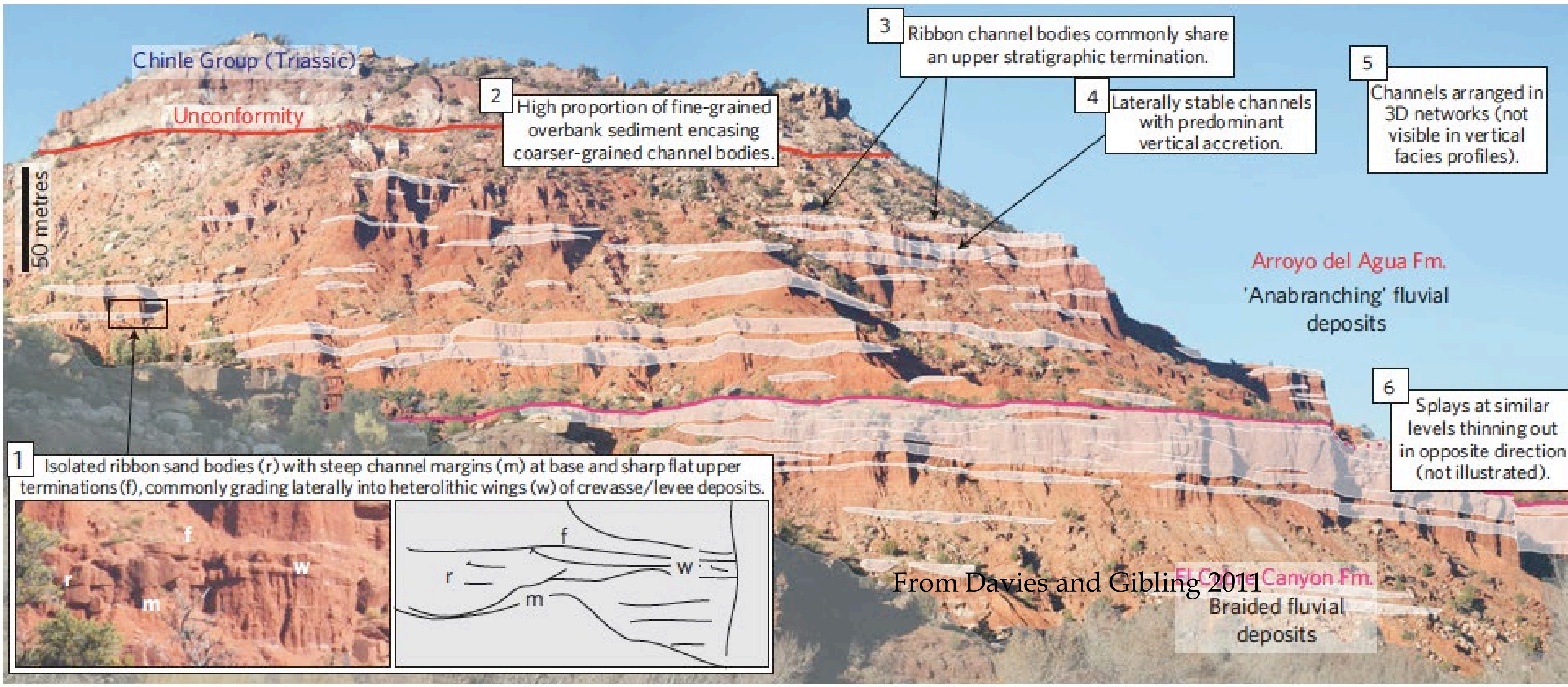
Using Dams to Restore Ecosystems

Michael M. Pollock NOAA Fisheries-Northwest Fisheries Science Center, Seattle WA
Brian Cluer NOAA Fisheries Western Regional Office, Santa Rosa, CA

What is a Dam?

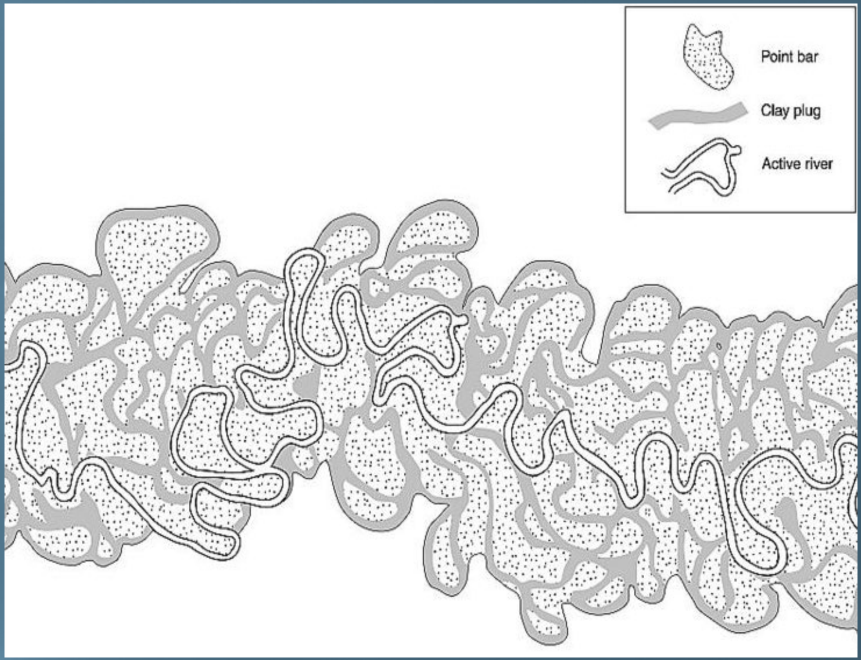
- Structure that impedes movement of water and sediment
- Usually considered beneficial to economic concerns and adverse to ecologic concerns
- Benefit/Harm often a question of scale
- Scale-appropriate dams can benefit economy and ecology
- The natural world provides many examples of dams and their long-term effects
- Natural dams a model for future dam-building efforts
- Key function of natural dams = groundwater recharge

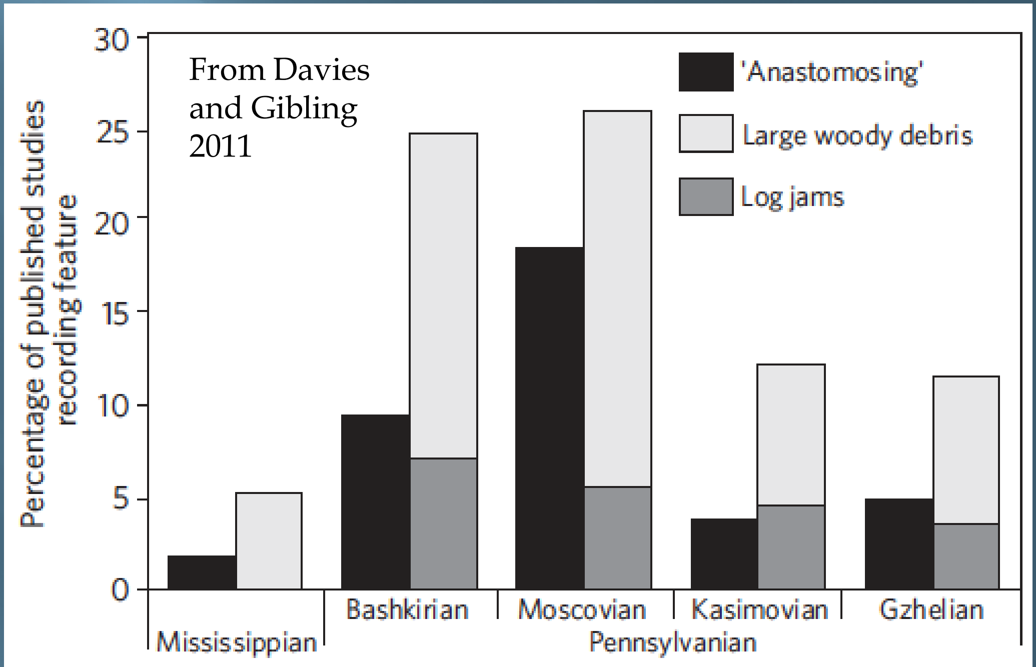
Rivers, plants and instream obstructions have been around for a long time (we haven't)



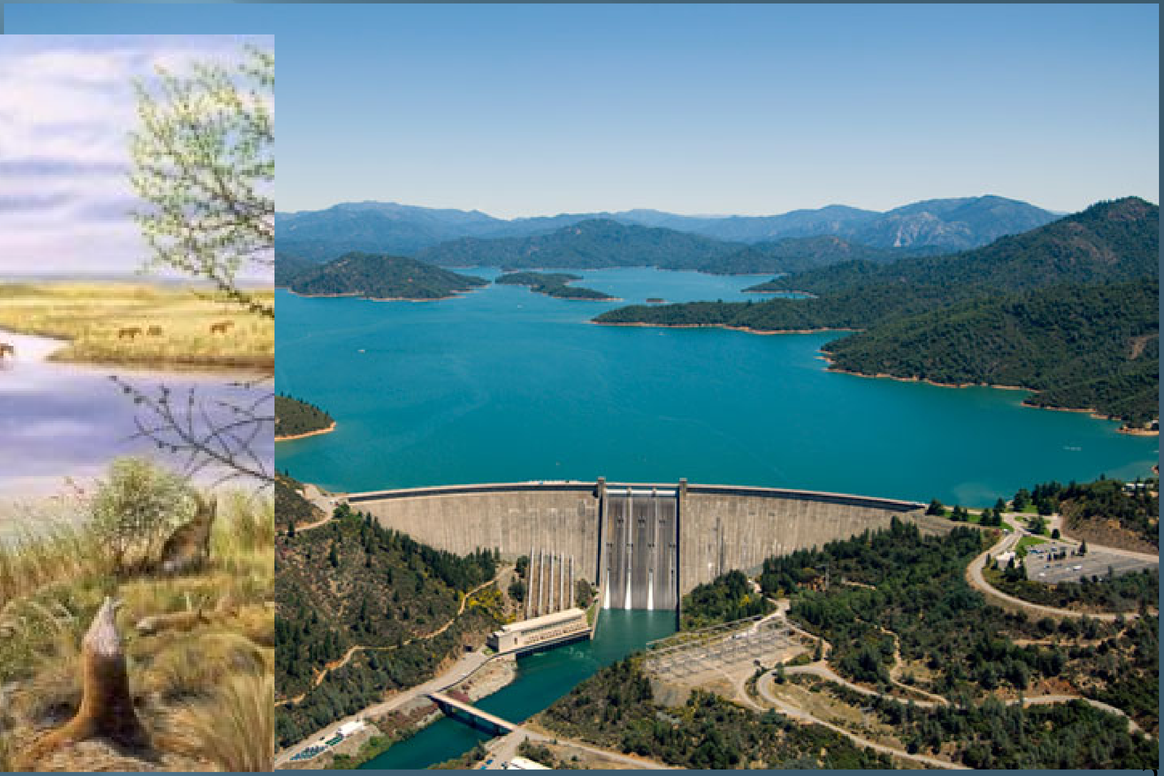
From Davies and Gibling 2011

Anastomosing, large wood and log jams (obstructions) all arose together in the geologic record about 320 mybp



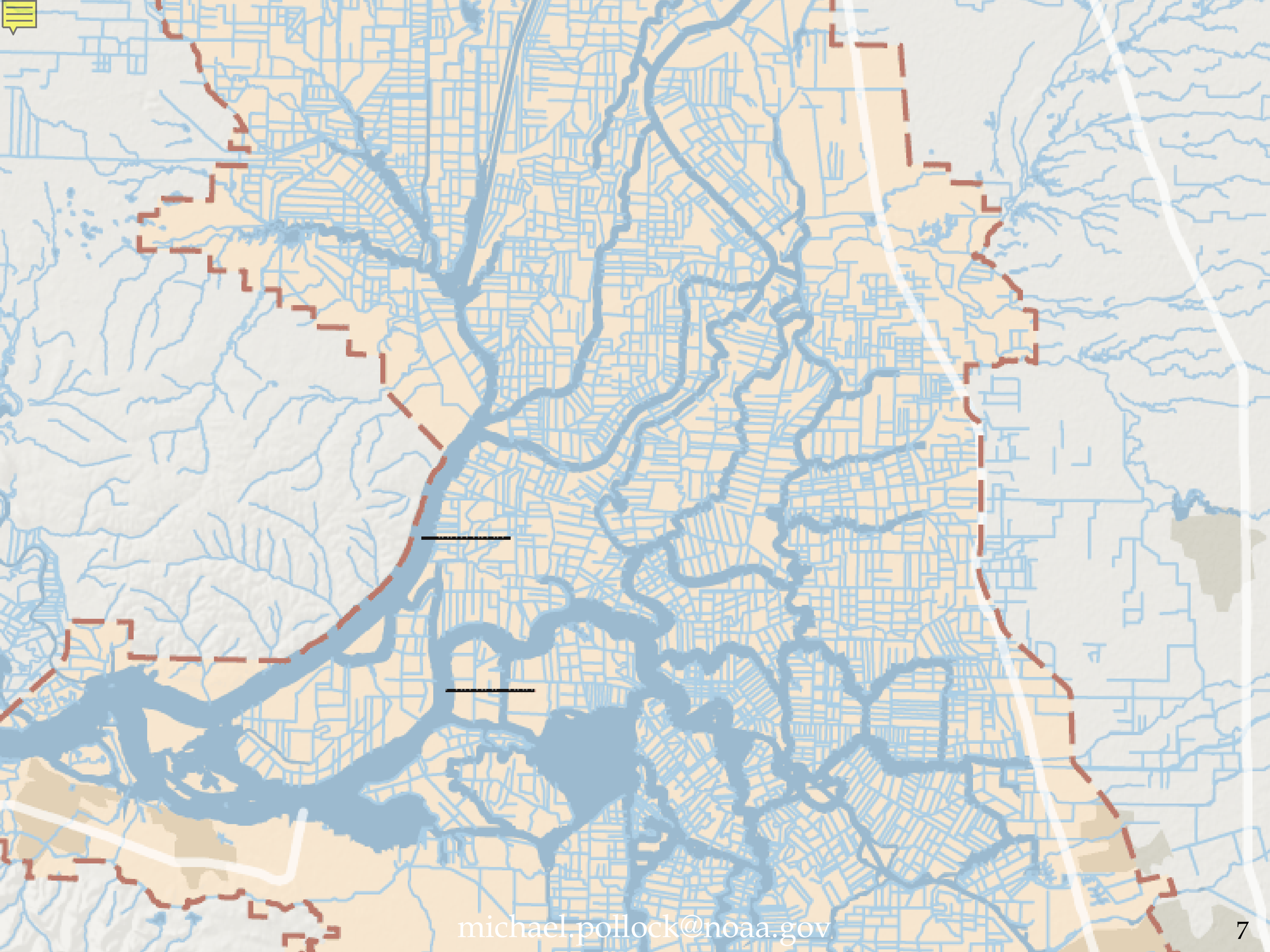


-Beaver appear in the Miocene (about 30 mybp); Beaver dams appear in the Pliocene (about 3-5 mybp)
-Humans appear about 3 mybp and human dams appear about 0.001-0.0001 mybp



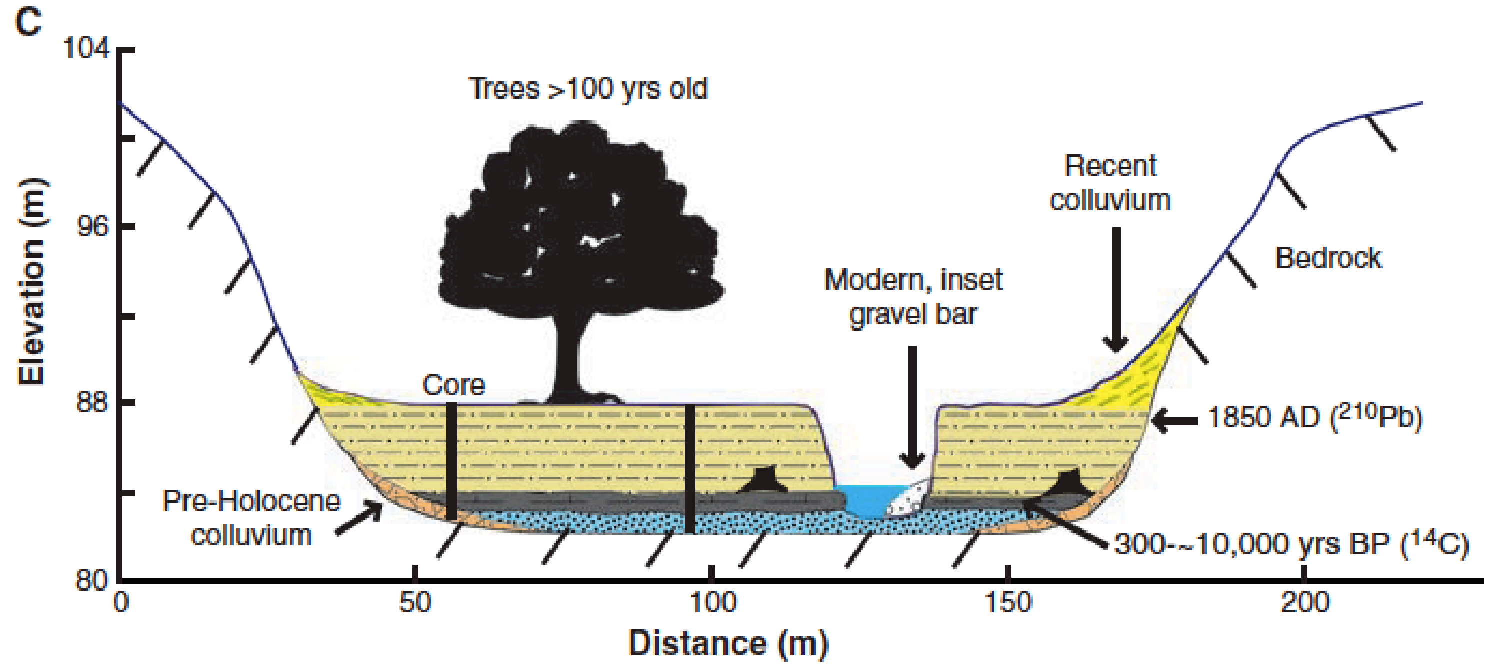
Incision is a widespread problem – leads to lower water tables

We are even “restoring” incised streams



michael.pollock@noaa.gov

"Gravel-bedded streams are thought to have a characteristic meandering form bordered by a self-formed, fine-grained floodplain. This ideal guides a multibillion-dollar stream restoration industry… We show instead that before European settlement, the streams were small anabranching channels within extensive vegetated wetlands that accumulated little sediment but stored substantial organic carbon."-Walter and Merritts 2008.

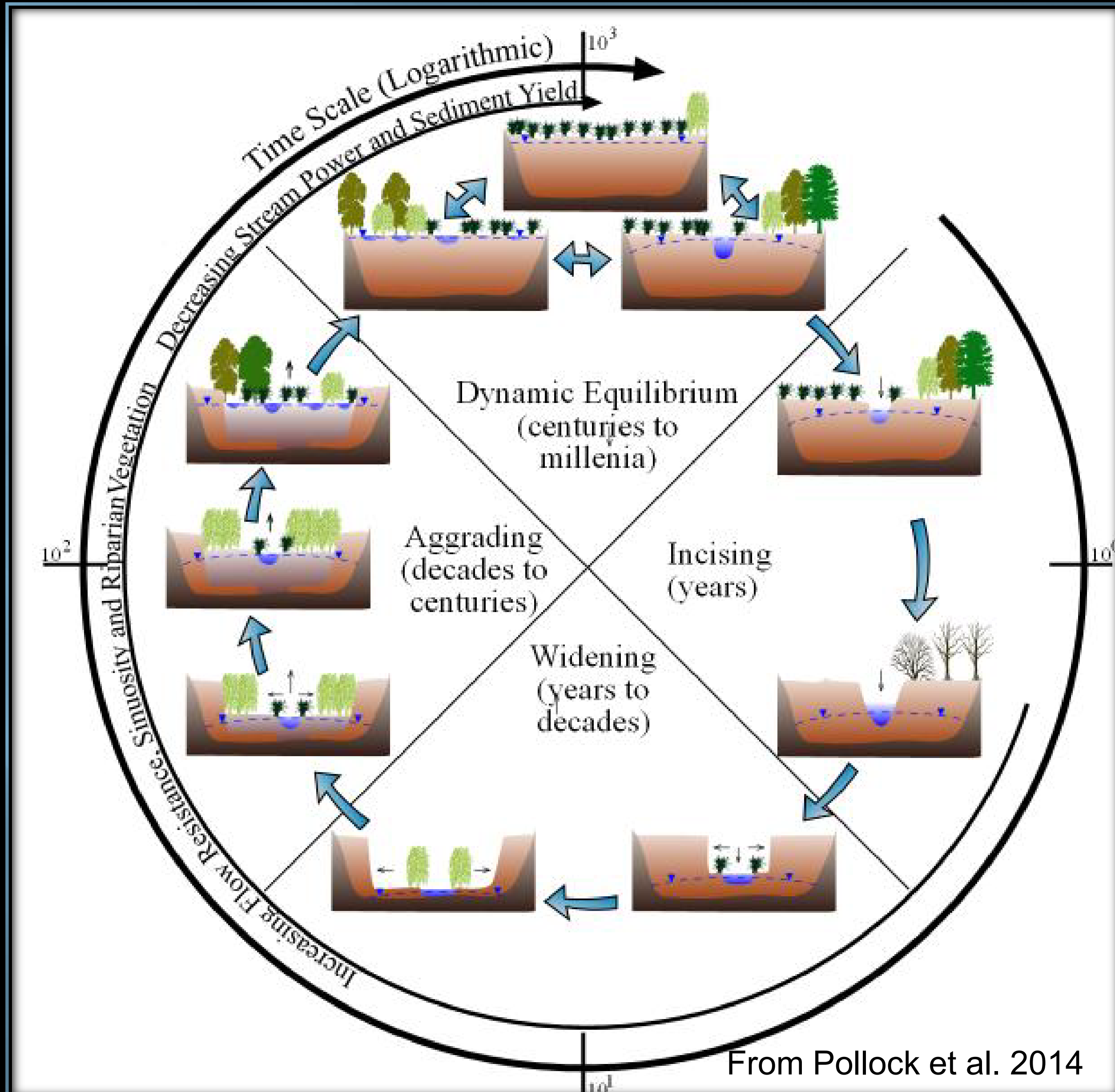


Putah Creek, California

Salmon River, Idaho

michael.pollock@noaa.gov

Natural Recovery Rates Can be Long

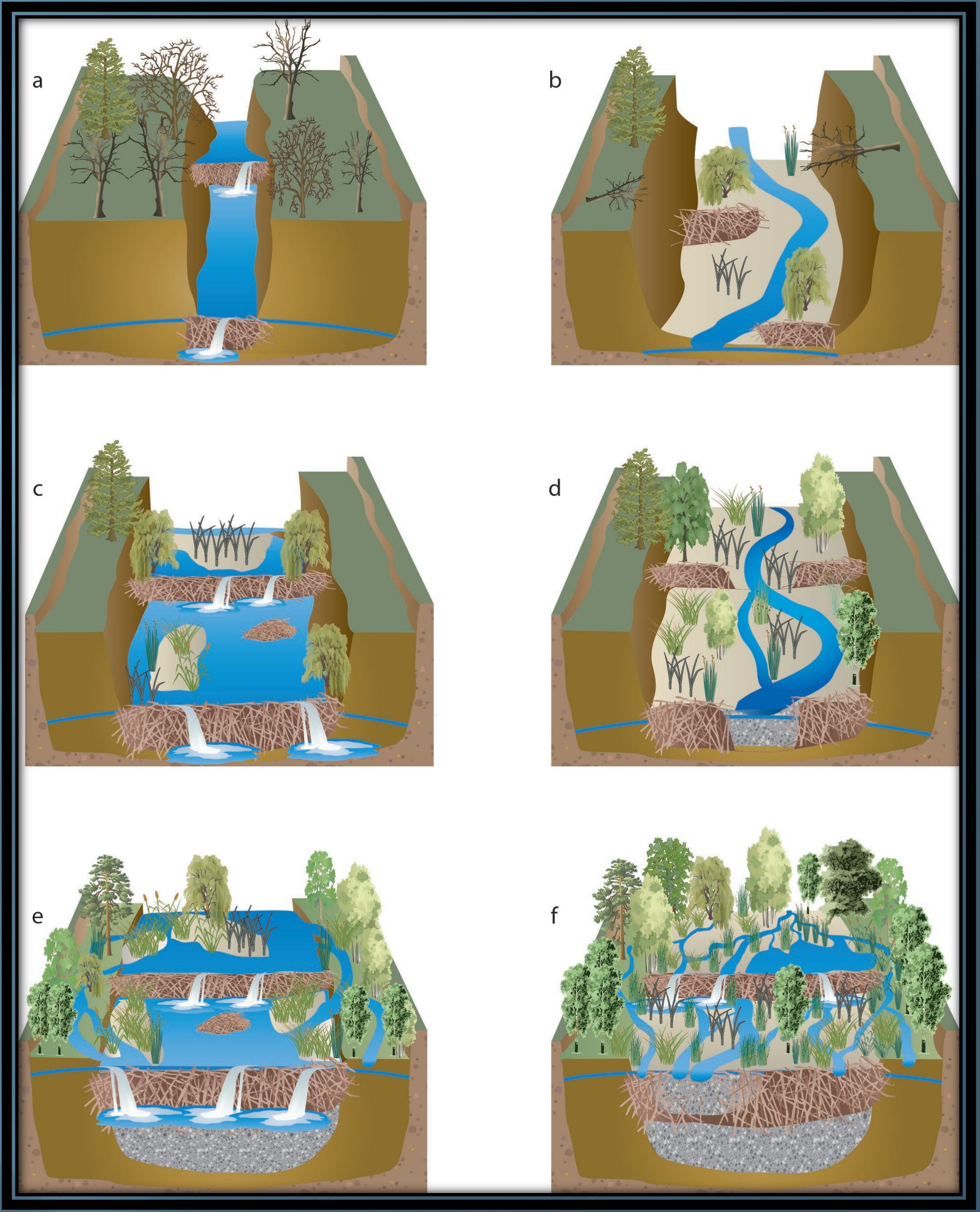


From Pollock et al. 2014

michael.pollock@noaa.gov

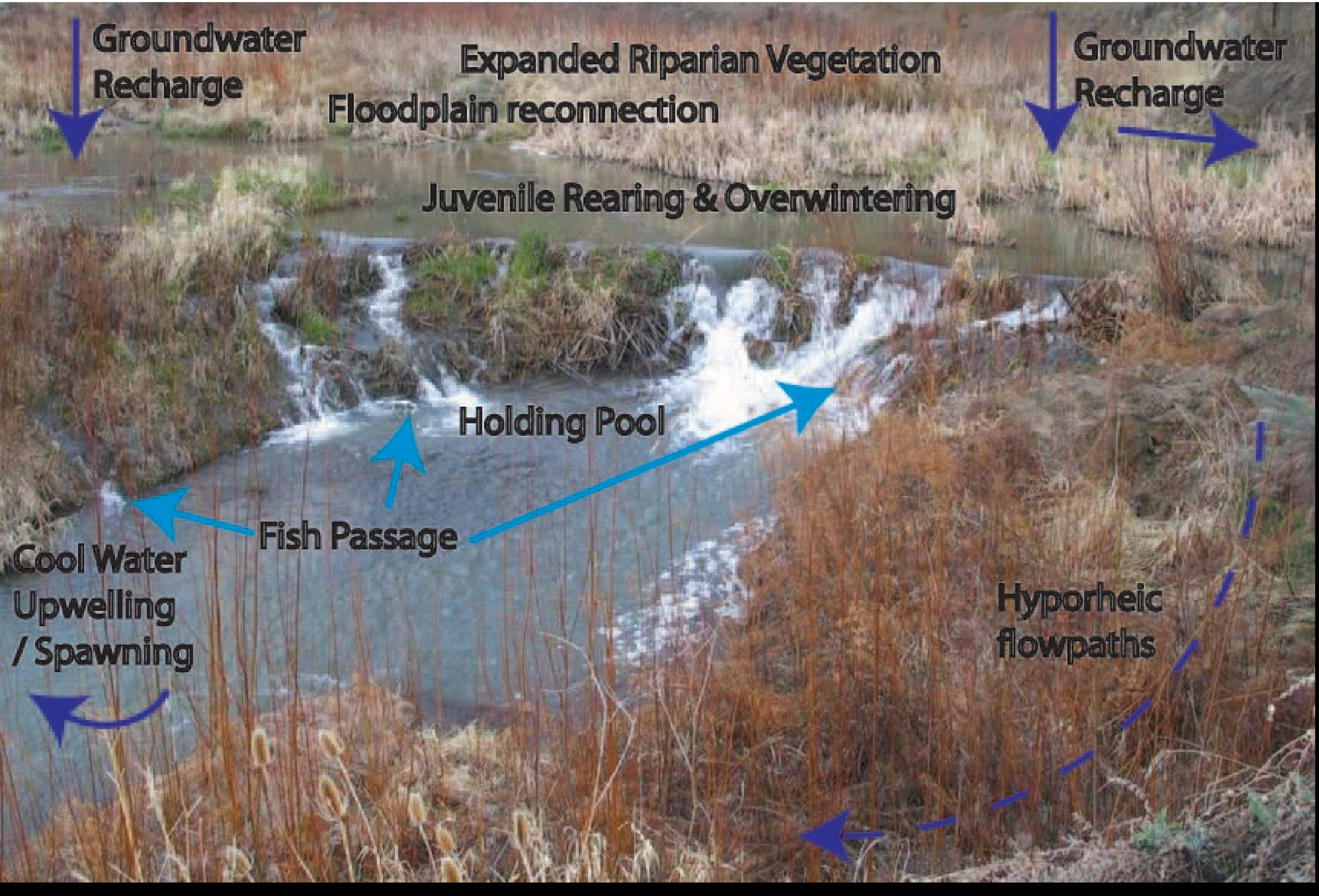
Beaver Dams

-Can reduce recovery by 1-2 orders of magnitude (year to decades instead of decades to centuries)



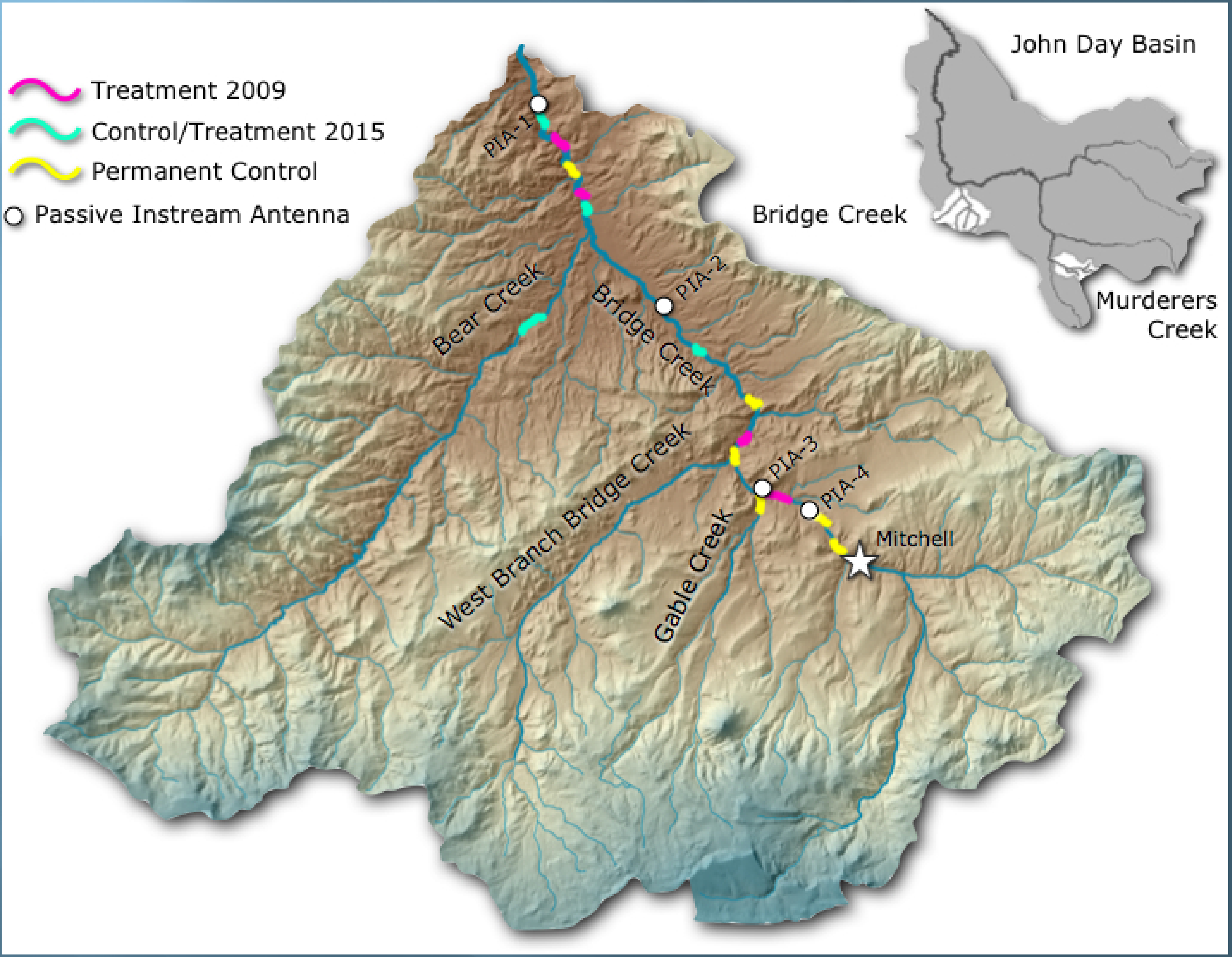
From Pollock et al. 2014

Beaver dams create high value habitat



Beaver Dams and Beaver Dam Analogues

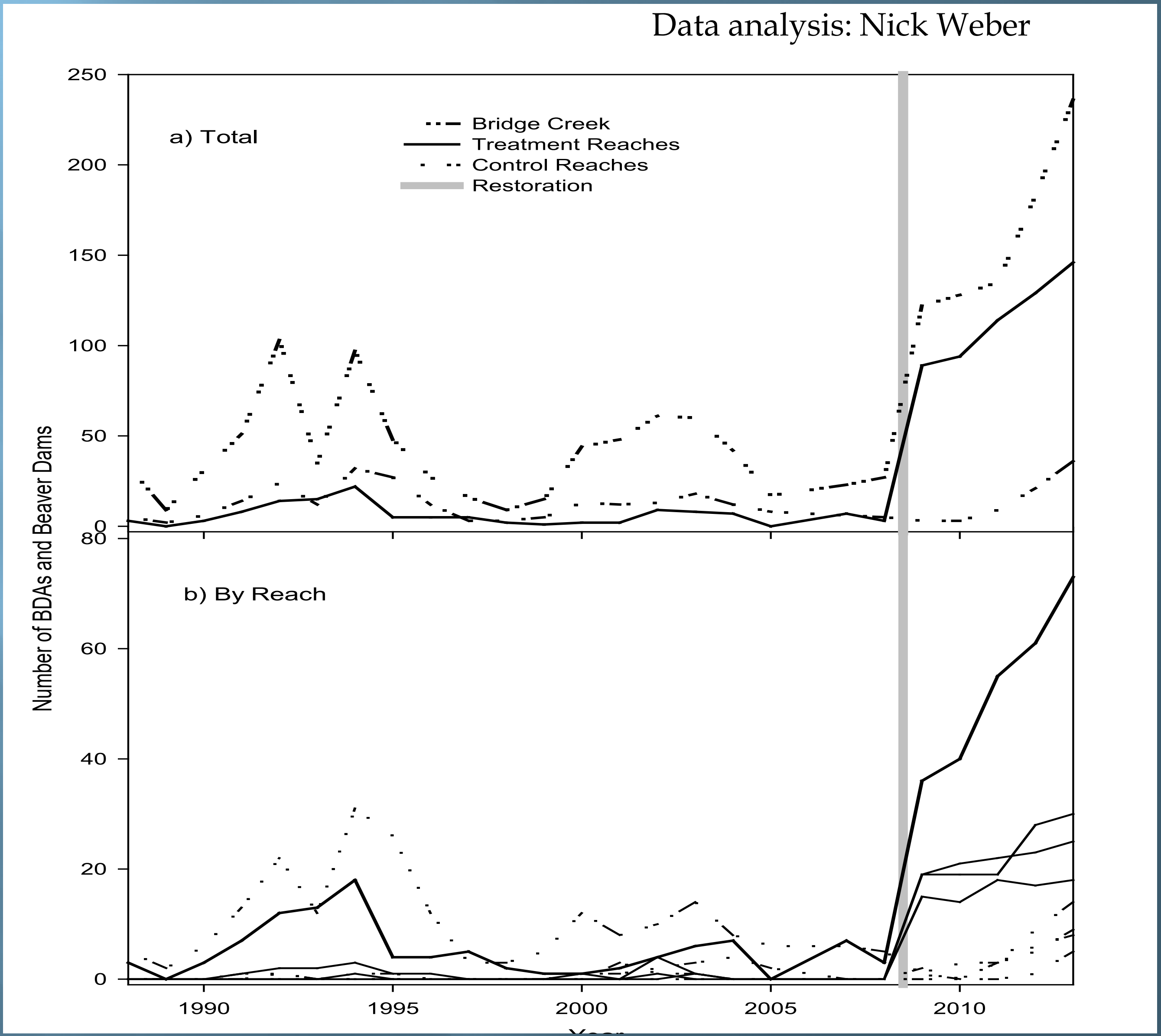
Bridge Creek Long-Term Restoration and Monitoring Project



Beaver Dam Analogues-Reach Scale Treatment

Figure courtesy of Carol Volk

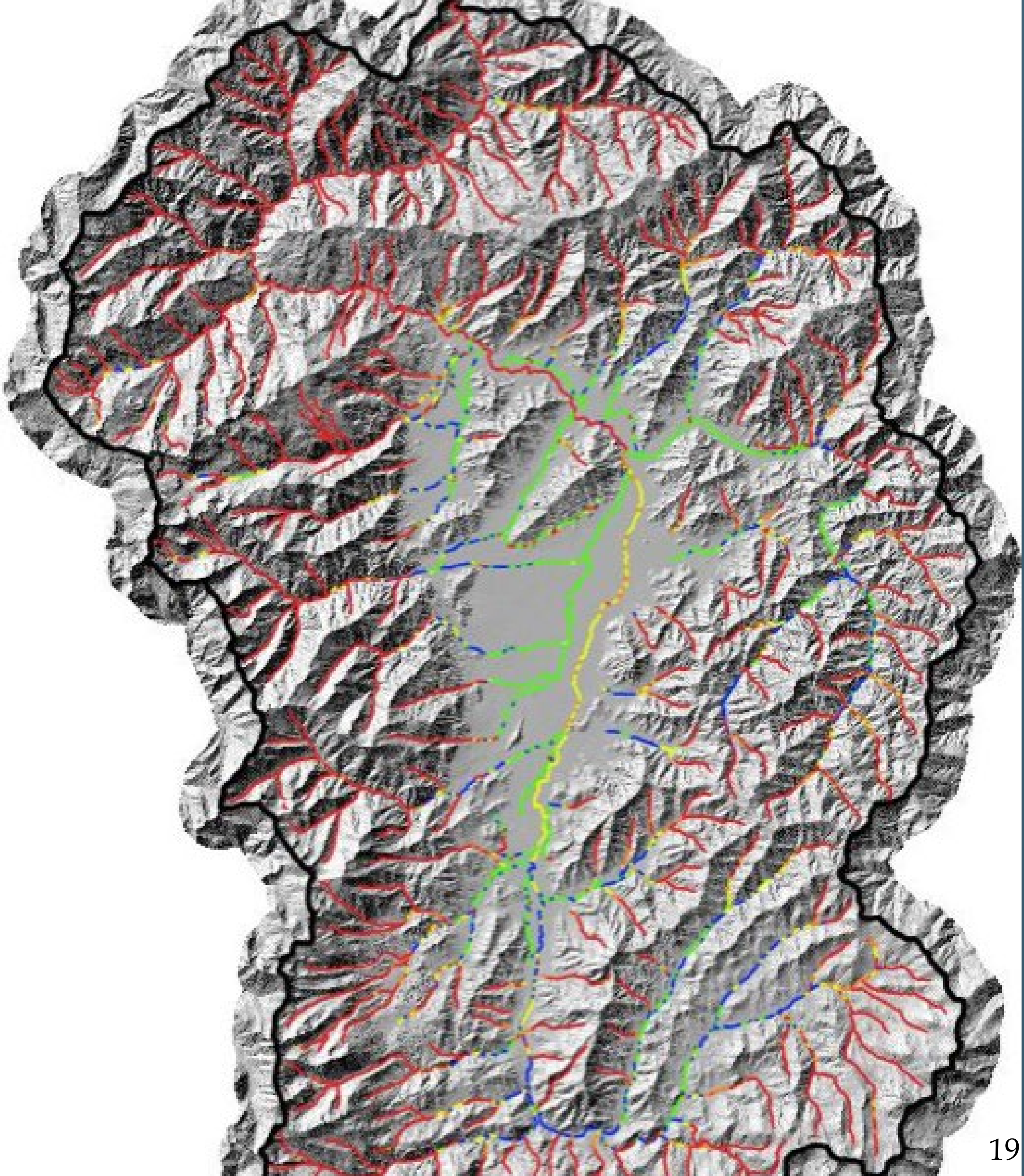
Beaver Response to BDAs



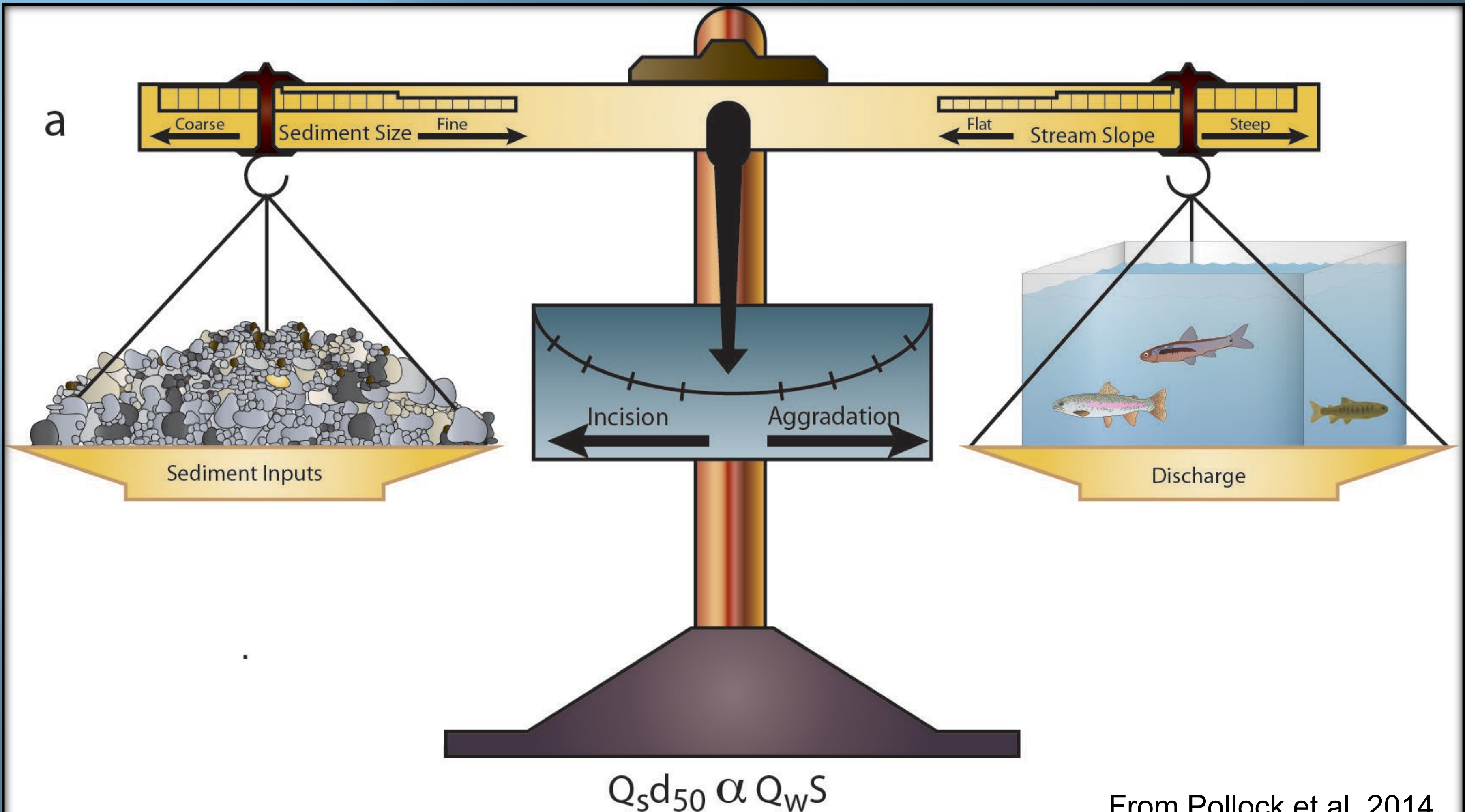
Beaver and BDAs working together

Photo: Courtesy of Nick Weber

Beaver Intrinsic Potential Model helps guide natural dam placement- very different from hydropower or storage dams



Principles for Restoring Incised Streams



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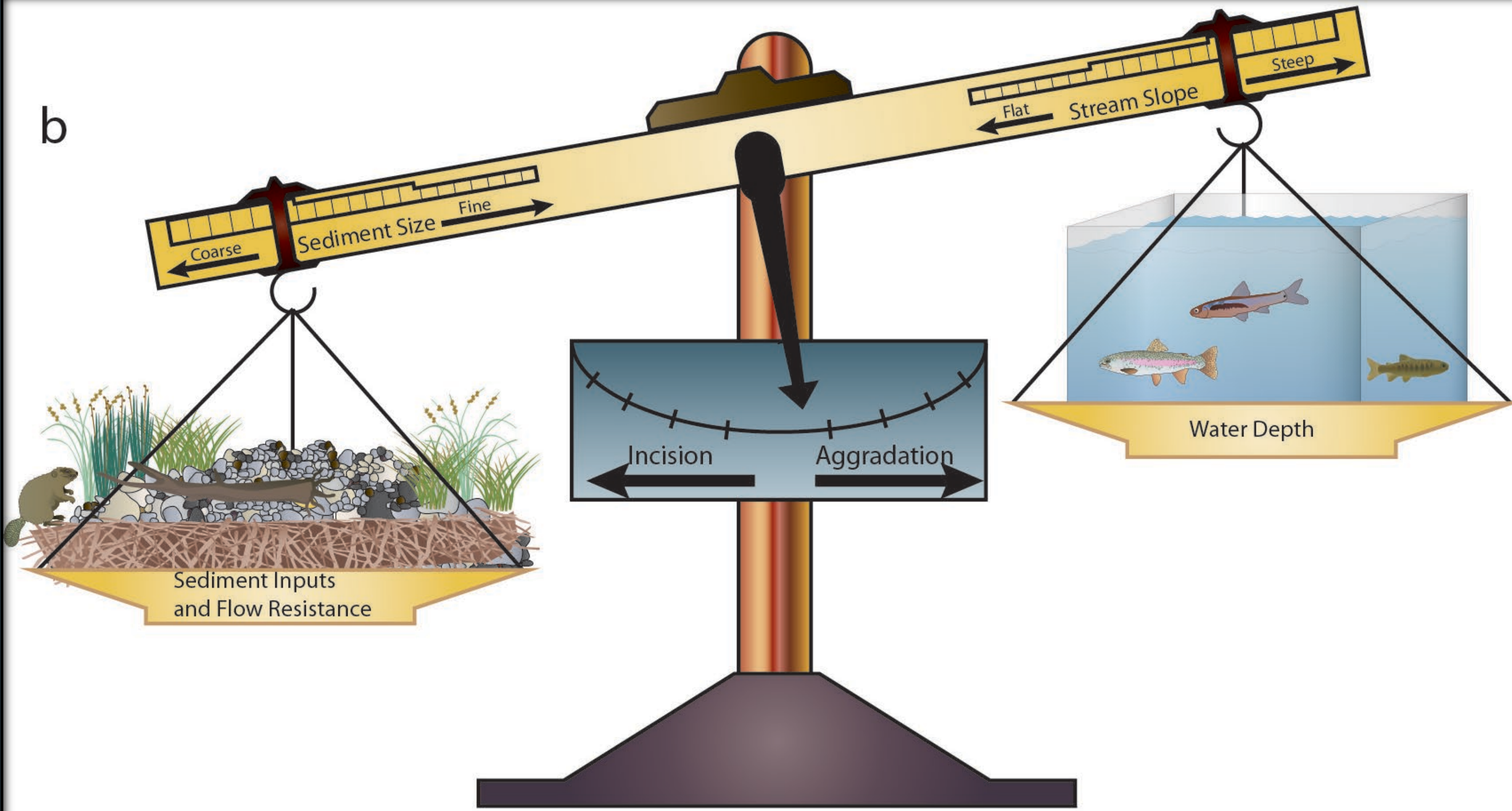
michael.pollock@noaa.gov

Key is Increased Flow Resistance (aka dams)

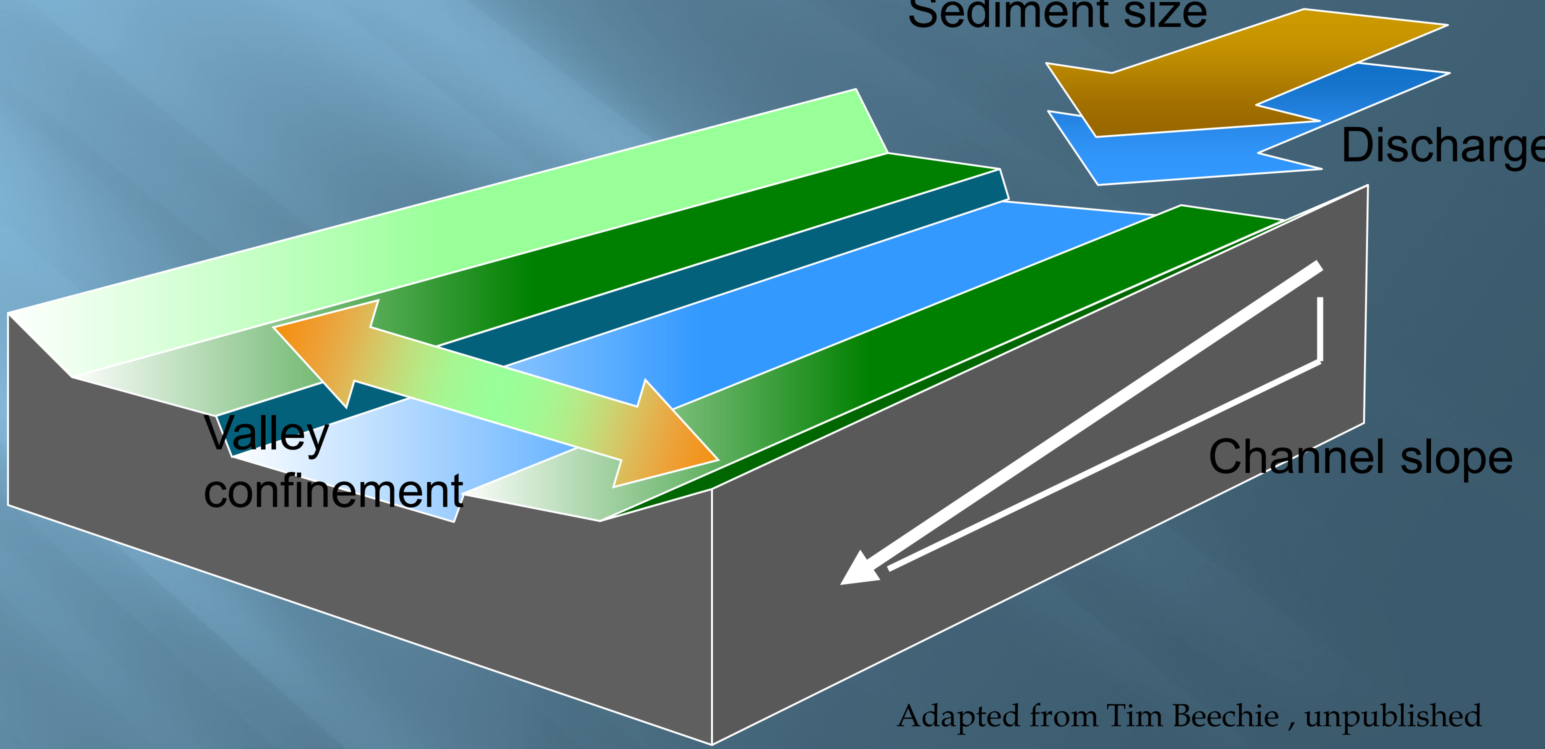


$$nQ_s d_{50} \alpha D_W S$$

From Pollock et al. 2014

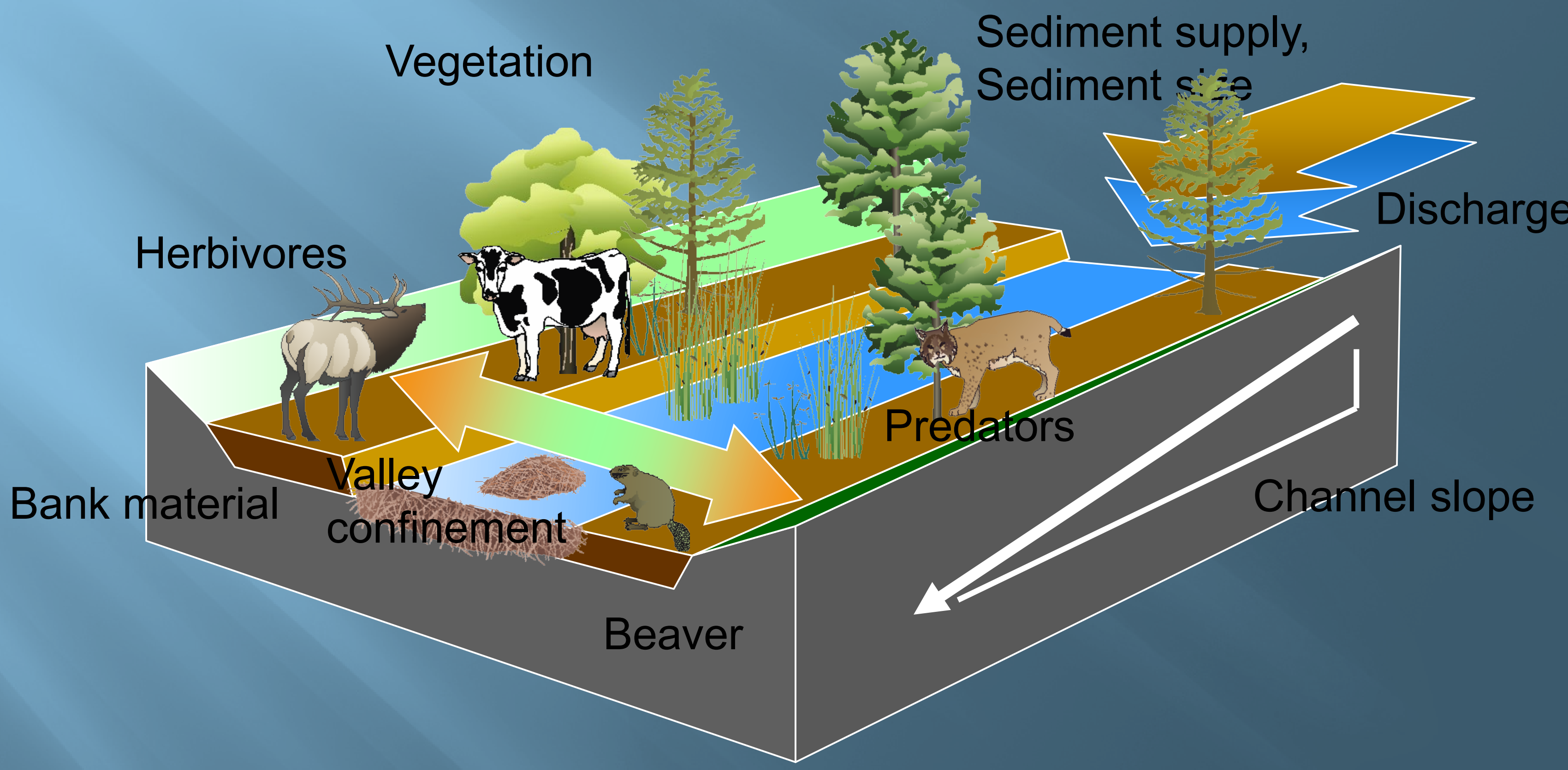
michael.pollock@noaa.gov

Factors Controlling Stream Ecosystem Formation



Adapted from Tim Beechie , unpublished

Factors Controlling Stream Ecosystem Formation



michael.pollock@noaa.gov

Types of Natural "Dams" Operating at Differing Time Scales

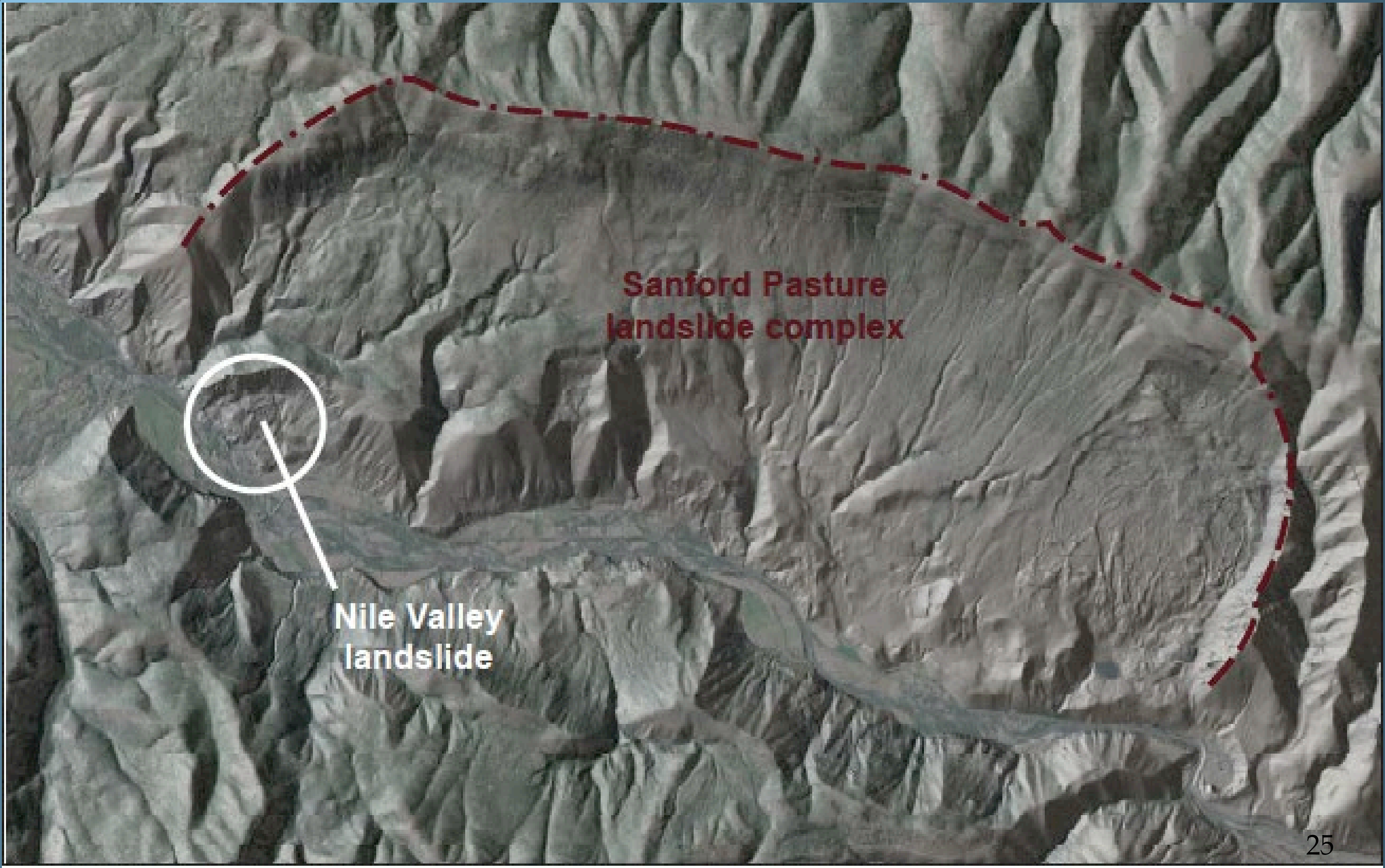
- Beaver Dams
- Live Vegetation
- Large Wood
- Landslides
- Alluvial Fans
- Sea Level Rise
- Tectonics

Increasing Time Scales

Key Functions:

- Increase flow resistance,
- Lower slope
- Reduce stream power/unit width

Landslides-Naches River, WA (Nile Valley)



Landslides Create Good Salmon Habitat

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

C. May[1], J. Roering[2], L.S. Eaton[3], and K.M. Burnett[4]
[1]Department of Biology, James Madison University, Harrisonburg, Virginia 22807, USA
[2]Department of Geological Sciences, University of Oregon, Eugene, Oregon 97403, USA
[3]Department of Geology and Environmental Science, James Madison University, Harrisonburg, Virginia 22807, USA
[4]U.S. Forest Service Pacific Northwest Research Station, Corvallis, Oregon 97331, USA

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

Sea Level Rise- A Grade Changer

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

- 1-6 foot rise predicted in next 85 yr, but predicted rates keep increasing.
- 1000+ yrs for 200 foot rise (big error bars), but on the scale of the rise and fall of civilizations
- Need sediment to counteract rising seas.

National Geographic 2014

Conclusions-1

- Dynamic tension between drainage and recharge goals
- Groundwater Recovery = Stream Restoration = Valley Restoration = Sediment Management
- Dams a natural and essential component to properly functioning streams
- Provide economic and ecologic value
- Observation of natural dams suggests how we can design dams for economic and ecologic functions

michael.pollock@noaa.gov

Conclusions-2

- Sediment is a resource
  - No sediment = no alluvial valleys
  - Base flow water elevation is key design feature
- Three components to stream and groundwater restoration
  - Sediment, Water and Biota
- Restorative processes play out at multiple spatio-temporal scales to:
  - Lower stream and valley slopes
  - Lower stream power per unit width
  - Increase retention rates of sediment and water
  - Good for fish, good for farms

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