# **Panel Session Part 1:** Integrated Restoration & Design Approaches

- **Rich Starr**, Ecosystem Planning & Restoration Columbia, MD

- **Jim Morris**, PE, Johnson, Mirmiran & Thompson (JMT), Cockeysville, MD

- **Joe Arrowsmith**, PE, Straughan Environmental, Columbia, MD

- **Bob Siegfried**, RES, Odenton, MD

# National Stream Conference – *Panel Discussion: Integrated Restoration & Design Approaches*

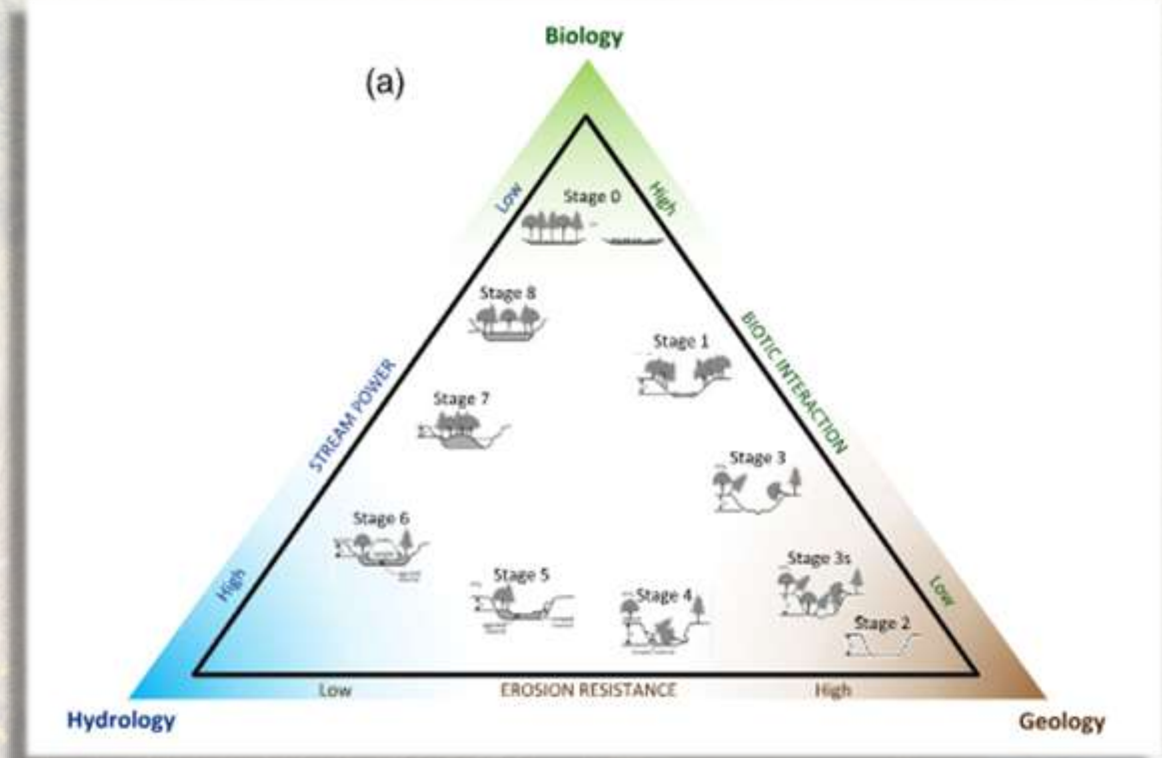
**Richard Starr**

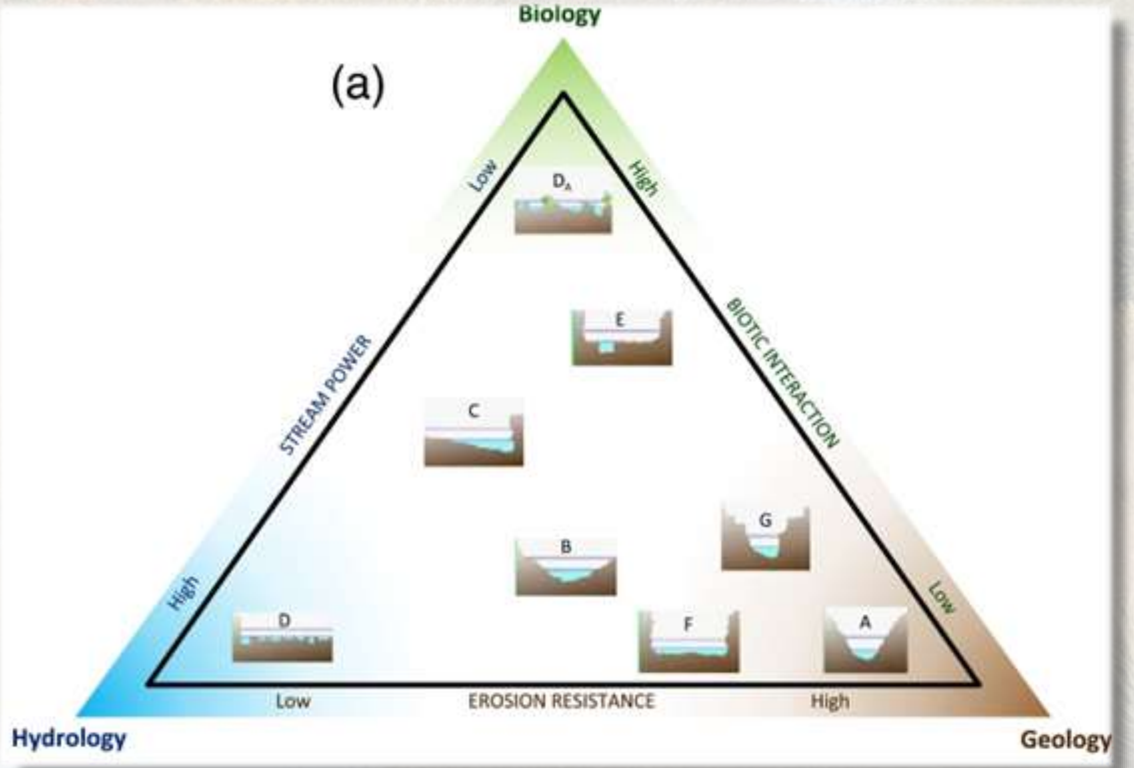
*Ecosystem Planning and Restoration*

**August 21, 2023**

# Integrated Restoration & Design

***Design a stream system that would naturally form and be self-sustaining over time and allows dynamic evolution to optimize ecological functional uplift***




Castro and Thorne 2019

# What Does this Mean?

- Project Purpose
- Project Goals and Objectives
- Stakeholder Interests
- Landscape Position
- Valley Type
- Stream System Type
- Watershed Condition
- Reach Level Condition
- Constraints/Stressors
- Restoration Potential

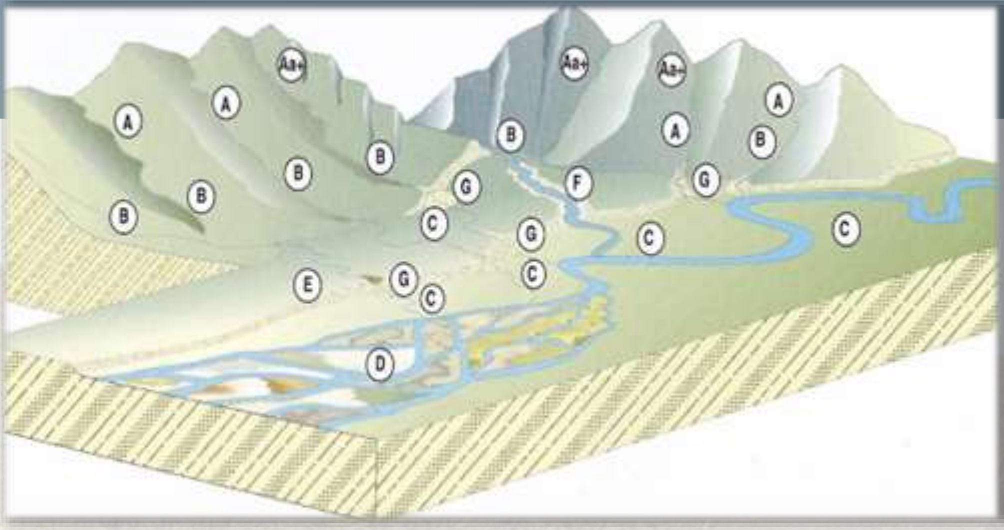
**Drivers**

Water Quality

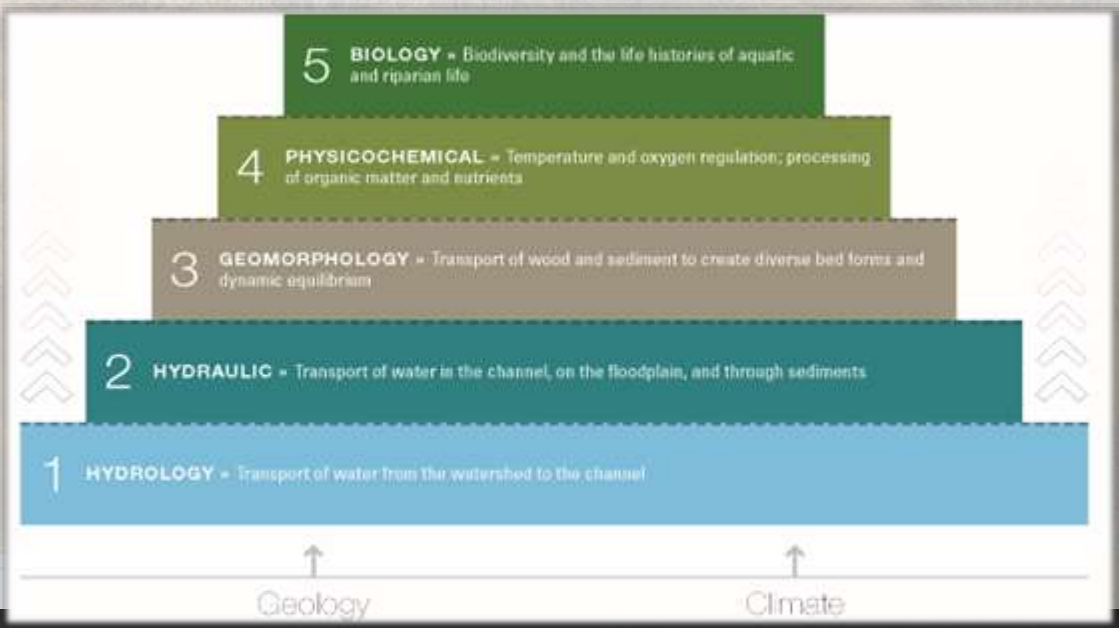
Biology

Stability

Others



Rosgen 2006




Harman et al 2012

# Design Approach Selection

***Focus on selecting restoration techniques rather than selecting a design approach.***

- **Meets project goals**
- **Addresses stressors and impairments**
- **Optimizing ecological uplift**
- **Minimizes impacts**







# Integrated Design

***Combination of design approaches and techniques can result in greater dynamic and resilient systems.***

- **Natural Channel Design**
- **Beaver Analog**
- **Valley Restoration**
- **Legacy Sediment Removal**
- **Regenerative Storm Conveyance**

Combined NCD /VR

NCD

VR

LSR

RSC

# Fundamental Principle of Natural Channel Design

***Design a stream system that will be self-sustaining over time, given existing and likely future conditions of the watershed, floodplain, and stream.***

Ridge/Valley Confined Valley NCD

Piedmont Unconfined Valley NCD/LCR

Coastal Plain Headwater RSC

Coastal Plain Unconfined Valley Base Flow Channel

# THANK YOU

**Richard Starr**
***Ecosystem Planning and Restoration***
Rstarr@EPRusa.net

**Learn more by visiting our website:**

# The Urban Toolbox

## Outfalls, Gullies, and Defining Success

**Joe Arrowsmith, PE**
Director, Ecosystem Restoration
jarrowsmith@straughanenvironmental.com
Straughan Environmental, Inc.

# Defining the urban headwater problem

1. Many urban headwaters have been lost permanently.
2. Remaining sites have been converted to stormwater conveyance (outfalls and gullies).
3. Urban valleys now regularly receive peak flows above and beyond any historical reference flood.
4. By nearly any metric they offer poor aquatic habitat (if any!).
5. They are a tremendous burden on downstream waters.


Most of them look something like this!

# But there is hope!

- **Receiving streams and rivers are still alive and RESILIENT!**
- **Urban headwaters are RESPONSIVE to intervention.**

# What does successful intervention look like?

1. **Introduce vertical stability**
2. **Improve the extent of water on the landscape**
3. **Provide "floodplain functions"**
4. **Create a vegetation gradient**

# The Toolbox

(examples)

# Step Pool Stormwater Conveyance (SPSC)

- Nature-based retrofit practice in degraded gullies
- Alternating sequence of riffles and/or cascades
- Steep slopes (close to 50% riffle/pool)
- Fill-based practice, including clean sand filter layer
- Grade control sized to safely pass 100-year event

# RSC

- Solution to “What can I do when my floodplain no longer has adequate width under modern hydrology?”
- Fill practice, reconnecting stream inundate floodplain fill terrace
- Series of large, broad (up to valley width) riffles, to consolidate energy, while sheltering areas behind them promoting floodplain functions
- Strong overlap with beaver dam analogs

<- Beaver have colonized this riffle!

# Zero Order/Valley Restoration

- Excavate floodplain at groundwater level.
  - At the headwaters, even a little goes a long way.
- Reconnect to legacy gravels.
  - (Or import a gravel lens)
- Rely on wetlands for grade control.

# “Roughened Channels”

- Create highly accessible floodplain/channel combination (high W/D).
- Spread flows across evenly sloped surface with max possible roughness.
- Rely on large wood, vegetation, and rock to contribute to roughness and support diversity in form.

Photo courtesy of Mike Adams, PE (Stantec)

# Urban Headwater Restoration

- Headwater sites are adaptive to a variety of techniques- choose the right approach.
- Elements of these approaches are inherently compatible and scalable.
- Local success is best measured by improvements to stability, areal extent of water and wetlands, diversity of habitat, and flood resilience.
- While this work is very far removed from a project with fishery goals, **the impact is transformational.**
  - We must emphasize the VALUE of converting a site that cannot support aquatic life to one that *can!*

# Thank you!

**Joe Arrowsmith, PE**

Director, Ecosystem Restoration

jarrowsmith@straughanenvironmental.com

Straughan Environmental, Inc.

# Floodplain Restoration Approaches

2023 National Stream Restoration Conference Expert Panel

August 21, 2023

Presented by Jim Morris, P.E.

# Floodplain Restoration Theory

## MANY ACCEPTABLE METHODS IN MANY PLACES

Floodplain Restoration is:

- The restoration of a stable stream / wetland and riparian complex on the native geologic base.
- Resilience-oriented
- Depositional environment
- Carbon sequestration
- Typically on a basal gravel layer in mid-Atlantic
- Often seen with accompanying buried hydric soil layers, typically found above matrix-supported quartz gravel
- Appropriate only where the geology supports its presence.

# Floodplain Restoration Theory

## WALTERS AND MERRITTS – MID ATLANTIC PIEDMONT

- Legacy Sediment model
- Mill dams pervasive, accumulated sediment from poor ag practices behind them.
- Basal gravel layer
- Hydric soil (wetland) layer
- Non-wetland terrace above abandoned wetland floodplain layer.
- Science - Natural Streams and the Legacy of Water-Powered Mills (2008)

CREDIT FRANKLIN & MARSHALL

# Floodplain Restoration Theory

## WALTERS AND MERRITTS – MID ATLANTIC PIEDMONT

- Legacy Sediment model
- Mill dams pervasive, accumulated sediment from poor ag practices behind them.
- Basal gravel layer
- Hydric soil (wetland) layer
- Non-wetland terrace above abandoned wetland floodplain layer.

### Natural Streams and the Legacy of Water-Powered Mills

Robert C. Walter*† and Dorothy J. Merritts*†

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 have mapped and dated many of the deposits along mid-Atlantic streams that formed the basis for this widely accepted model. These data, as well as historical maps and records, 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. Subsequently, 1 to 5 meters of slackwater sedimentation, behind tens of thousands of 17th- to 19th-century milldams, buried the presettlement wetlands with fine sediment. These findings show that most floodplains along mid-Atlantic streams are actually fill terraces, and historically incised channels are not natural archetypes for meandering streams.

The meandering gravel-bedded stream bordered by a self-formed, fine-grained floodplain emerged as the characteristic river form based on pioneering studies in mid-Atlantic and western streams of the United States (*1–4*). Today, this ideal—of alternating pools and riffles along sinuous channels with gravel point bars and fine-grained overbank floodplain deposits—guides a multibillion-dollar stream restoration industry (*5*, *6*). Many streams in the low-relief, tectonically inactive mid-Atlantic Piedmont of the United States are deeply incised, with steep eroding banks, and carry anomalously high amounts of suspended sediment (*7*). Fine-grained deposits bordering many eastern streams are thicker than would be expected from just their recent flood deposits (*1*, *3*). These Holocene deposits typically form broad surfaces, referred to as the "valley flat," that were interpreted as floodplains formed by a combination of migrating, meandering stream channels and overbank deposition of silts and clays (*1*, *3*, *8*). The geometry of single-channel meandering streams has been viewed as the result of self-adjusting hydraulic variables in response to changing discharge and sediment load, and agriculture and urbanization have been cited widely as the causes of recent aggradation and degradation (*1*, *3*, *4*, *8–10*). This pattern of stream development and morphology has been considered as typical of streams and rivers in stable landscapes.

We observe that crests of breached, historic milldams merge with valley-flat surfaces and that most modern streams are incised deeply below this surface. This observation led us to hypothesize that a rapid, regional transformation of stream valleys had occurred in eastern North America, from widespread aggradation as a result of damming (base-level rise) to subsequent incision and bank erosion due to dam breaching (base-level fall). We propose that valley sedimentation not only resulted from accelerated hillslope erosion caused by deforestation and agricultural development (*8*, *11*) but also was coupled with widespread valley-bottom damming for water power, after European settlement, from the late 17th century through the early 20th century. Damming was essential to the extensive trapping of sediment in broad valley flats that correspond to reservoir surfaces.

We test this hypothesis by examining the following lines of evidence: (i) historical accounts of widespread, intensive water-powered milling that impacted most first- to third-order streams in the mid-Atlantic region; (ii) historical maps showing multiple dams and ponds, and our observations in the field and from light detection and ranging (LIDAR) data of aggradation in these ponds that caused sedimentation upstream into tributaries and swales; (iii) historical, geological, and geochemical data showing rapid sedimentation in valley bottoms during the period of early land clearing; (iv) field observations and remote-sensing data, including LIDAR, showing that downstream-thickening wedges of sediment grade to milldam heights and, hence, that dams produced temporary, higher base levels; and (v) field observations and laboratory data showing that the morphologies and functions of presettlement streams were substantially different from those of modern streams. We revisited the same streams and specific reaches used in early studies that pioneered modern fluvial geomorphology, including fundamental ideas regarding meander migration, floodplain formation, hydraulic geometry, and fluvial response to land clearing. These streams include the Brandywine River (in Pennsylvania and Delaware) and Seneca Creek, Watts Branch, and Western Run (in Maryland) (*1–4*, *8*, *9*, *11*), all of which lie within the Piedmont physiographic province of the mid-Atlantic region. In all, we studied Piedmont streams in 20 watersheds throughout Pennsylvania and Maryland (drainage areas from 11 to 1230 $km^2$; fig. S1).

**Milldam history.** Dam building for water power in the eastern United States began in the

Department of Earth and Environment, Franklin and Marshall College, Post Office Box 3003, Lancaster, PA 17604–3003, USA.

*These authors contributed equally to this work.

†To whom correspondence should be addressed. E-mail: robert.walter@fandm.edu (R.C.W.); dorothy.merritts@fandm.edu (D.J.M.)

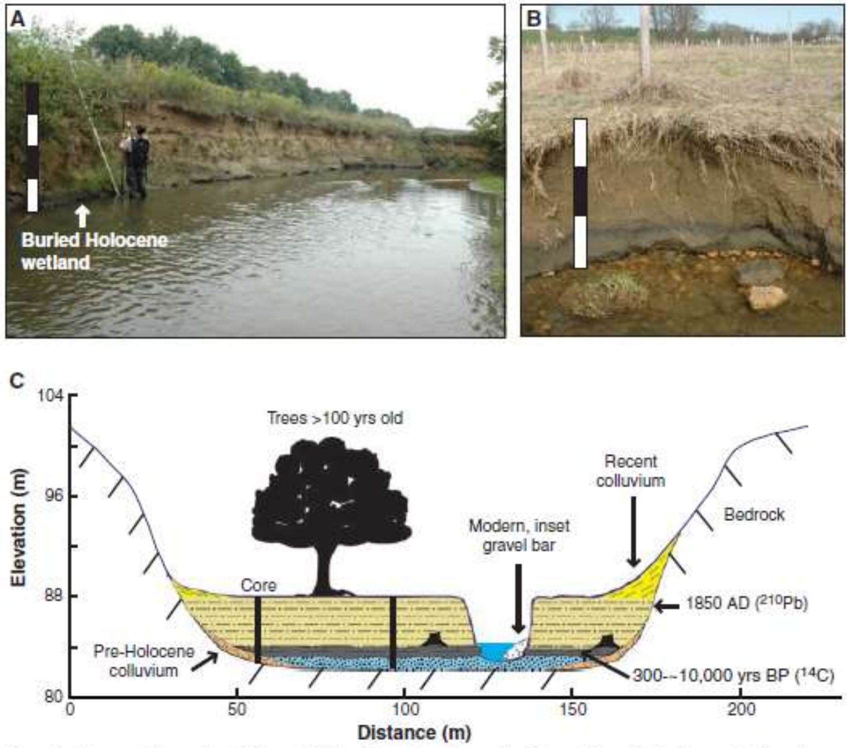



**Fig. 3.** Streams throughout the mid-Atlantic region (see also figs. S1 and S2) have similar characteristics: vertical to near-vertical banks consisting of 1 to 5 m of laminated to massive fine-grained sediment overlying a Holocene hydric soil and a basal gravel overlying bedrock. **(A)** Western Run, Maryland. **(B)** Big Spring Run, Pennsylvania. Scale bars in (A) and (B) are marked in 0.5-m increments; the banks in (A) and (B) are ~2.2 and ~1.4 m high, respectively. **(C)** Conceptual model based on composite stratigraphy from multiple sites, including stream-bank exposures, trenches, and cores.

www.sciencemag.org SCIENCE VOL 319 18 JANUARY 2008

CREDIT WALTERS AND MERRITTS, SCIENCE

# Floodplain Restoration Theory - Mid-Atlantic Piedmont

## SOIL / STRATA ORIGINS

- Periglacial Gravel / Matrix
- Periglacial - relating to or denoting an area adjacent to a glacier or ice sheet or **otherwise subject to repeated freezing and thawing.**
- Watershed Sediment & Organic Matter
- Mineral / Ag soils from landscape accumulated behind dam
- Fluvial, Colluvial, Periglacial Mechanisms
- **Indigenous activities?**
- Beaver activity and soil building
- Other colonial floodplain disturbances
- **Risk of contaminated sediments in any area with industrial history**

# Different Forms in Different Places

## GLACIATION

- Typically younger systems, more active watershed
- Lift vs. cut depending on the impacts prior
- Some references still seen, particularly in higher elevations
- Differing substrate origins (moraines, till, periglacial)
- Beaver part of soil building activity, actively controlling hydrology
- Can see contrasts easily in the upper mid west (driftless area vs. glaciated areas)

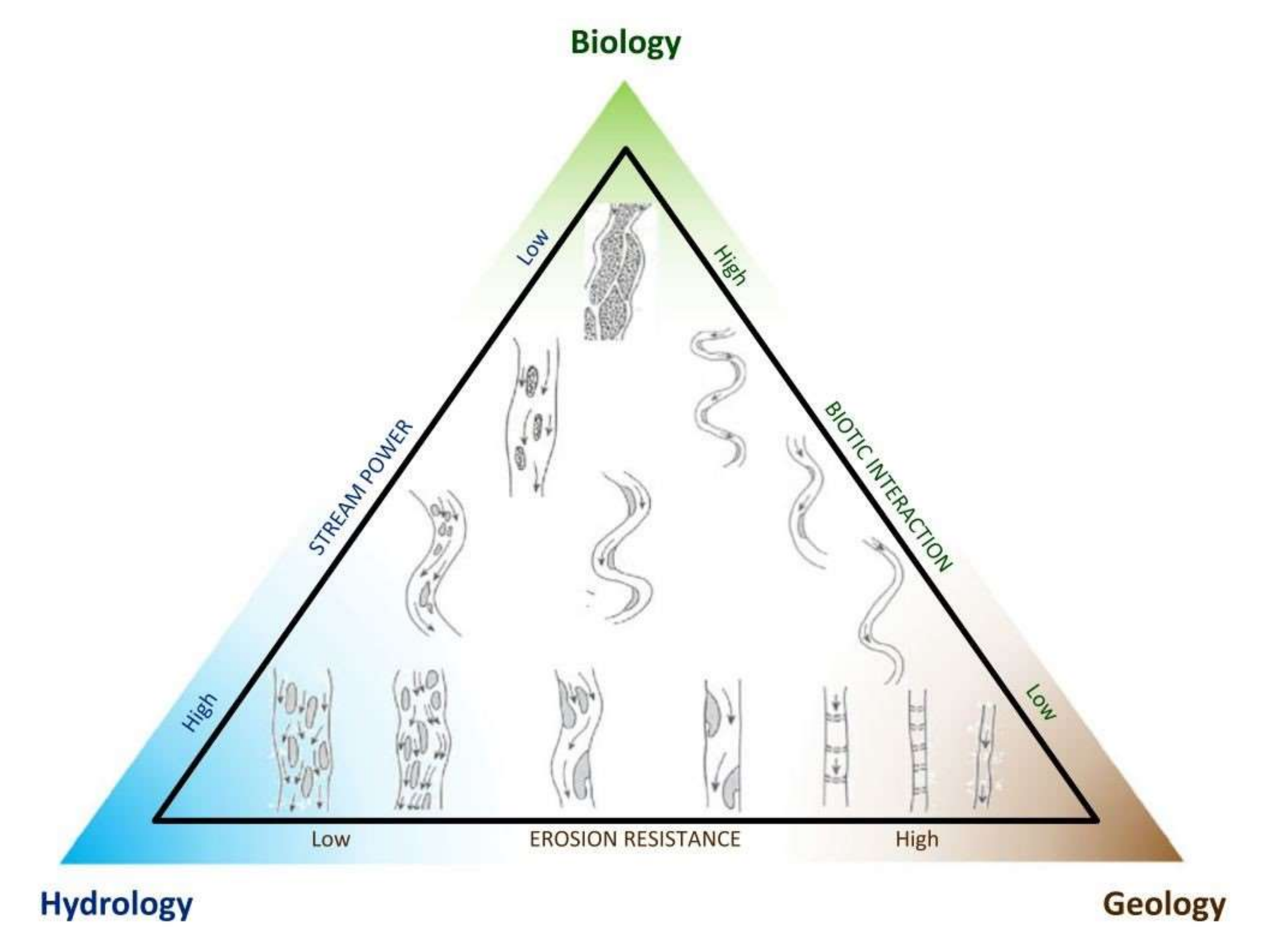
## COASTAL PLAIN

- Older, weathered systems
- Beaver dominated
- Heavily impacted by ditching, drainage
- Differing substrate origins (sands, small gravels)
- See both fill on top of wetlands and incision through wetland and basal layer
- Often incised down to marine layers (>1 Million years MD)
- Low gradient, anadromous fish passage

# Floodplain Properties

## PROPERTIES

- Biology-dominated system
- Beaver were part of the equation as dam or lodge builders, burrowed into banks, managing vegetation
- Origins following last ice age, limited vegetation
- Hydric soils developed later, with watershed sediments and organic matter
- Mixed trees, shrubs, emergent vegetation
- Stream Evolution Triangle (Castro et al. 2019)



# Floodplain Design

**MULTIPLE ACCEPTABLE TECHNIQUES AND METHODS**

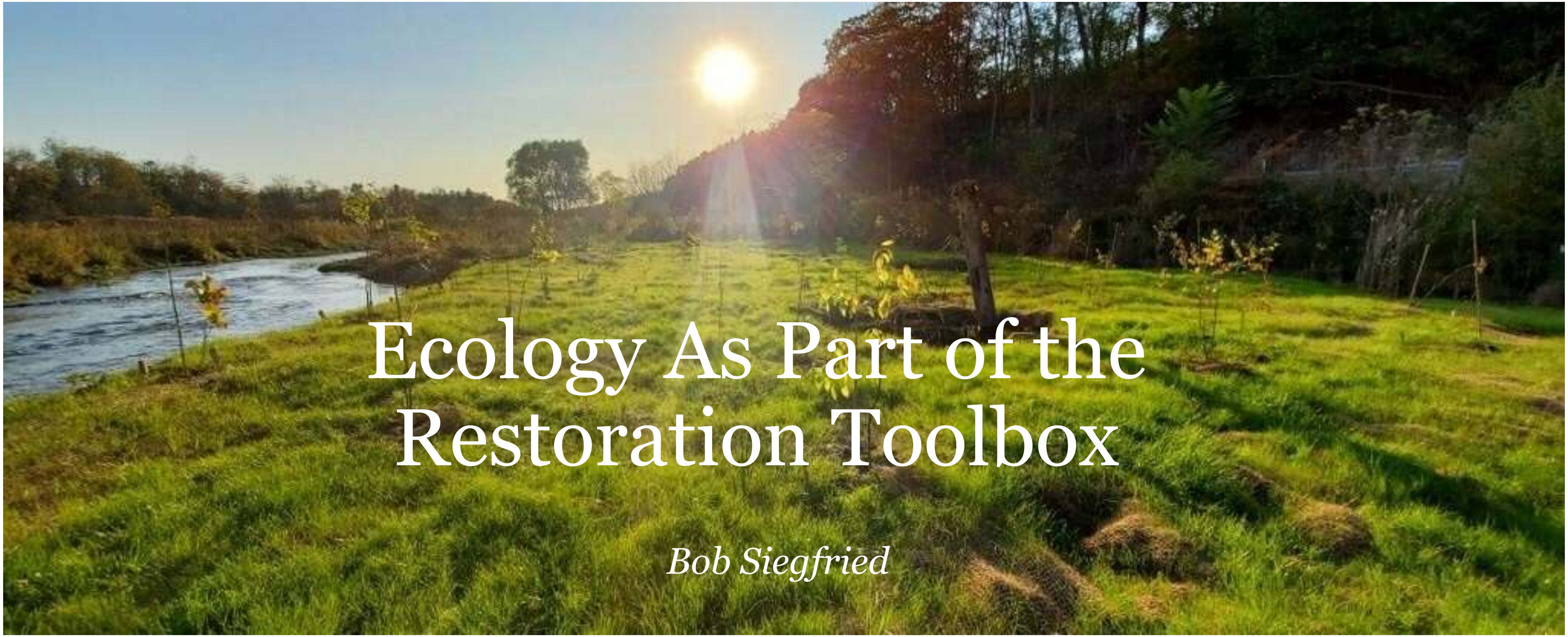
- Modeling (2D, 1D)
- Reference Conditions
- Design based off geology
- Design based of properties of target / historical species present (site potential)
- Specialized consideration for urban systems

# Questions and thank you!

Jim Morris

jmorris@jmt.com

www.jmt.com



# Ecology As Part of the Restoration Toolbox

*Bob Siegfried*

Proud sponsor & exhibitor

**Find us at booth #A25**

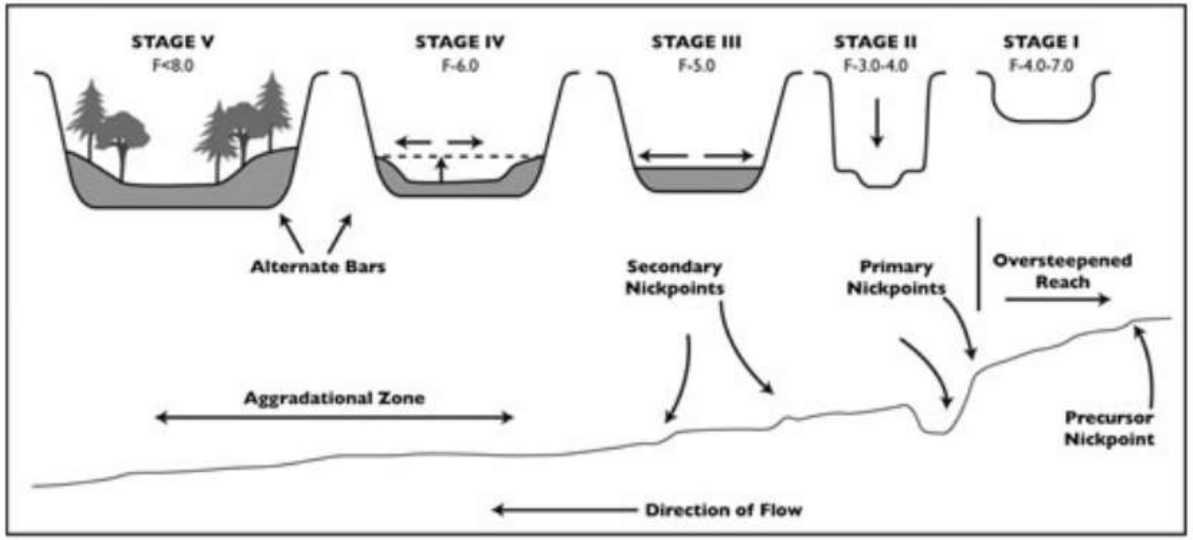
res Restoring a resilient earth for a modern world

# Pre-2010 – The Lack of Ecology in Stream Restoration

## Pre 1990s Fisheries Focused Structures

Biology Was Outcome And Not A Driving Force In Channel Formation

## 1990s- 2000s Channel Evolution Model



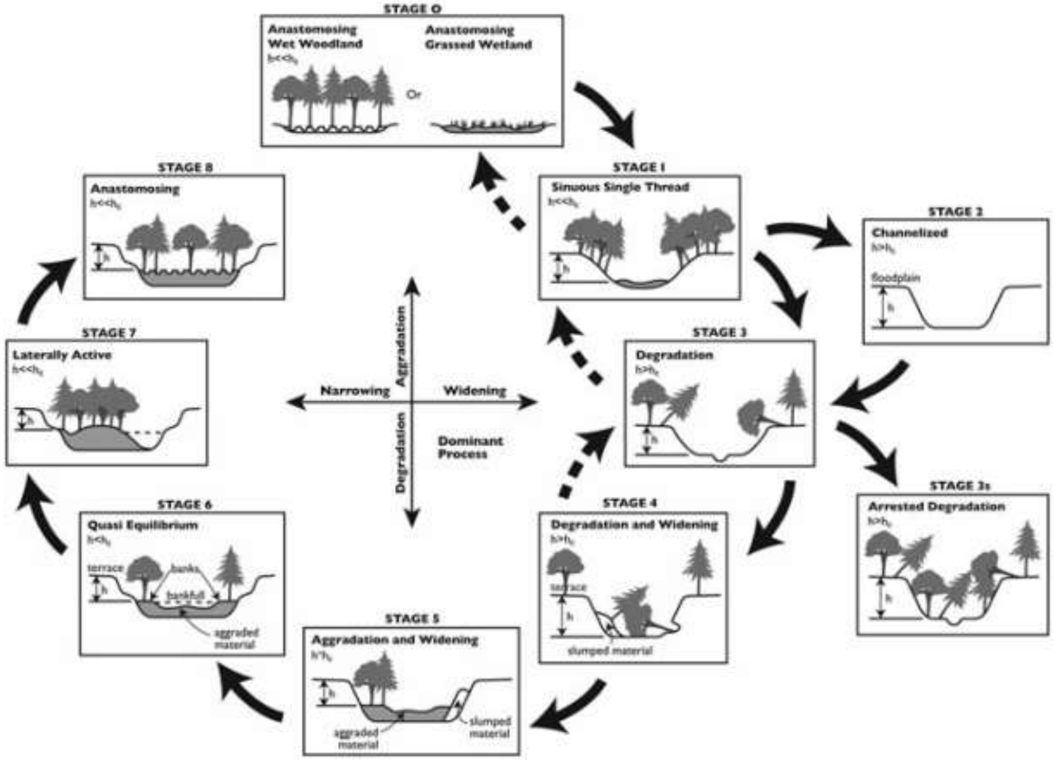

Period when Hydrology/Hydraulics and Sediment Dominated the Discussions of Channel Formation

- Natural Channel Design
- Process Based Approaches

res

# Post–2010 - Ecology Outcomes in Stream Restoration

## Stream Evolution Model (Cluer & Thorne 2014)




SEM Added Habitat and Ecosystem Services as Outcomes of Stream Evolution

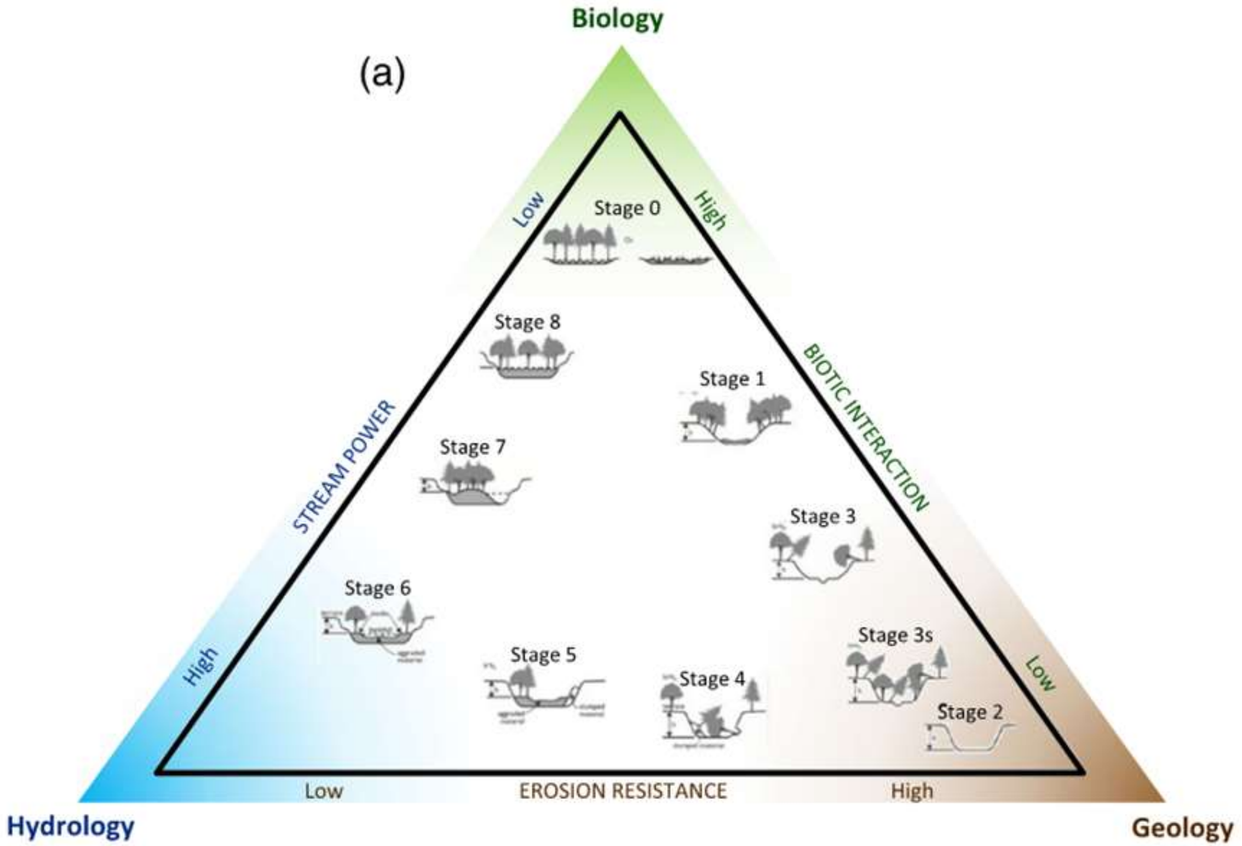
## Stage Zero Design Approaches

Baseflow or No Channel within Active Floodplain

# Post–2020 - Ecology DRIVEN Stream Restoration

## Stream Evolution Triangle (Castro & Thorne 2019)

Biology Recognized as **DRIVING** Factor in Stream Evolution




## Importance of Ecology as Driver

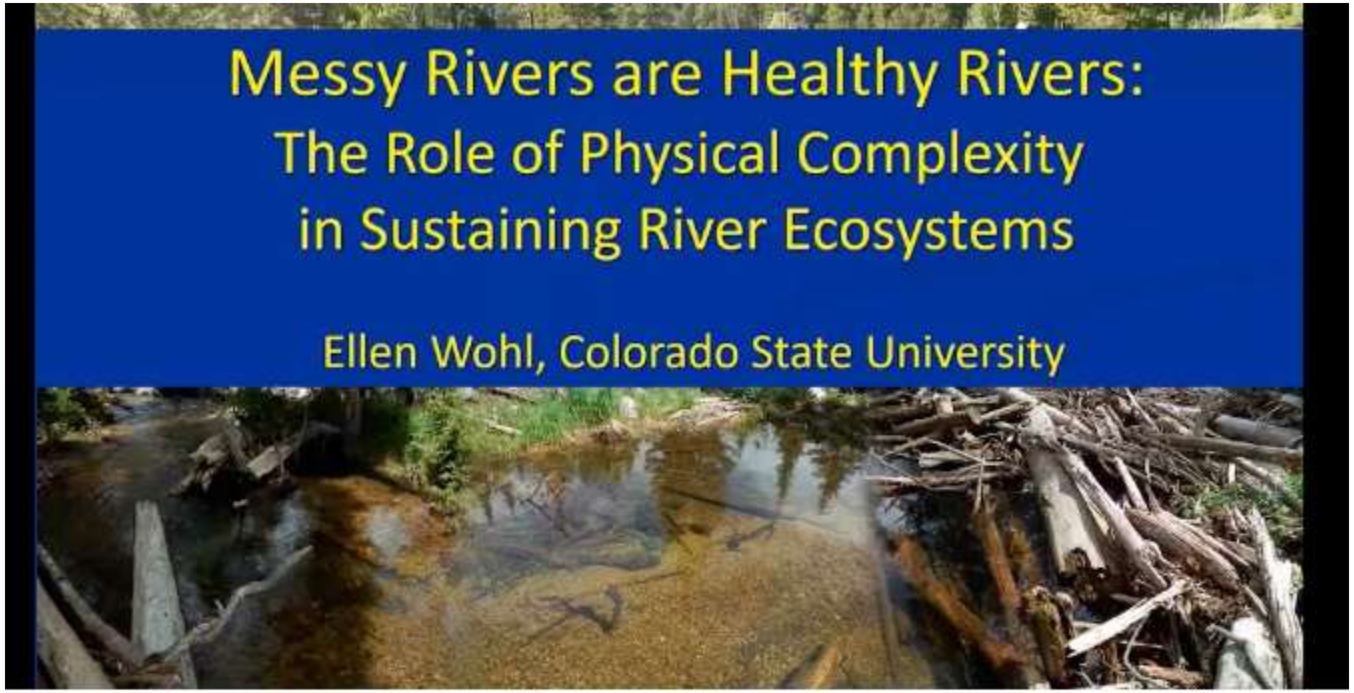
- Engagement with Entire Valley
- Retention of Materials – Water, Sediment, Wood, Carbon, etc.'
- Retention Creates Dynamic Mosaics of Habitats In Channel and Floodplain
- Heterogeneity Drives Species Diversity and Ecosystem Services

# Post–2020 - Ecology DRIVEN Stream Restoration

**Keystone Biotic Drivers of Stream Formation and Dynamic Alluvial Valley Health**

- **Vegetation**
- Beavers
- Freshwater Mussels
- Gravel Spawning Fish
- Net Spinning Caddisflies

# Post–2020 - Ecology DRIVEN Stream Restoration




**How Do We Build Messy Rivers?**

- Engage Entire Valley
- Retention instead of Transport
- Reward Heterogeneity
- Flexible Success Criteria
- Avoid Static Monitoring
- Accept Beaver Activity

The Restoration Profession Has to Educate Agencies, the Public, Landowners that Messy Rivers are Healthy Rivers

res

# Contact Us

Bob Siegfried

Sr. Project Manager

bsiegfried@res.us

res