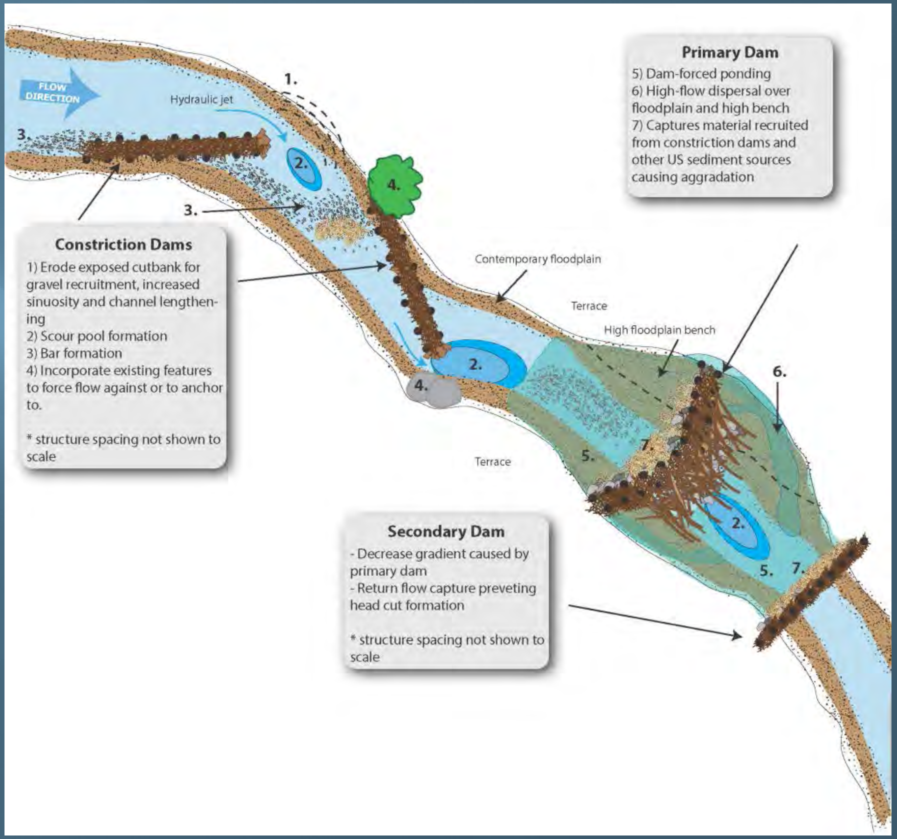
BDAs work together





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Tectonics can lower stream gradients