

Brian Cluer Ph.D.

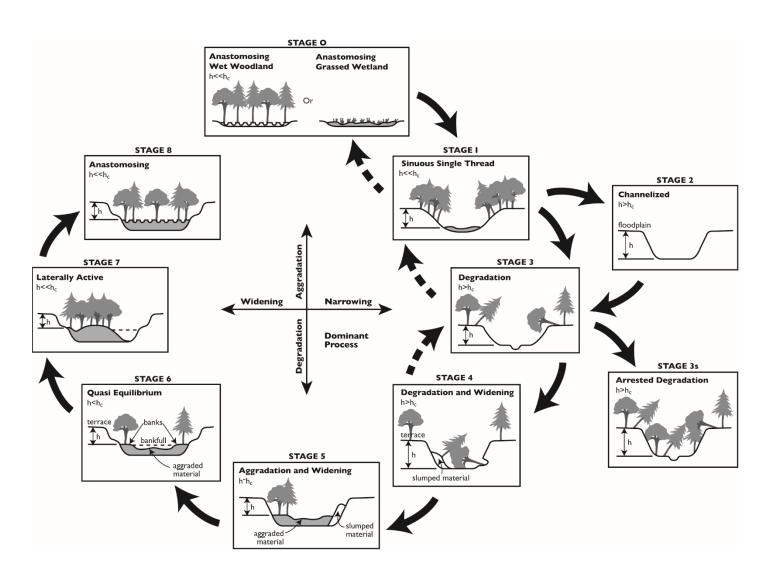
Fluvial Geomorphologist-NOAA WCR

#### Outline

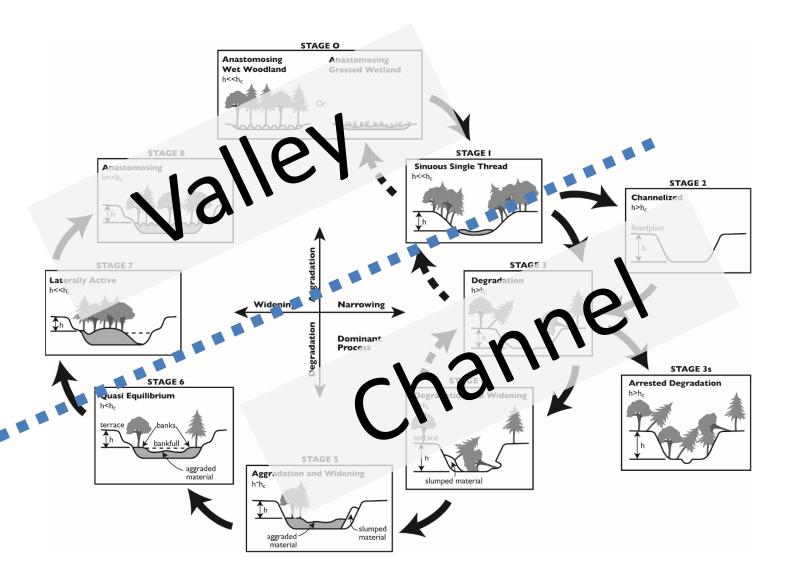
- Segue from SEM geomorphic template:
- Ecosystem template
- Physical and biological processes
- Attributes
- Evidence for Stage 0 pre-disturbance
- Examples of using the SEM to assess valleys and guide restoration



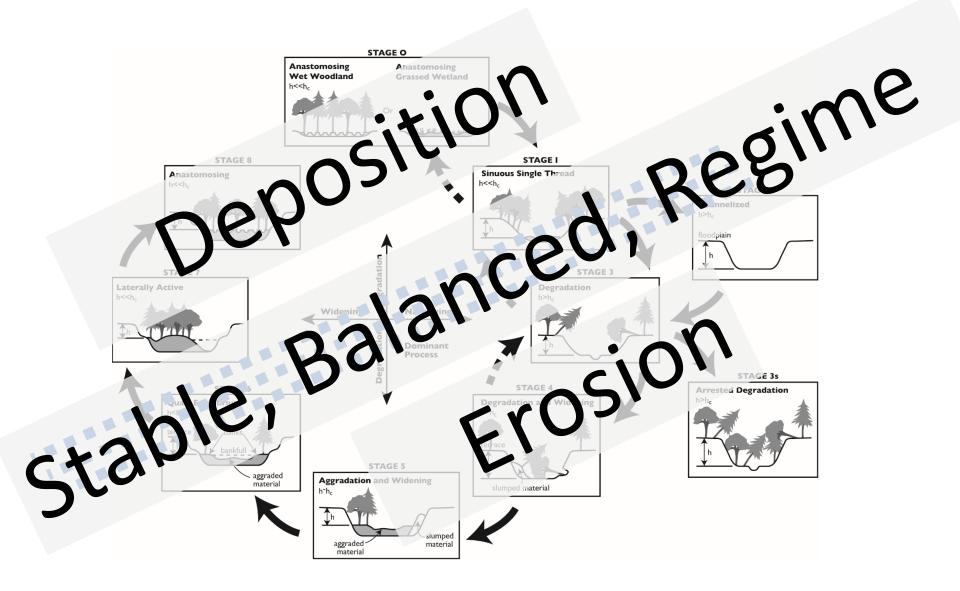
# SEM is a cycle



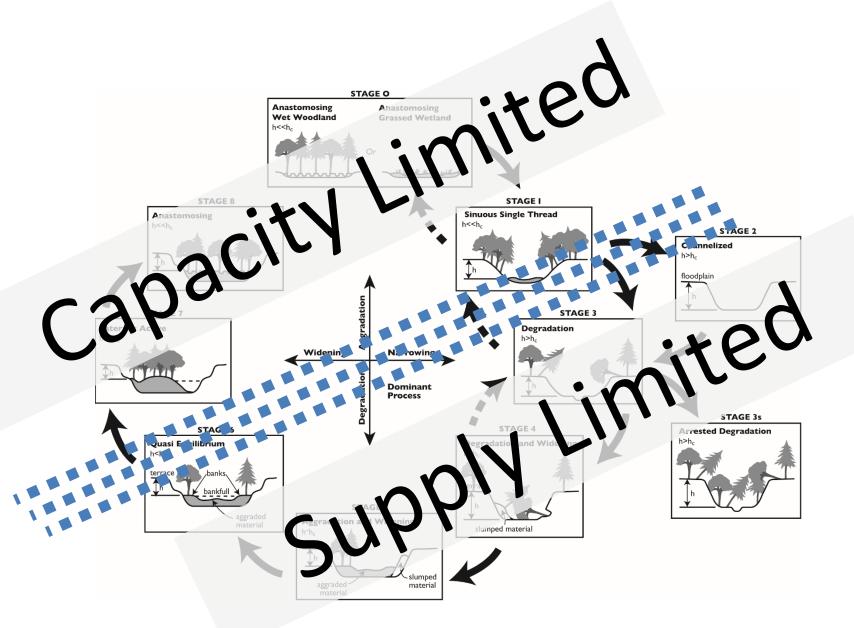














# SEM Part 2: Habitat and Ecosystem Benefits

Principle of functional ecology: the potential for a stream to support large, rich, diverse, and resilient ecosystems increases with scale, morphological diversity, and hydroperiod.

Key source: Thorpe et al. 2010

# Literature: attributes and benefits

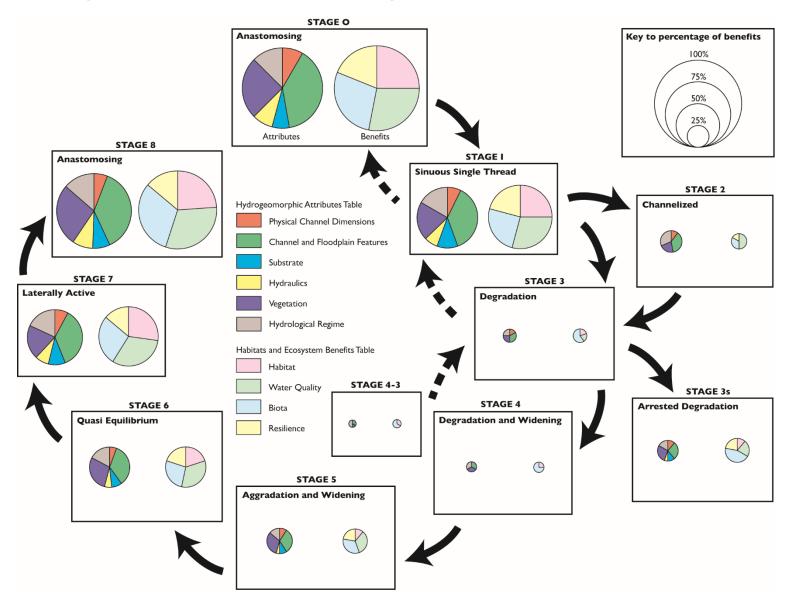
- Score:
- o = absent
- 1 = scarce/partly functional
- 2 = present and functional
- 3 = abundant/fully functional
- Hydrogeomorphic attributes (26)
  - Number and dimensions, channel
  - Hydrologic regime, floodplain
  - Hydraulic complexity
  - Channel and floodplain features
  - Substrate sorting/patchiness
  - Vegetation sediment interaction

Table 4

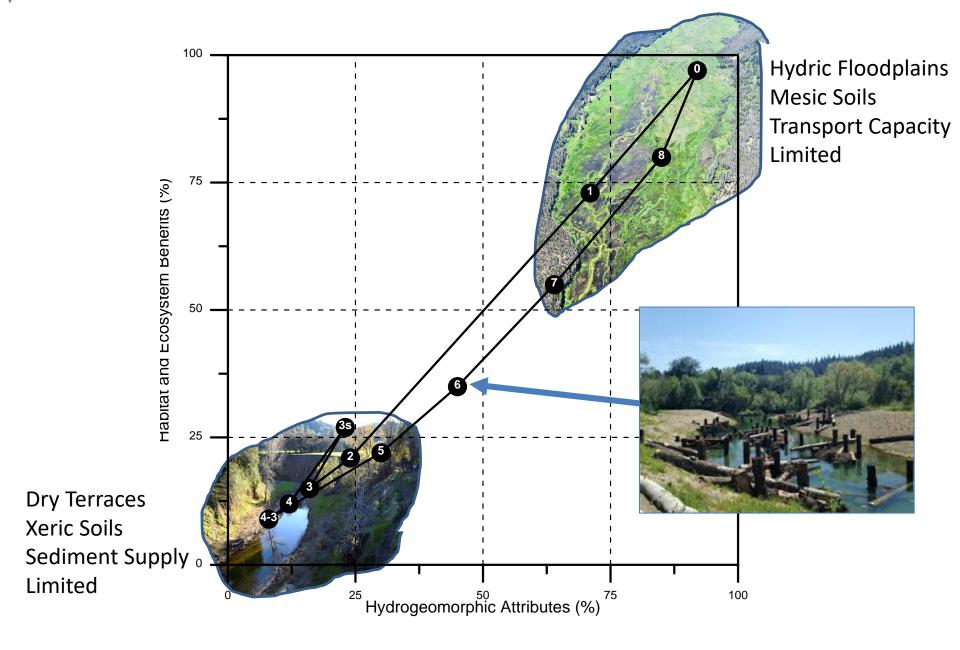
- Habitat and Ecosystem Benefit attributes (11)
  - Refugia in extremes flood/drought
  - Water quality clarity/temperature/nutrient cycling
  - Biota diversity/natives/1° & 2° productivity
  - Resilience to disturbance

Table 5

## Ecosystem overlay



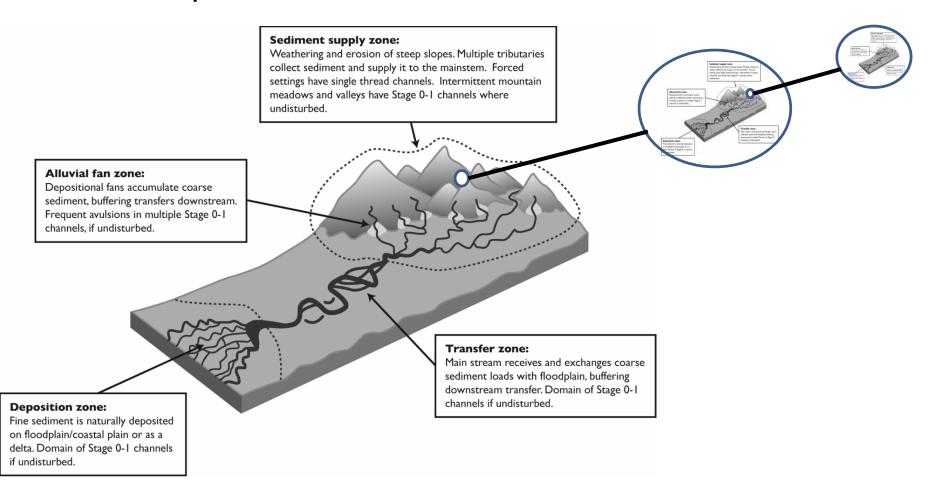




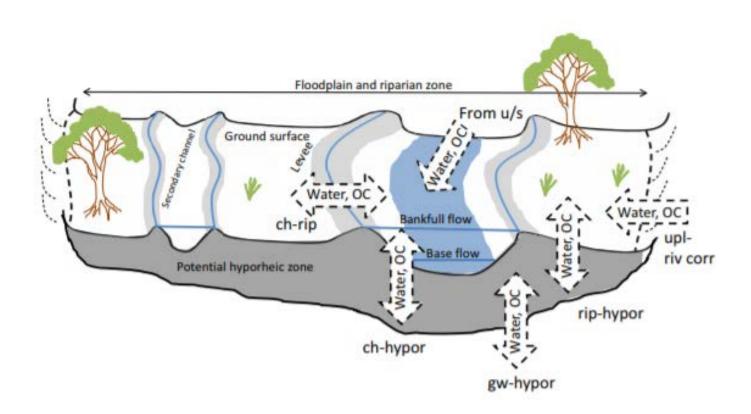
# What Processes Operate in Stage 0? & What Ecosystem Services Does Stage 0 Deliver?

#### **DEPOSITION ZONES**

#### Net deposition over time



# Organic Carbon Storage



From Wohl et al., 2017.

#### Resilient

- Resilient to watershed disturbances – natural disasters
- Attenuation of:
  - Floods
  - Sediment events
- Large accommodation space



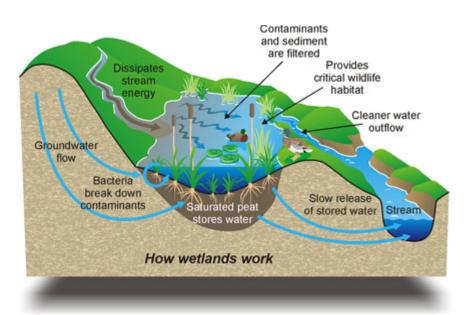
## High water table

- No deep drainage channel
- Prolonged surface / ground water connection
- Groundwater recharge = area x time x rate



#### High water quality

- Deposition of suspended solids, dissolved solids
- Cycle nutrients
- Dense vegetation cool shade
- Efficient hyporhesis
- Together; effective in ameliorating <u>high</u> and <u>low</u> temperatures and clarifying water



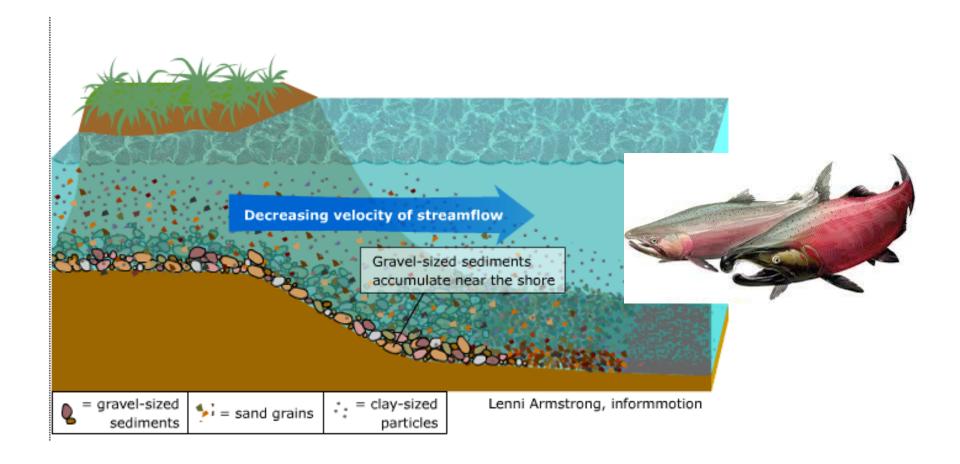
#### Habitat

Dry season, Salmon River ID



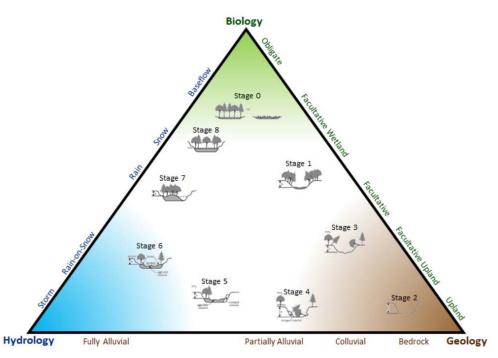
- Prolonged hydroperiod
- Extensive and diverse area
  - Anabranches (network of islands and channels) create
     multiple, marginal deadwaters, and great hydraulic diversity

- Hydraulic diversity, drives particle sorting
  - Numerous well-sorted bed material patches
- Unit stream power is limited
  - Patches are resilient



### **Vegetation Interactions**

- Dense vegetation interacting with and moderating physical processes
- High wood supply and retention
- Abundant leaf litter



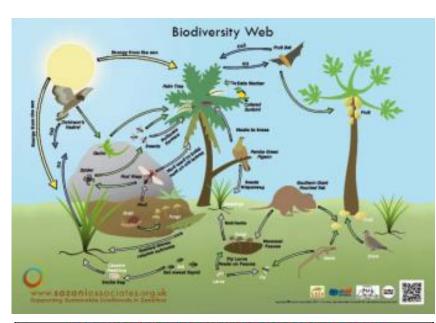


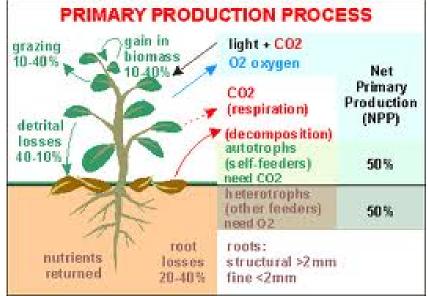
from Castro and Thorne 2019

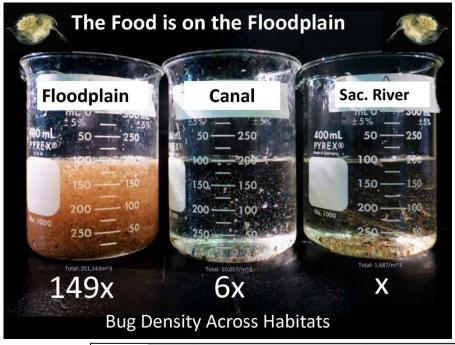
Willow Creek, CA

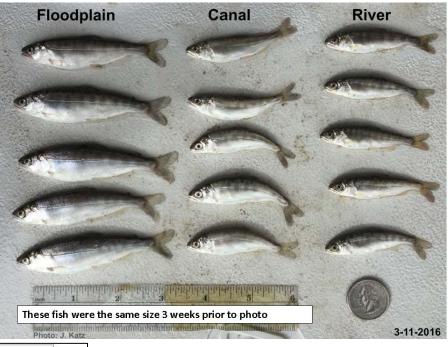
#### Biota

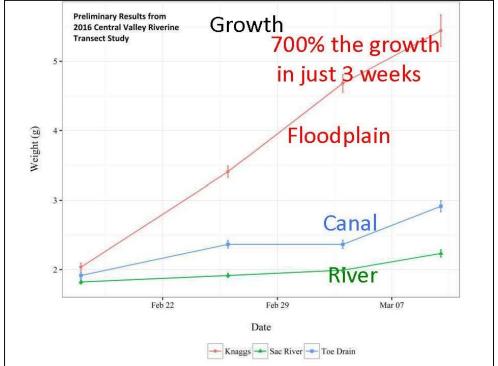
- Highest biodiversity and proportion of native species
- 1<sup>st</sup> and 2<sup>nd</sup> order productivity in quiet shallow water
- High unit productivity
- Large productive space











- 1. Two orders more food.
- Magnitude greater growth rate.
- 3. Magnitude greater fish abundance.

Jacob Katz 2016



#### **Salmon Population**

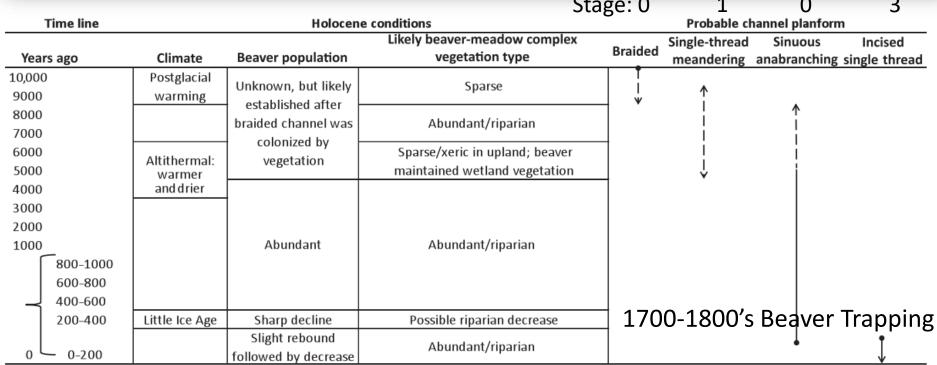
High capacity channels minimize habitat for the first two salmon life stages, undermining the lifecycle.

Mathematically, after low survival at the first two life stage transitions, nothing can change the population outcome.

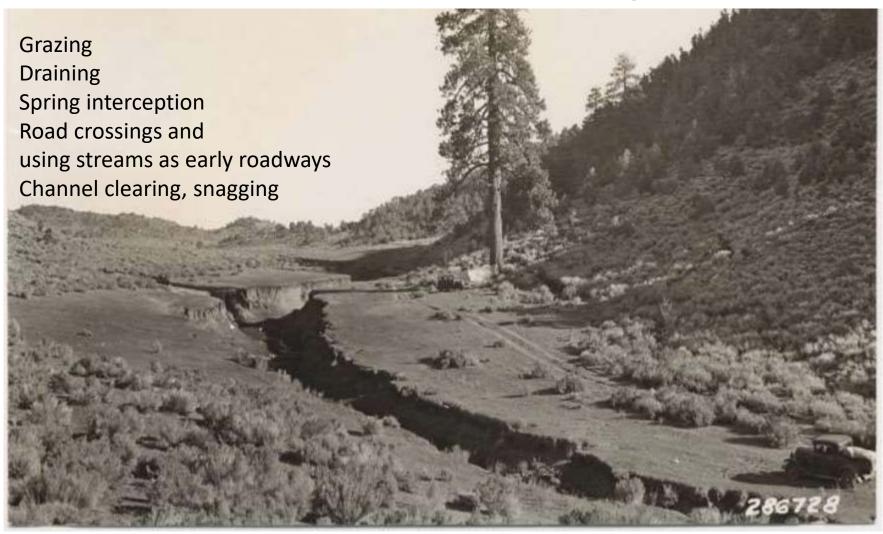
TRANSITION SURVIVAL RATES	AVERAGE
Two spawning adults, transition to Eggs in the gravel = 5000	Eggs
Eggs in the gravel to emergent Alevin transition—70 to 90 % = 4000	(0.80)
Alevin to free swimming Parr transition== 140	(0.035)
Parr to Ocean entry Smolt transition1 to 20 % = 14	(0.10)
Smolt to Ocean feeding Adult transition1 to 18 % = 1.26	(0.09)
Ocean Adult to Freshwater Spawner90 % = 1.1 S	pawners
Unimpaired Watershed Conditions	
*Bradford, M.J. 1995. Comparative review of Pacific salmon survival rates	Pendrovater  Boti  Canada  Can

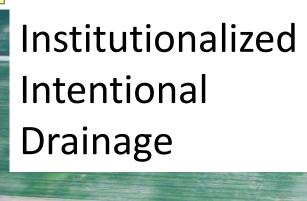
## Was Stage 0 common?





# Accidental drainage





US Swamp Land Act of 1850 provided a mechanism for reverting title of federally owned swampland to states if agree to drain the land and turn it to productive agricultural use.

Era of drainage channels, draining floodplains, developing water supplies to irrigate on demand, and building infrastructure defenses from floods.

LaGrand River, OR

# How DYNAMITE

streamlines streams

Practically every farm in the heavy crop-producing areas of the United States needs some ditching, and there is hardly a stream in the entire boundary of the Union that does not need to be corrected to give better service in discharging the large amounts of waste water from heavy rains, and to protect low lands.



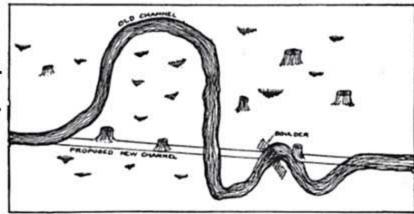
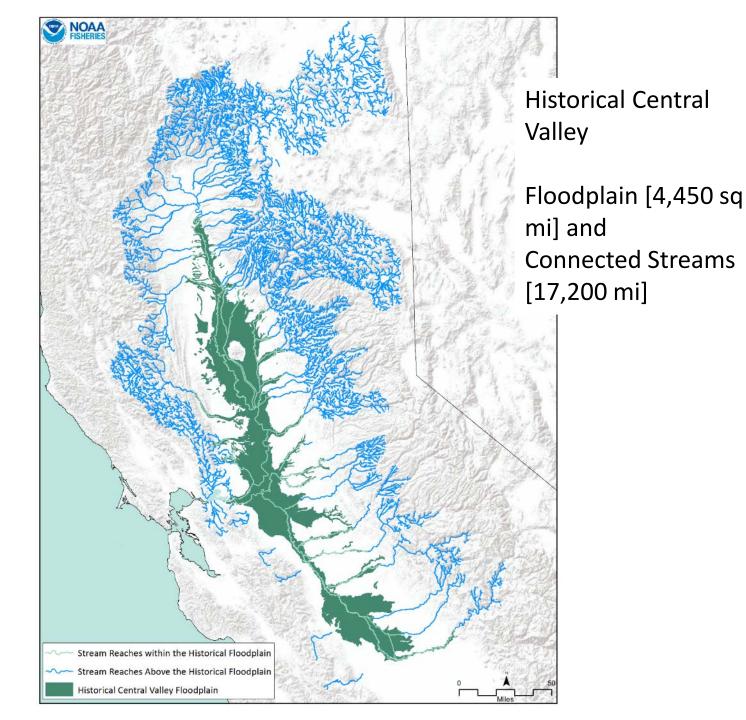


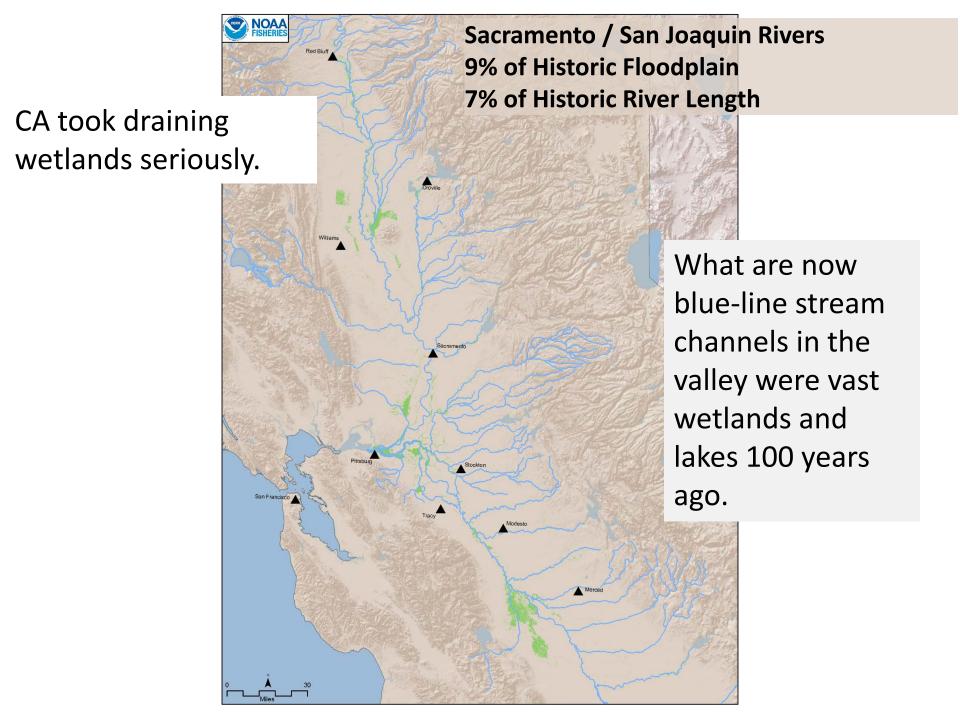
FIG. 54. DIAGRAM OF STREAM TROUBLES THAT MAY BE CORRECTED BY BLASTING.

CROOKED STREAMS are a men-ace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined. Lives are lost. Banks are undermined, causing cave-ins that steal valuable acreage.

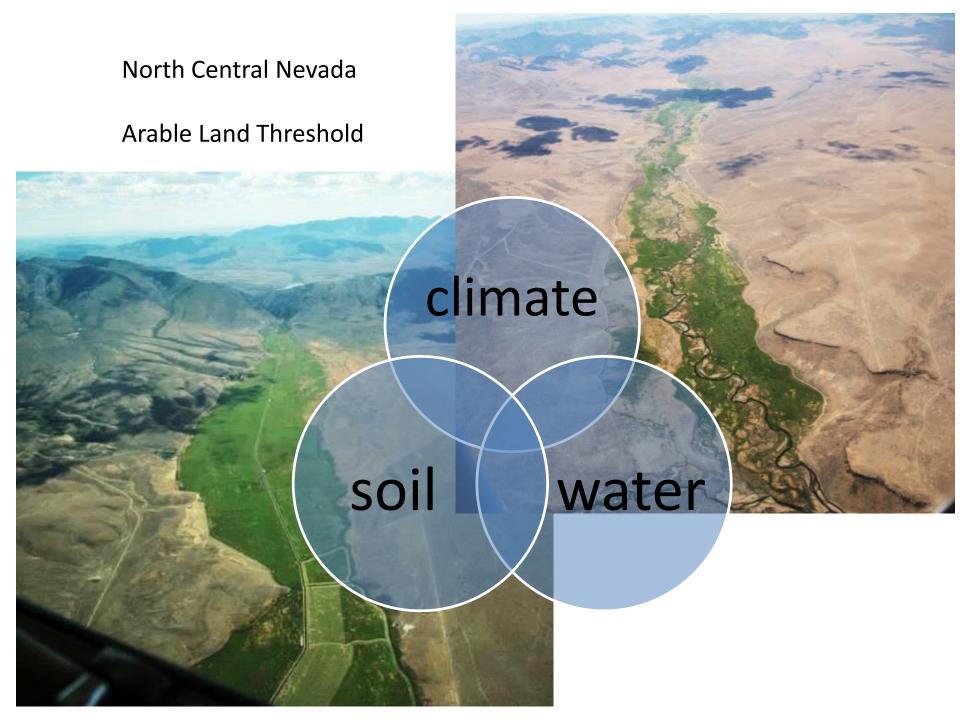
Data from the SWFSC IP model (streams)

The Bay Institute "From the Sierra to the Sea -The Ecological History of the San Francisco Bay Delta Watershed" 1998 (floodplain)





North Central Nevada **Arable Land Threshold** 



Pre-disturbance land conditions are poorly documented; pre-photography.

Post-2000, research papers challenge single-thread, meandering as a natural, ubiquitous pre-disturbance condition:

- Historic reconstructions:
  - SFEI in California
  - Walter and Merritts in Mid-Atlantic
  - Brown, Lewin, Surian in Europe
  - Montgomery and Collins in PNW
- Observations:
  - Beyond the arable threshold
- Geologic evidence:
  - Alluvial basins can not be explained by high capacity channels and rare+brief floodplain flows.

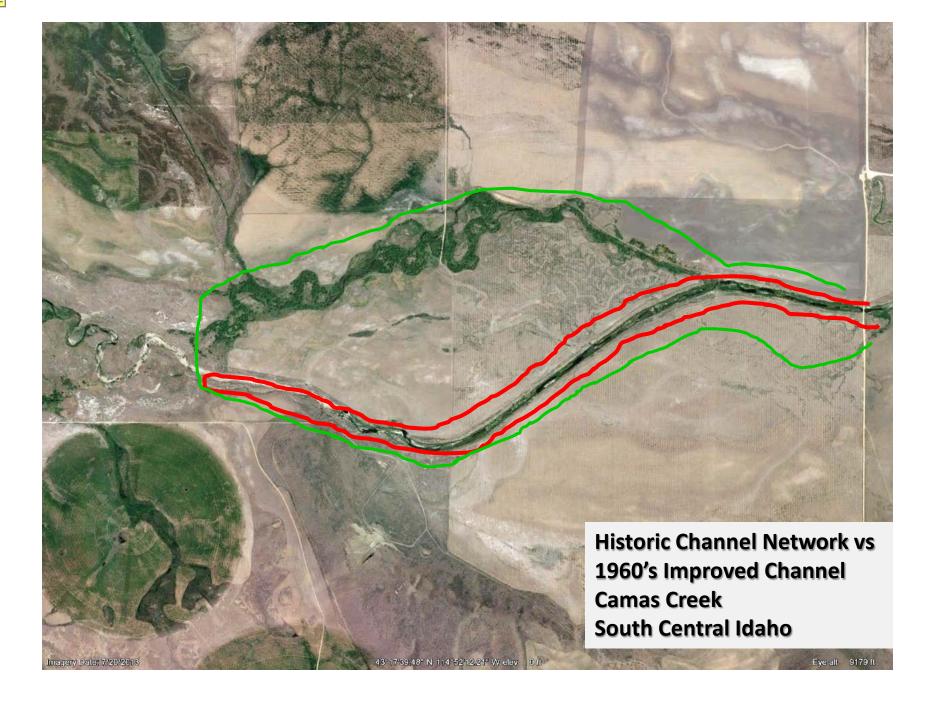


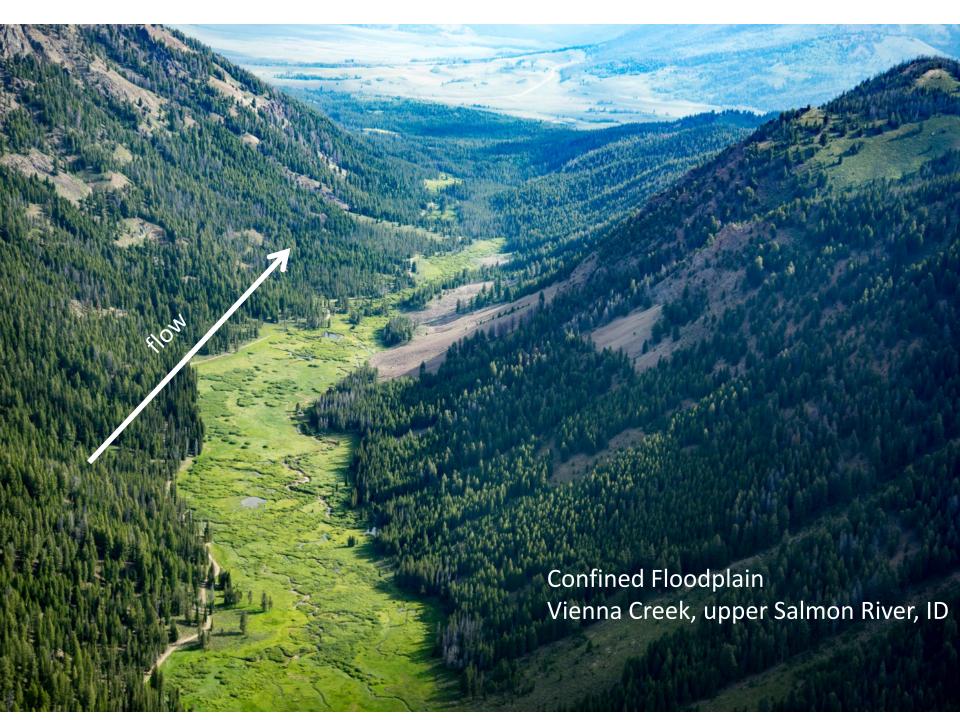
# Using the SEM to analyze valleys and guide restoration







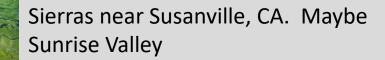


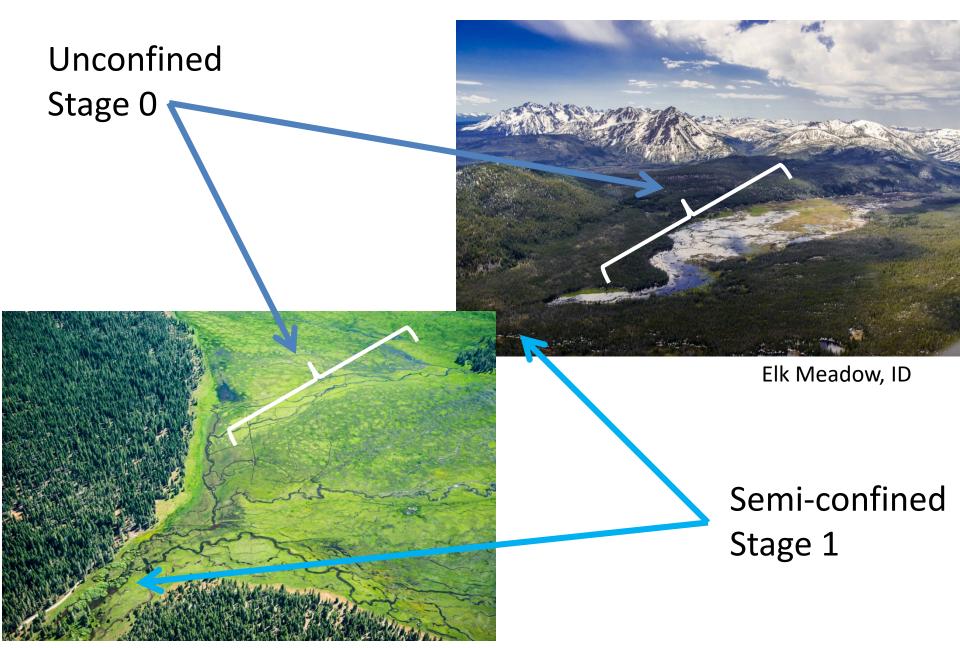






Flow

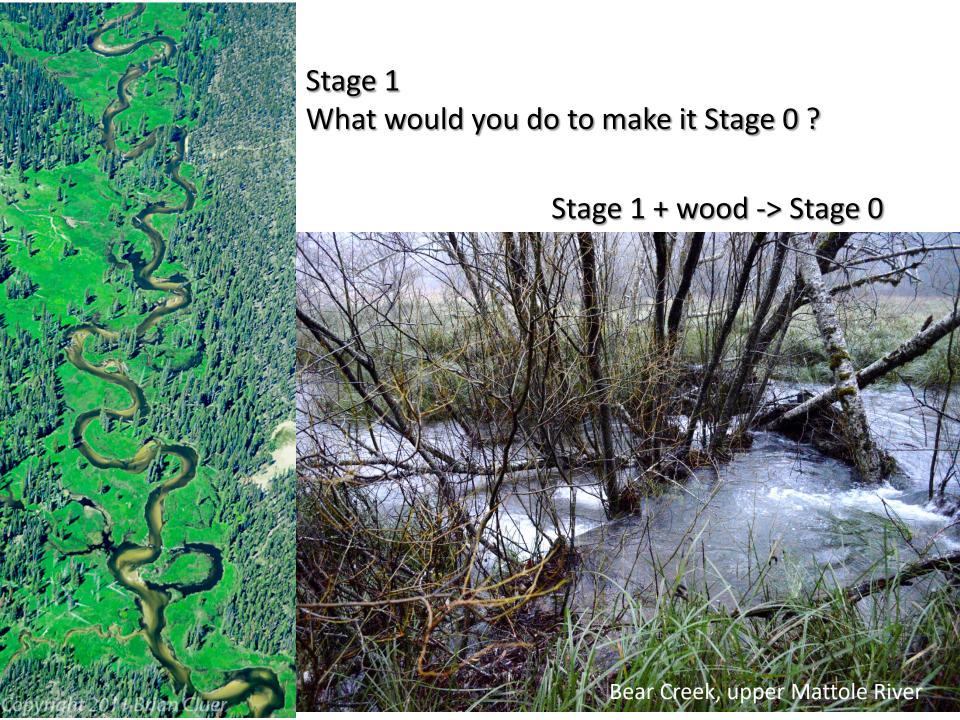




Somewhere in the Sierras near Susanville, CA. Maybe Sunrise Valley?

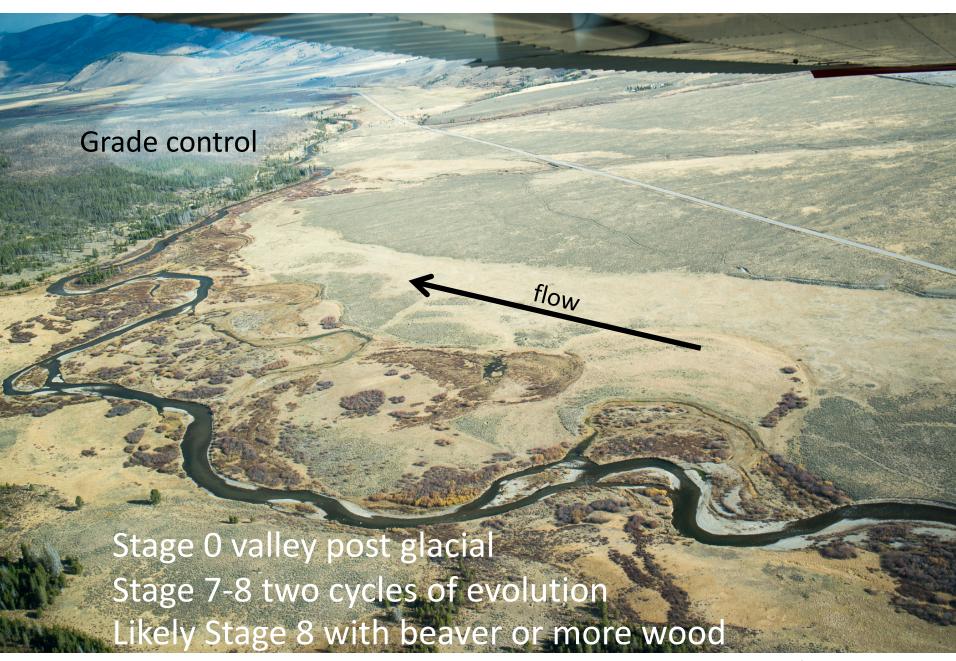


Stage 1
What could we do to make it Stage 0?





Upper Salmon River, ID

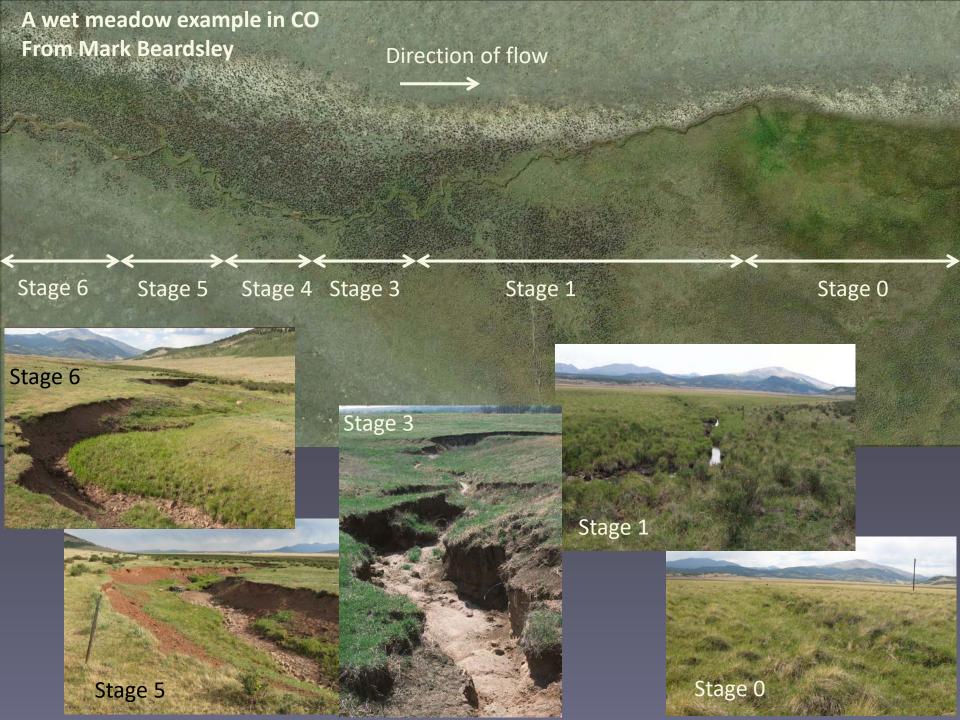


Upper Salmon River, ID





Klamath River, CA

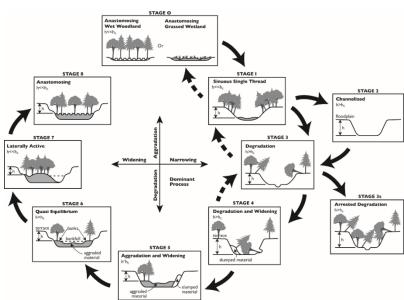




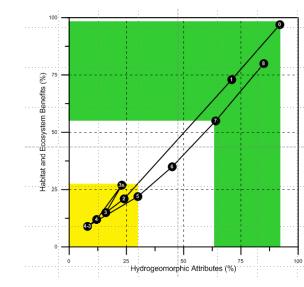


## Cluer and Thorne (2013) argued:

- there is a continuum of stream conditions that includes their alluvial valleys, not just channels
- high capacity "equilibrium" channels are not the historic norm
- undisturbed streams interact frequently and for long duration with their valley
- there are significant ecological differences between floodplain-connected and incised stages, between the historic and current streams

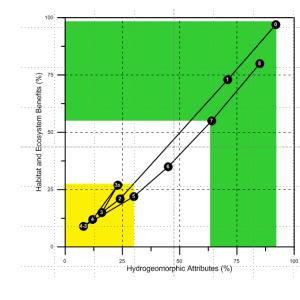


## Summary Relevant to this Workshop



- Valley evolution to Stage 0 results from:
  - Deposition = dominant physical process, influenced or controlled by biological processes
- Once channelized (Stage 1, 2 and 3), return to Stage 0 can occur naturally or through intervention with sediment and biological inputs.
- At Stage 4 or 5, evolution to Stage 8 can occur naturally through:
  - a lot of bank erosion and eventual channel aggradation,
  - or interventions that fill the channel.
  - Larger interventions can restore to Stage 0.

## The SEM and Stage 0



- Emerging perspective on stream channel management that views the channel and drainage as the problem, and sediment and deposition as a solution instead of the problem.
- Challenges practice, policy, and regulation.

Assume every alluvial valley has been manipulated and has a relatively recent channel that is incised.

Reference valleys are hard to find, have to be reconstructed.





## References:

- Bradford, M.J. 1995. Comparative review of Pacific salmon survival rates. *Canadian Journal of Fisheries and Aquatic Sciences*, v52(6): 1327-1338, <a href="https://doi.org/10.1139/f95-129">https://doi.org/10.1139/f95-129</a>
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