Geomorphic and Ecological Basis for Restoring Stage 0, and Introduction to Sessions

Brian Cluer and Colin Thorne

Restoration Symposium February 6, 2018

Goals for the talk:

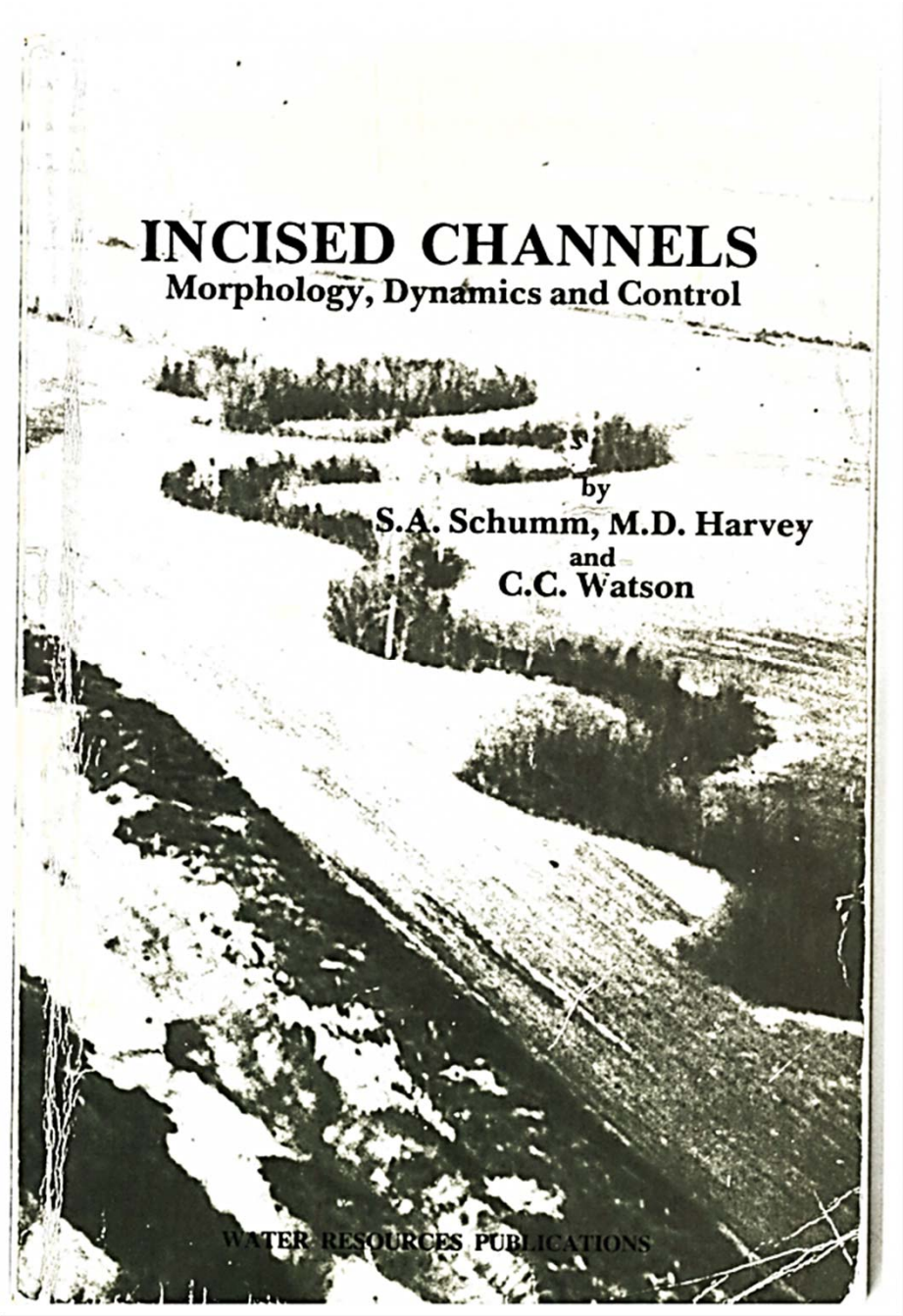
- Origin and context for SEM and Stage 0 concept
- Attributes of Stage 0 streams
- Introduction to the presentations

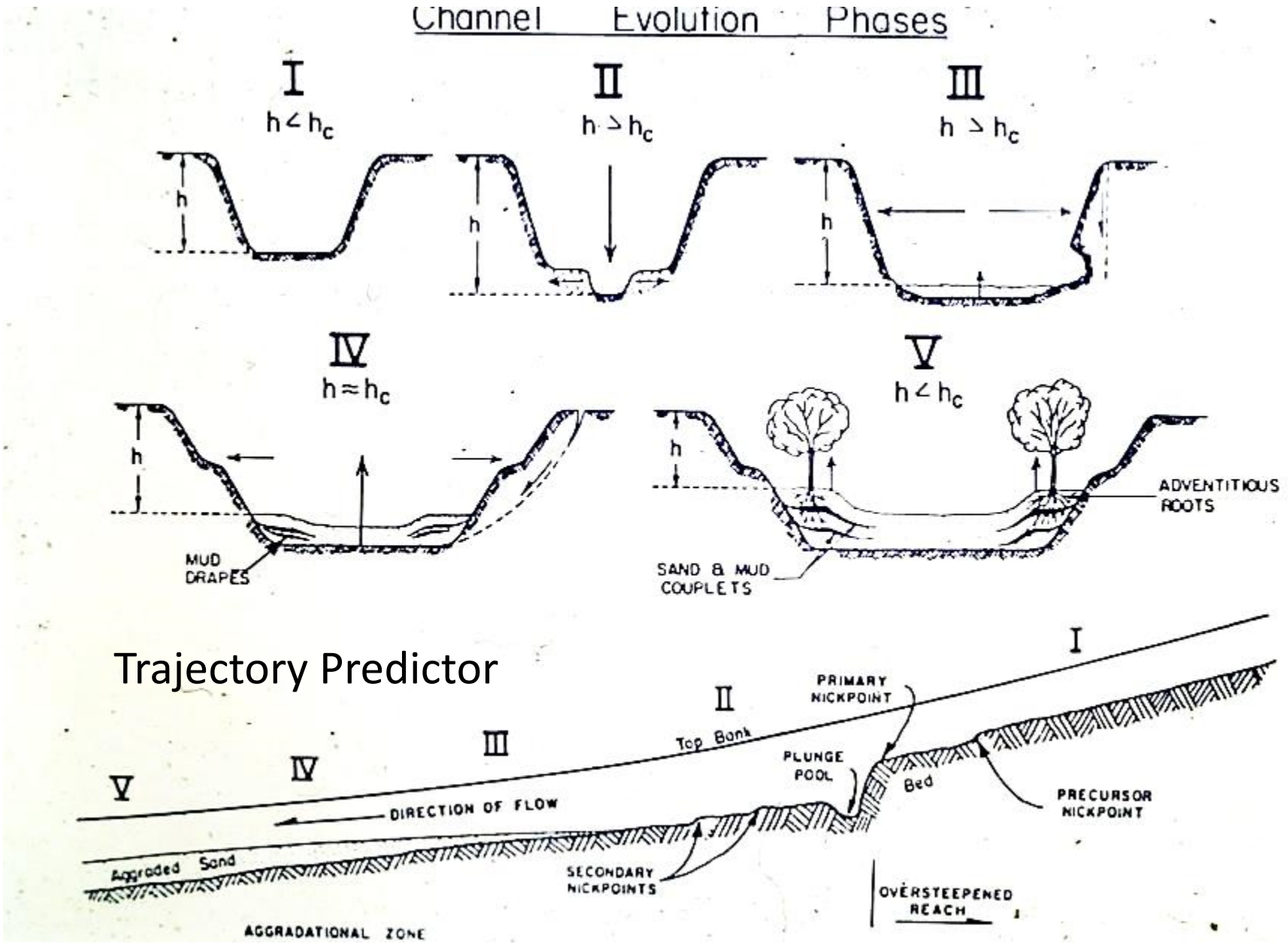
The Channel Evolution Model

INCISED CHANNELS
Morphology, Dynamics, and Control

Schumm, S. A., Harvey, M. D. & Watson, C. C. (1984).

Water Resources Publications,
Littleton, Colorado.

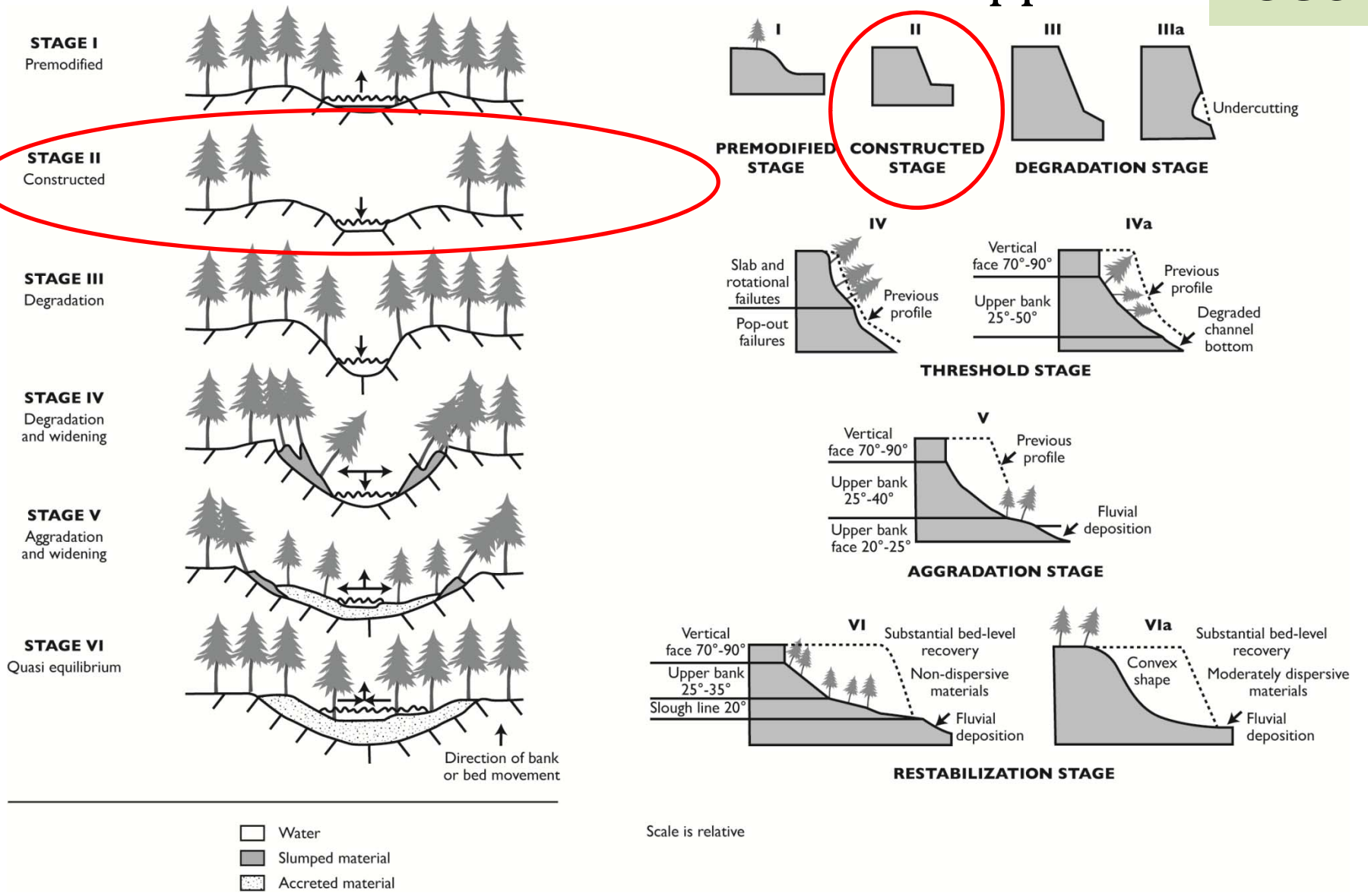




Schumm, S. A., Harvey, M. D., & Watson, C. C. (1984). *Incised channels: morphology, dynamics, and control*. Water Resources Publications.

Andrew Simon and Cliff Hupp

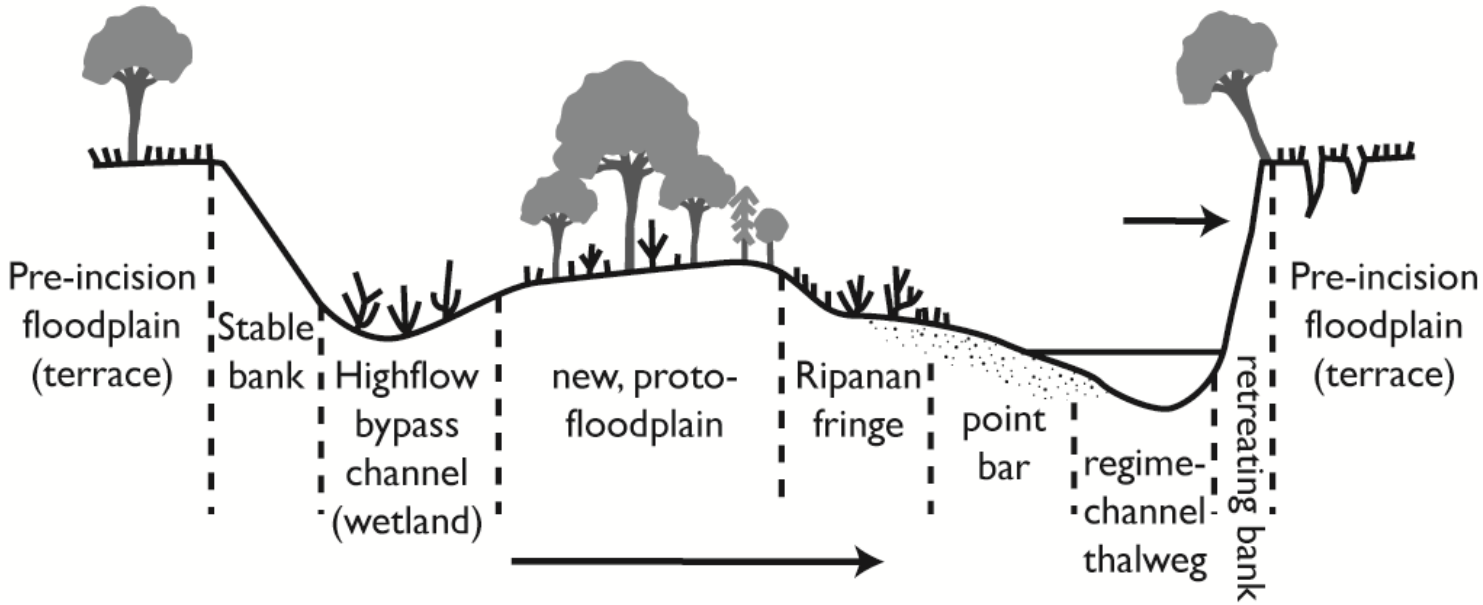
1986



Simon, A. & Hupp, C. R. 1986. Channel evolution in modified Tennessee channels. In, Proc. 4th Interagency Sedimentation Conf., Las Vegas, NV. US Govt., Washington DC, 8.22-8.29.


Late-stage Evolution in Senatobia Creek, Mississippi
Straight channel begins to meander
Colin Thorne 1990s

Colin Thorne 1999 - Late Stage Evolution

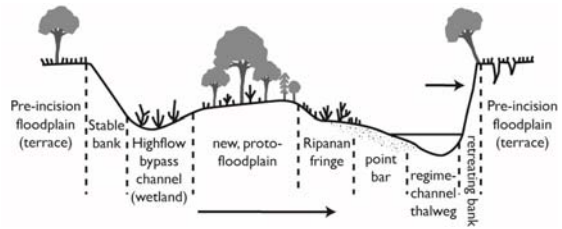


Stage 7 "Laterally Active"

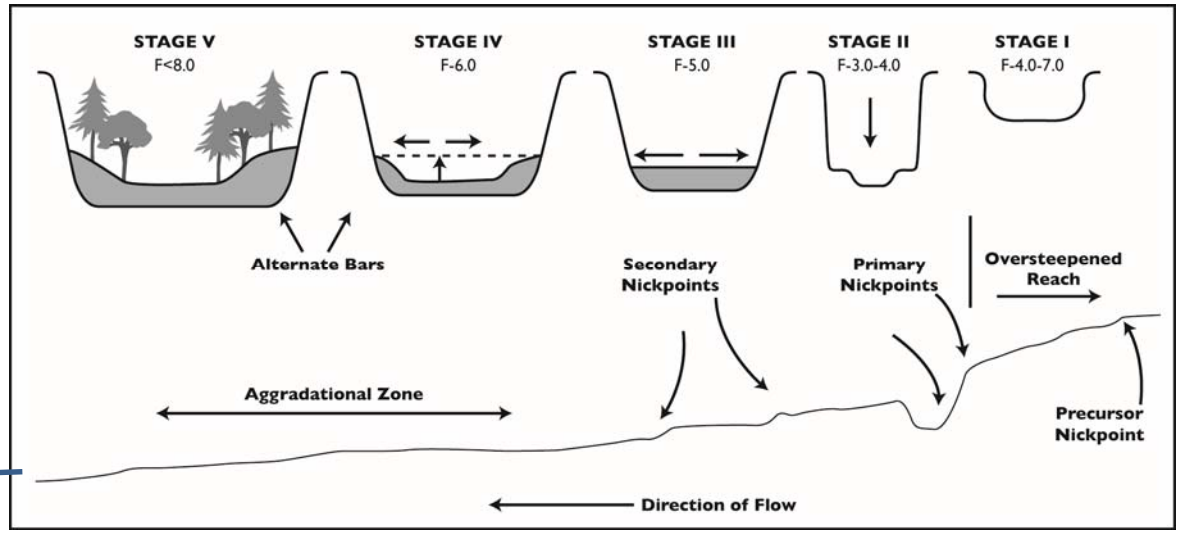
Proposed addition to CEM: Stage VI (Schumm, Harvey and Watson)
Stage VII (Simon and Hupp).

Thorne, C.R. 1999. Bank Processes and Channel Evolution in the Incised Rivers of North-Central Mississippi, Incised River Channels, Darby and Simon (eds.), Wiley, ISBN 0-471-98446-9, 97-122.

Can the CEM be extended further?



aggradation



US Swamp Land Act of 1850 essentially provided a mechanism for reverting title of federally owned swampland to states

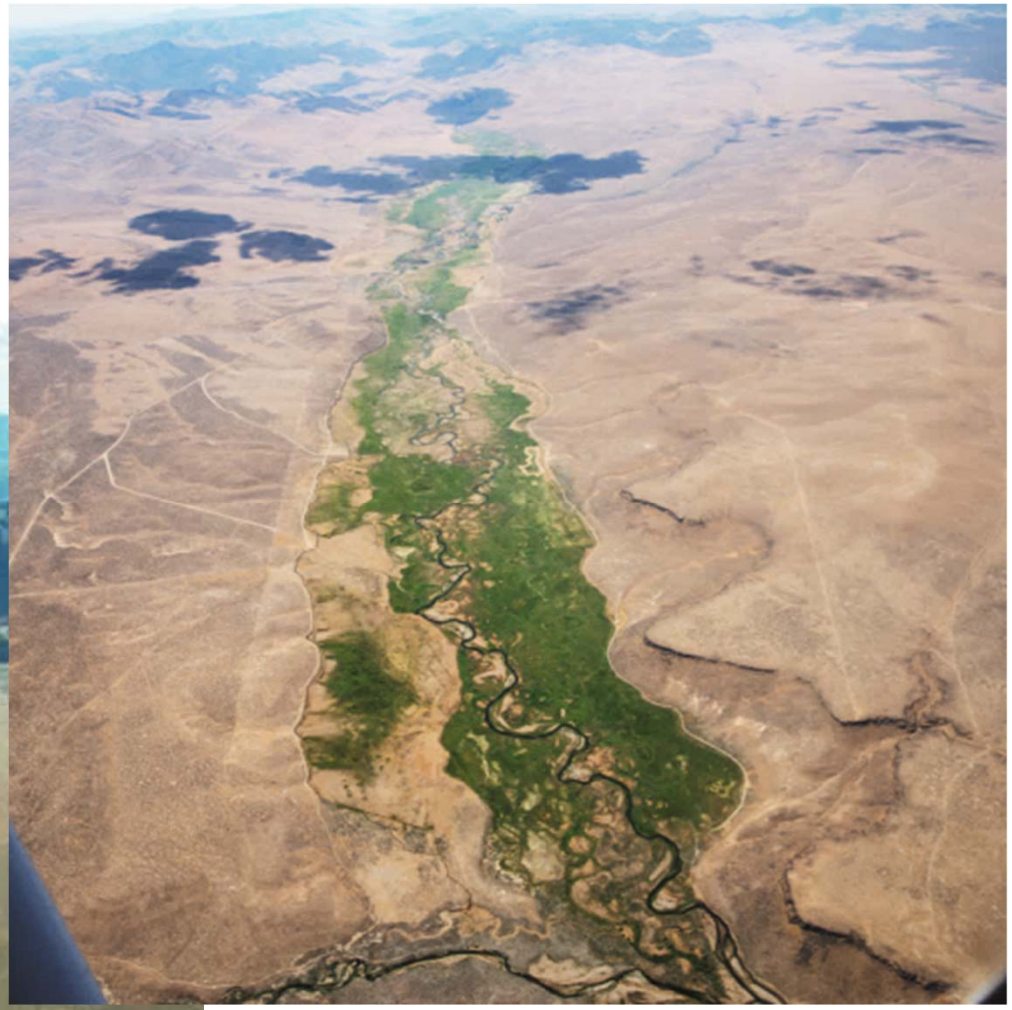
Eel River, CA

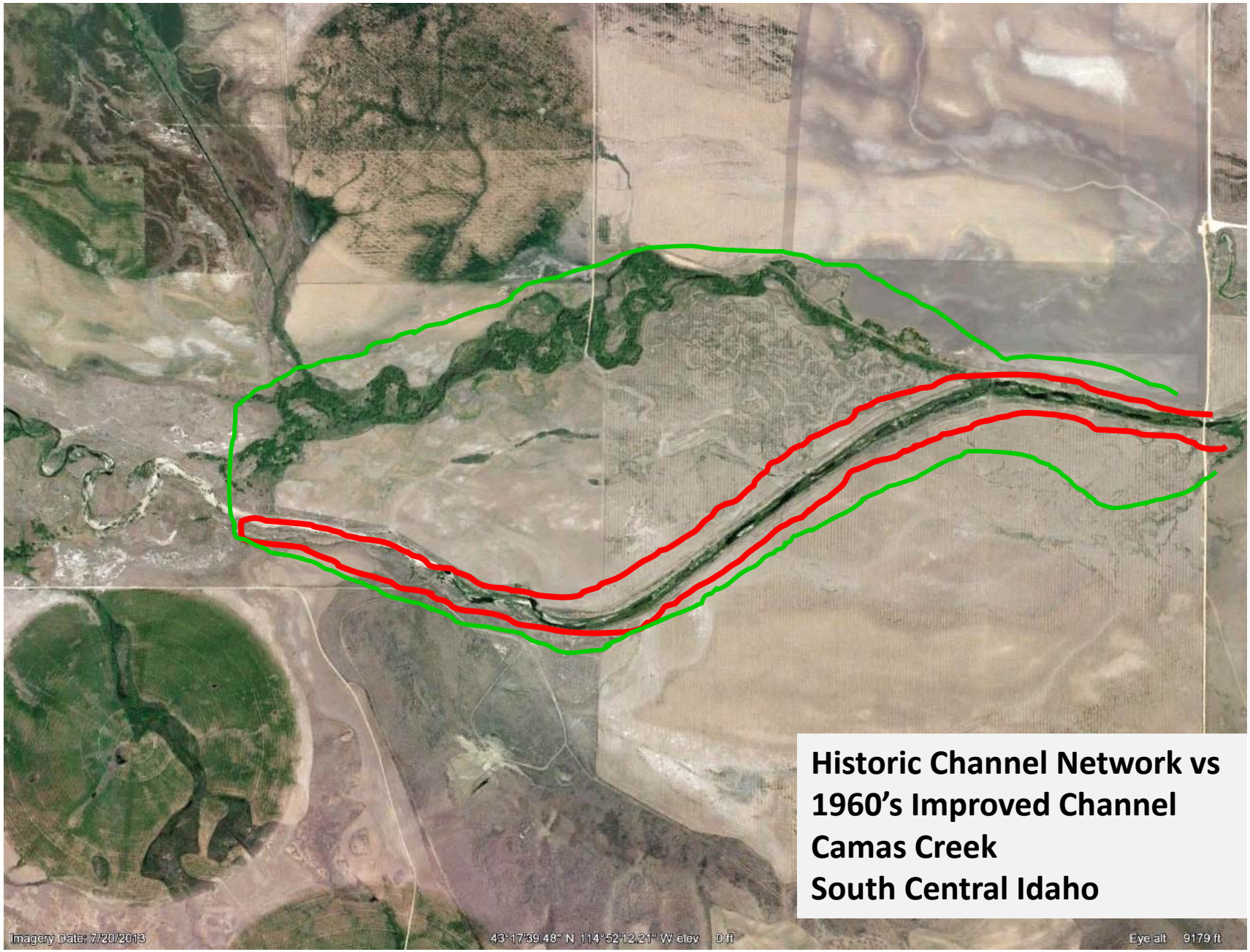
Era of draining floodplains, and Building defenses from floods.

LaGrand River, OR

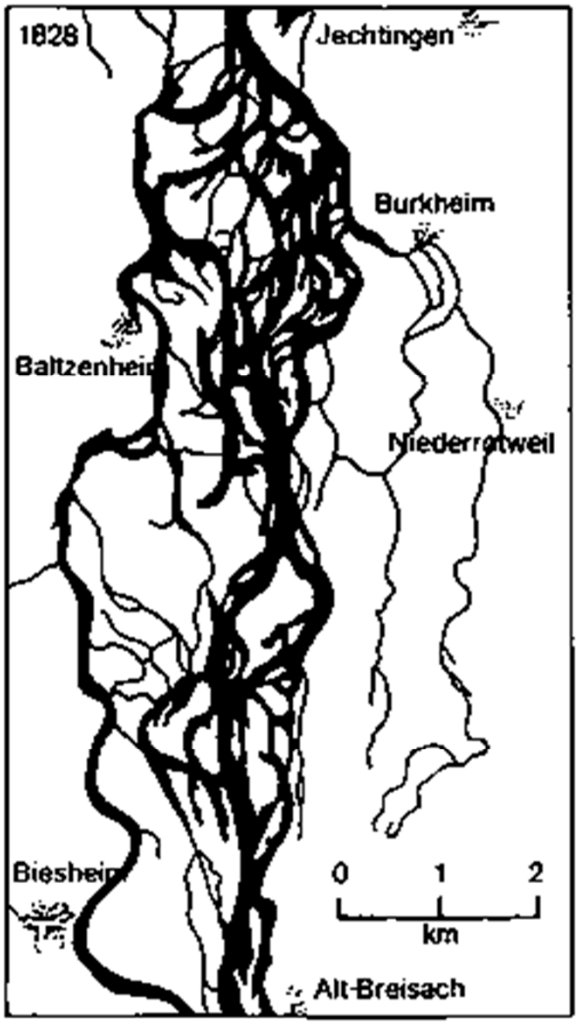
North Central Nevada

Edge of Arable Land

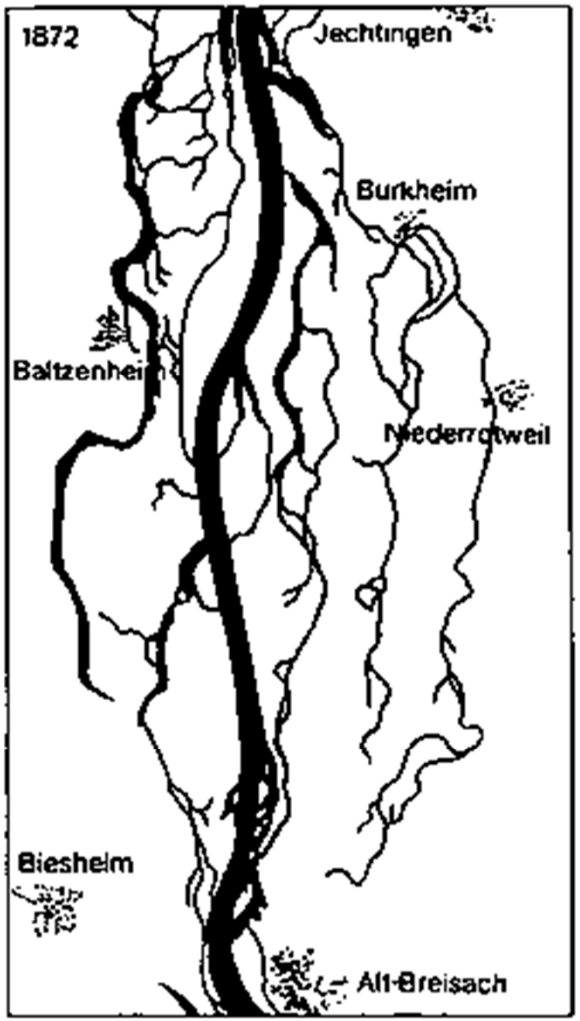



Historic Channel Network vs
1960's Improved Channel
Camas Creek
South Central Idaho
Imagery Date: 7/20/2013
43°17'39.48" N 114°52'12.21" W elev 0 ft
Eye alt 9179 ft

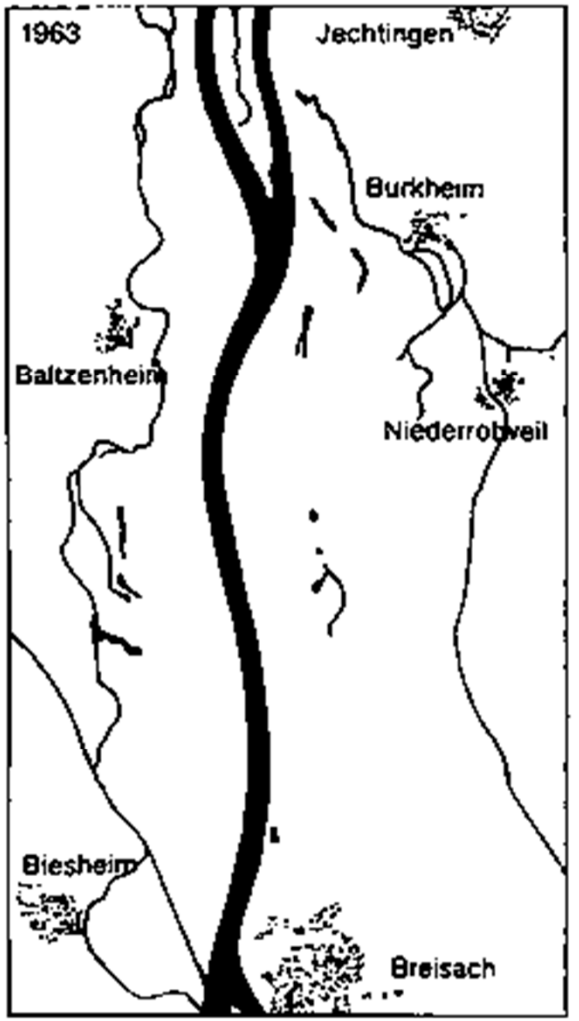
Example from Europe - Upper River Rhine at Breisach Germany



Anastomosed
1828 – Prior to
river training



Anabranched
1872 – after re-alignment
by Johann Gottfried Tulla



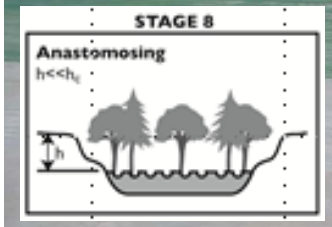
Meandering
1963 – fully canalised
single-thread

- Historic reconstructions:
  - Grossinger et al in California
  - Walter and Merritts in Eastern Piedmont
  - Brown and Sear in UK
  - many others
- Observations:
  - Willow Creek
  - Family farm
  - many others

Cluer and Thorne 2013

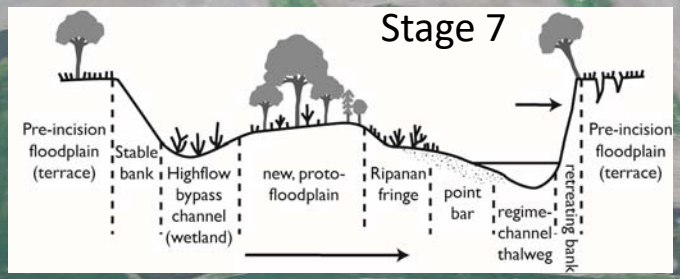
- Extended CEM to incorporate successor and precursor stages

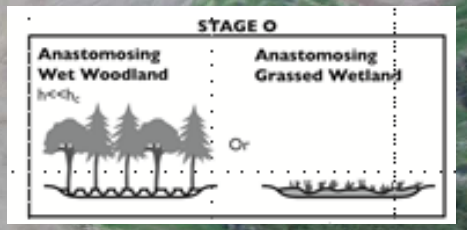
100's – 1000's



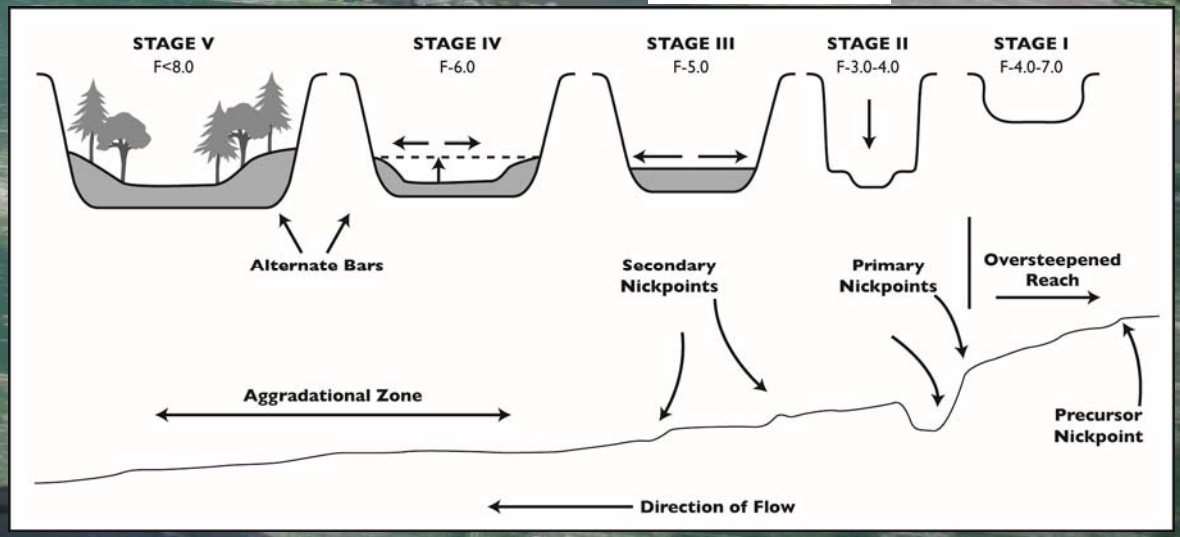
10's – 100's yrs

Stage 7

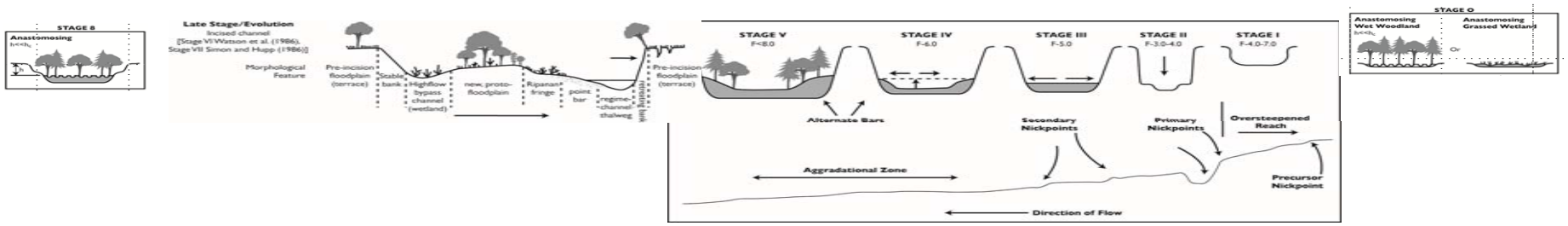




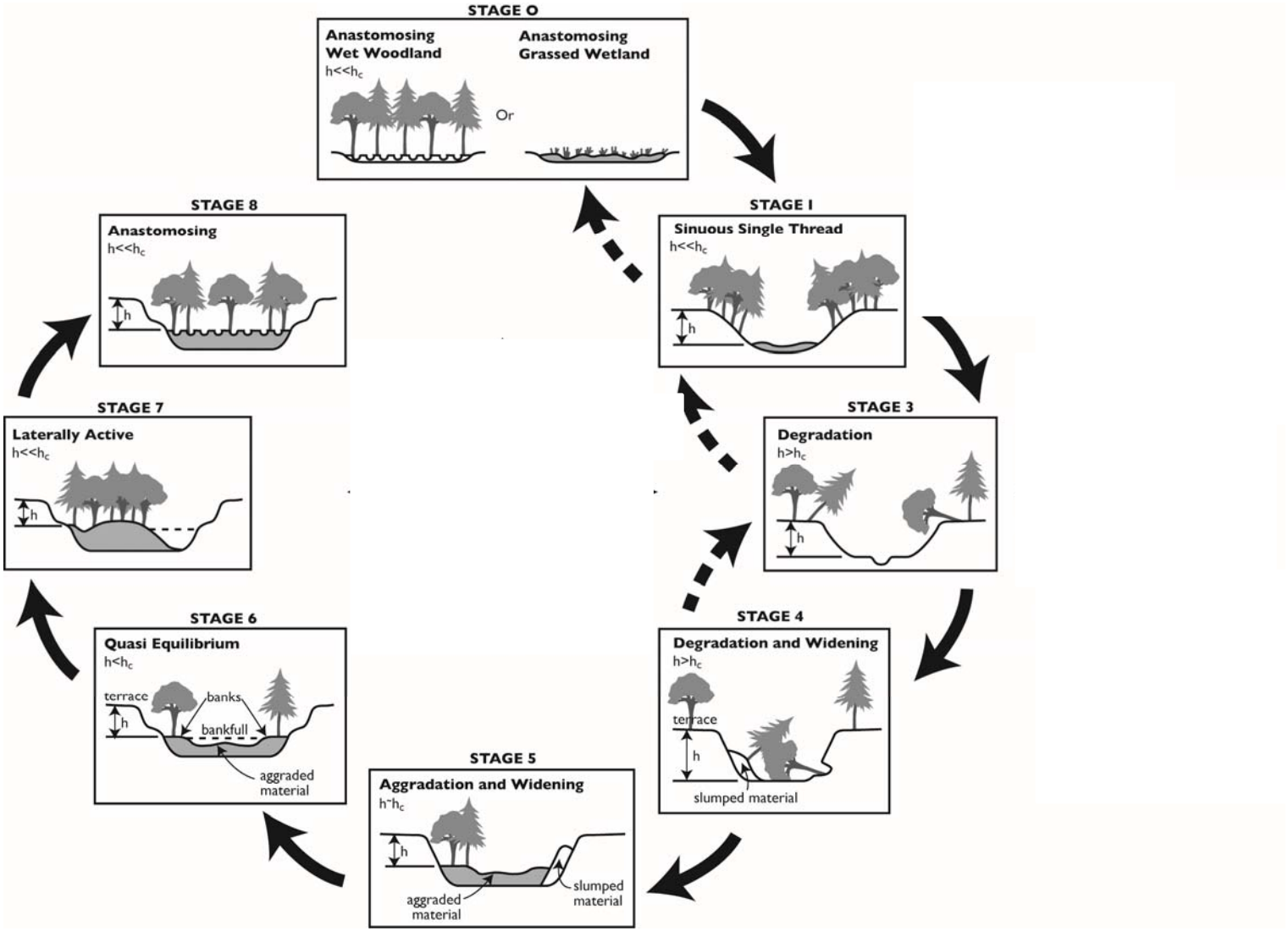
1-10 years



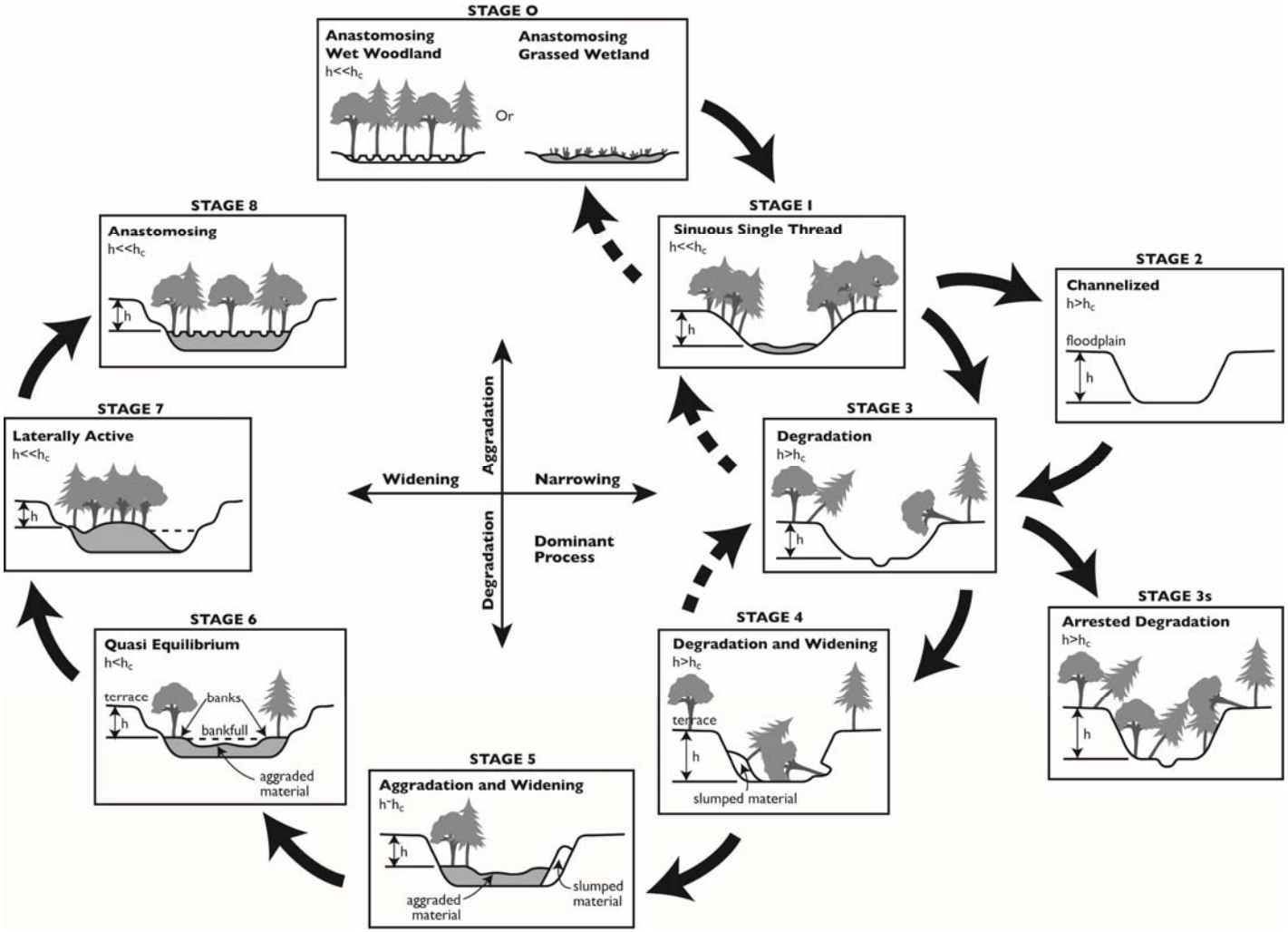
Geomorphic Template



Geomorphic Template



SEM derived from CEM



Part 2
Principles of functional ecology link habitat and ecosystem benefits to each SEM Stage.

- The potential for a stream to support rich, resilient and diverse ecosystems increases with morphological diversity, scale and hydroperiod.

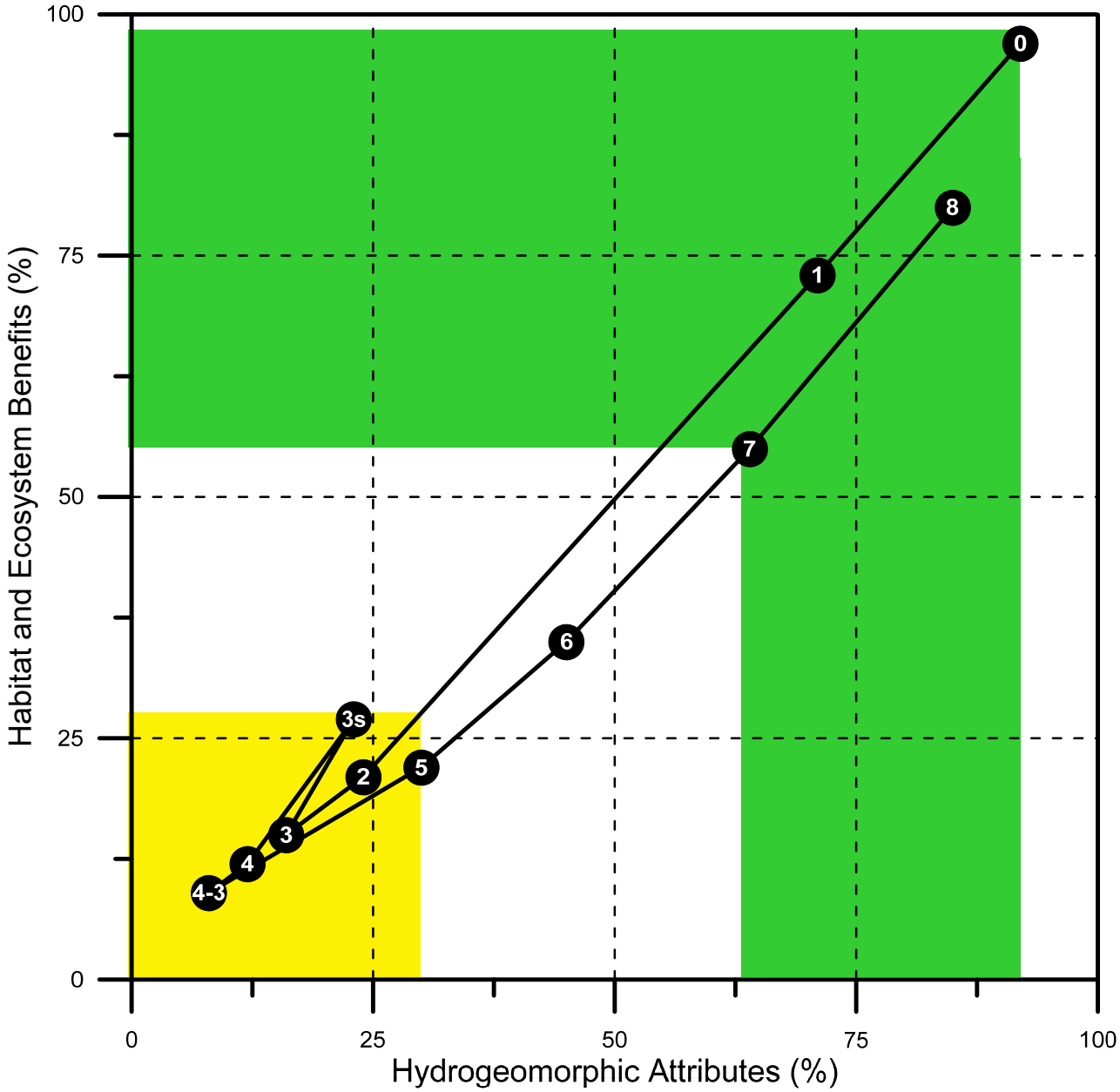
Primary literature: Harper et al 1995, Padmore 1997, Newson and Newson 2000, Thorpe et al 2010

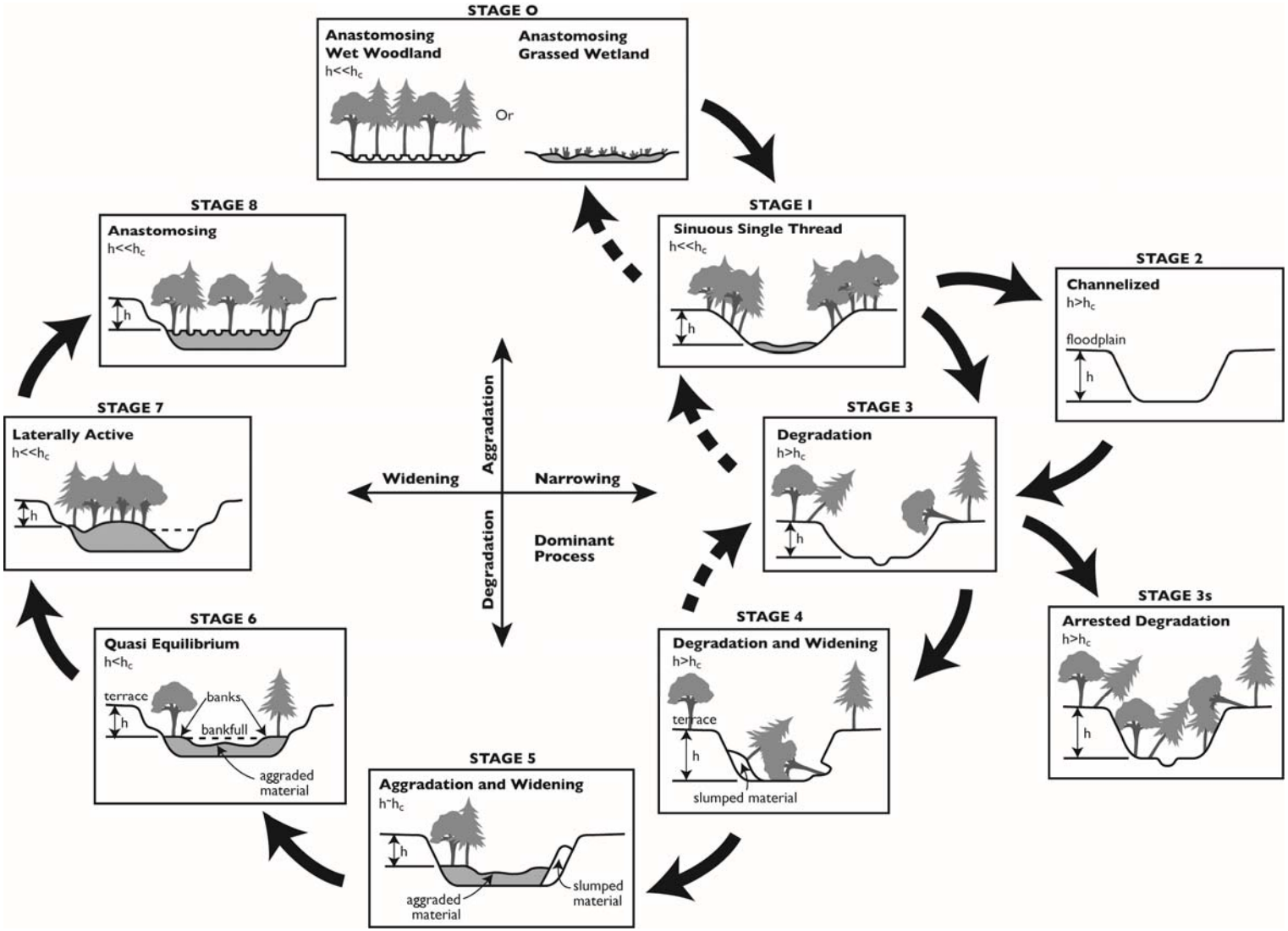
Literature: attributes and benefits

Ordinal Score:
0 = absent
1 = scarce/partly functional
2 = present and functional
3 = abundant/fully functional

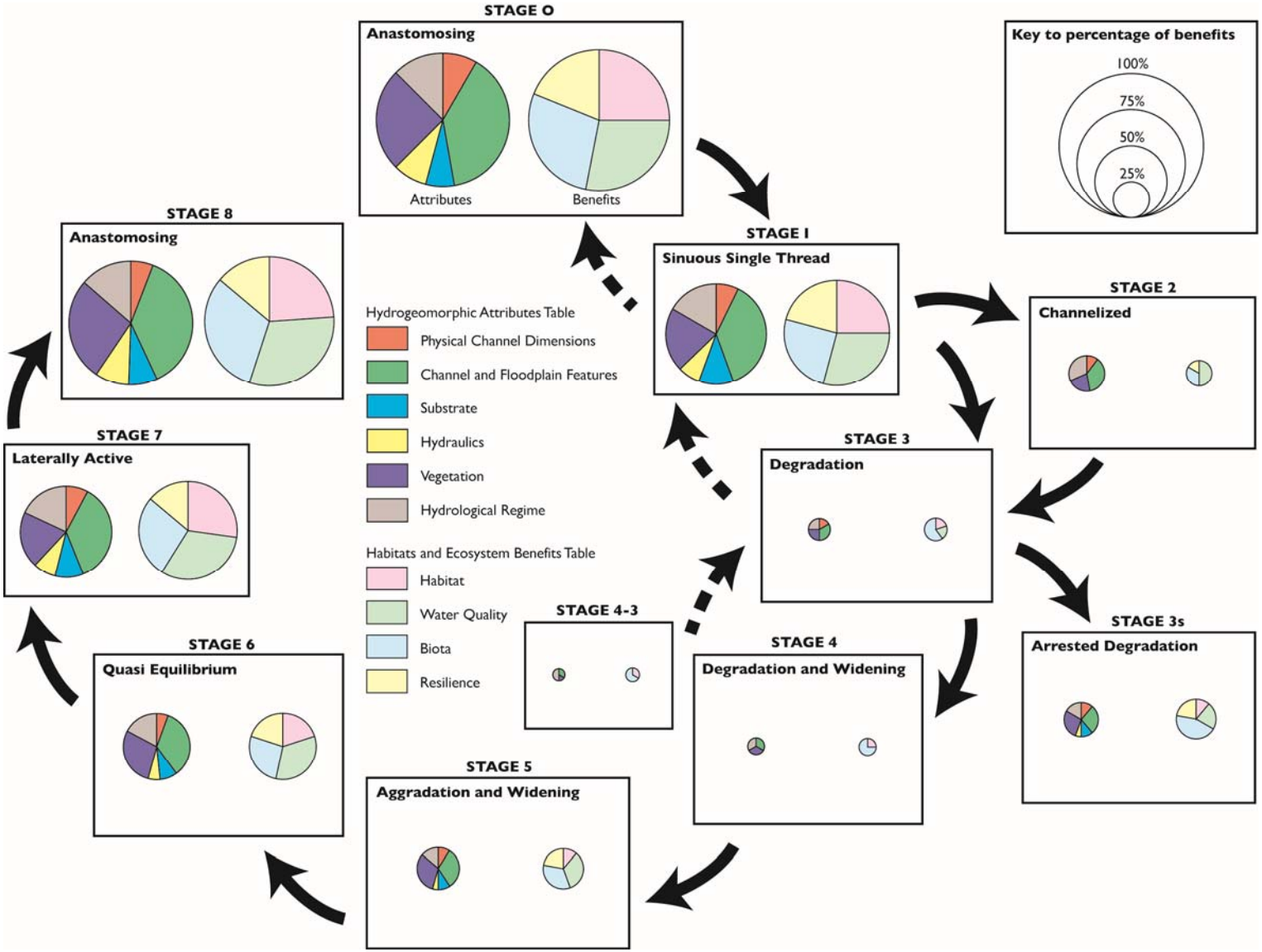
- Hydrogeomorphic attributes (26)
  - Number and dimensions, channel
  - Hydrologic regime, floodplain
  - Hydraulic complexity
  - Channel and floodplain features
  - Substrate – sorting/patchiness
  - Vegetation – sediment interaction

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


100
75
50
25
0
Habitat and Ecosystem Benefits (%)
0
25
50
75
100
Hydrogeomorphic Attributes (%)
0
1
2
3
3s
4
4-3
5
6
7
8


STAGE O
Anastomosing
Wet Woodland
h<<hc
Or
Anastomosing
Grassed Wetland
STAGE I
Sinuous Single Thread
h<<hc
h
STAGE 2
Channelized
h>hc
floodplain
h
STAGE 3
Degradation
h>hc
h
STAGE 3s
Arrested Degradation
h>hc
h
STAGE 4
Degradation and Widening
h>hc
terrace
h
slumped material
STAGE 5
Aggradation and Widening
h~hc
h
aggraded material
slumped material
STAGE 6
Quasi Equilibrium
h<hc
terrace
banks
h
bankfull
aggraded material
STAGE 7
Laterally Active
h<<hc
h
STAGE 8
Anastomosing
h<<hc
h
Aggradation
Widening
Narrowing
Degradation
Dominant Process

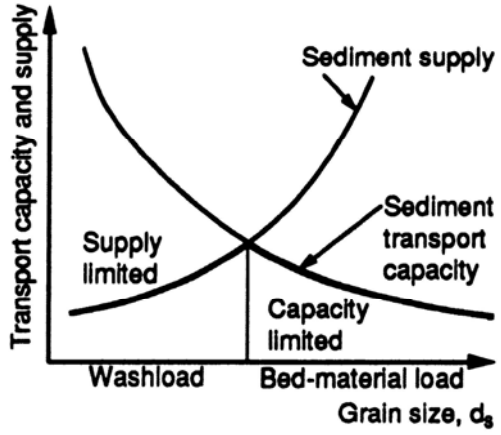
Ecosystem overlay

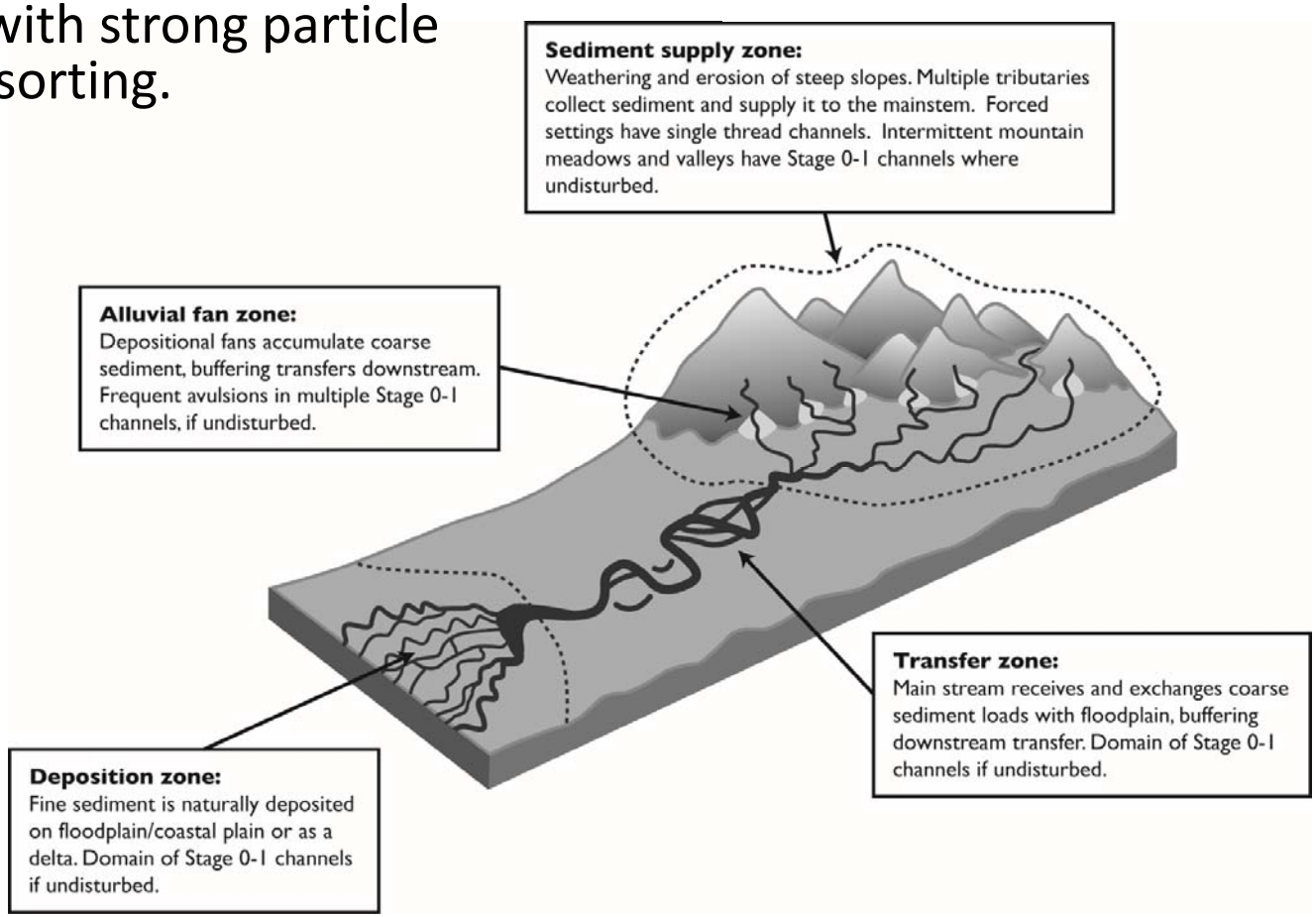


What Distinguishes Stage 0 ?
and
What Ecosystem Services Does Stage 0 Deliver ?

PHYSICAL:

1. DEPOSITION ZONES
   - Transport capacity limited.
   - When mature, supply and capacity may balance, with strong particle exchange and sorting.





2. Large accommodation space

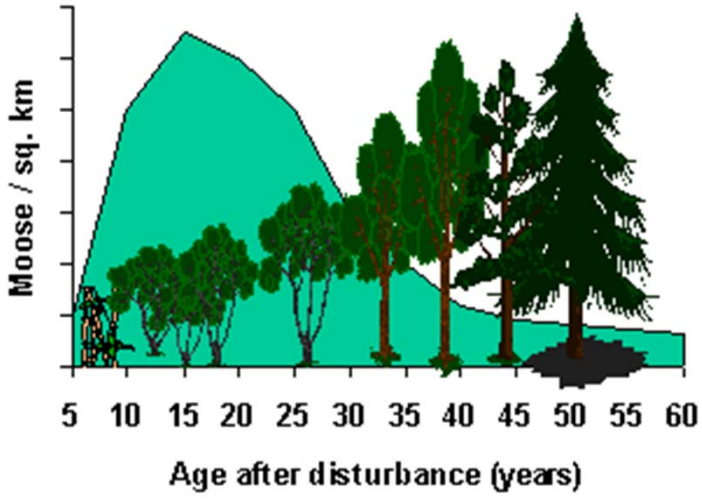
- Maximal flood attenuation.
- Maximal GW recharge
- Maximal sediment pulse attenuation.
- Resilient to entire range of watershed processes and pulses.

3. High water table

- No deep drainage channel.
- Stream flow and ground water connection.
- High interaction between flow, sediment, and vegetation.
- Small channels easily moderated by vegetation.

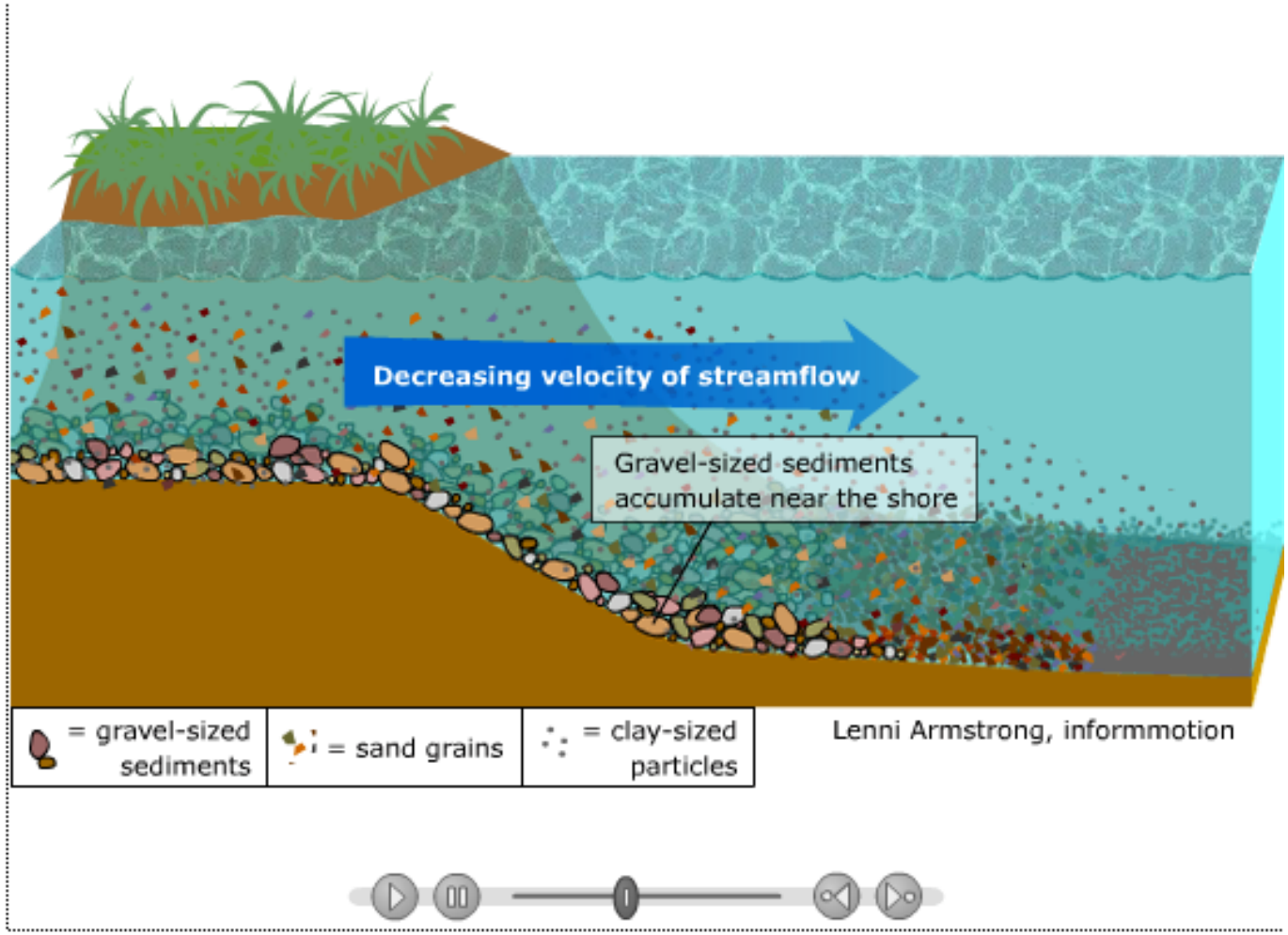
Vegetation Attributes

- Frequent, small channel adjustments and high, reliable water table - proliferation and succession of aquatic, emergent, riparian and floodplain plants.
- Dense vegetation interacting with and moderating physical processes.
- High wood supply and retention.
- Abundant leaf litter.



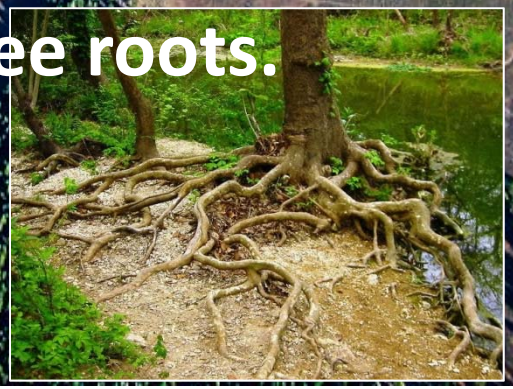
- Morphological diversity in-channel and on the extensive and fully connected floodplain.
- Branches create multiple, marginal deadwaters, and maximum hydraulic diversity.

- Hydraulic diversity drives numerous, well-sorted bed material patches.



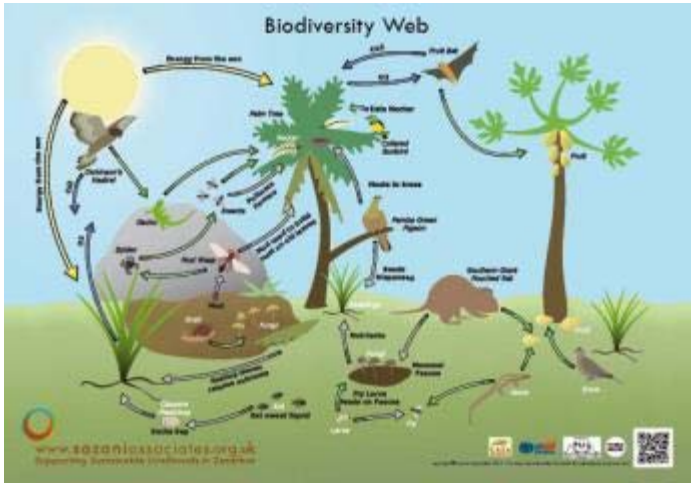
4. Habitat and Ecosystem Services unlike it's incised family members

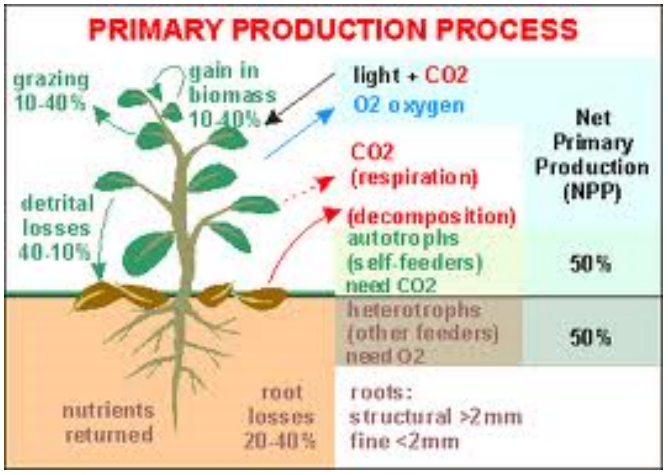
- **Multiple channels, islands and broad floodplain - rich palette of diverse habitats in close proximity.**
- **Flood refugia**
- **Drought refugia**
- **High water table and continuous hyporhesis quickly rewets**
- **Channel margins evolve semi-continuously - expose tree roots.**

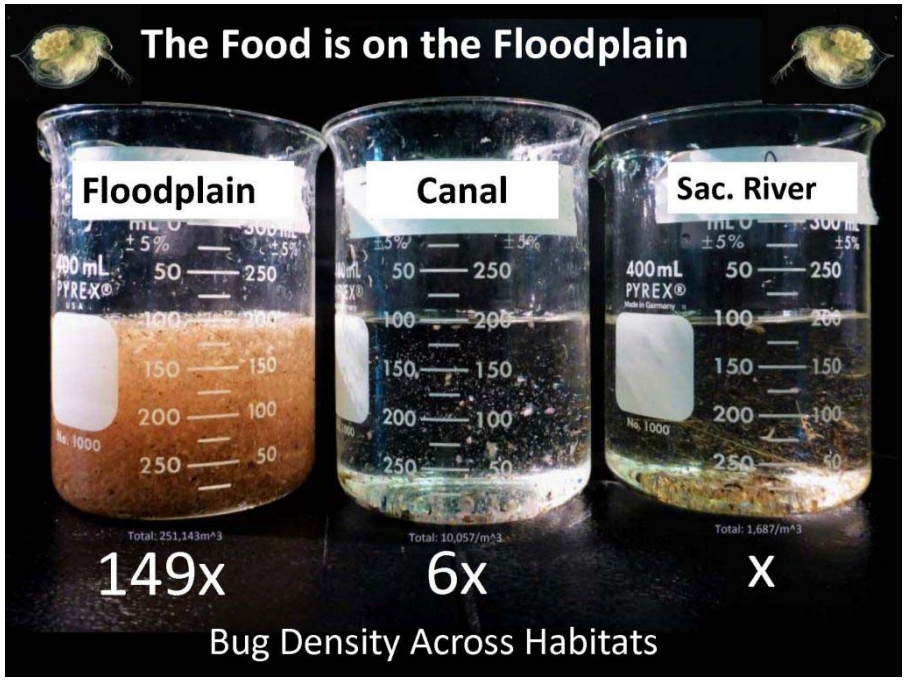


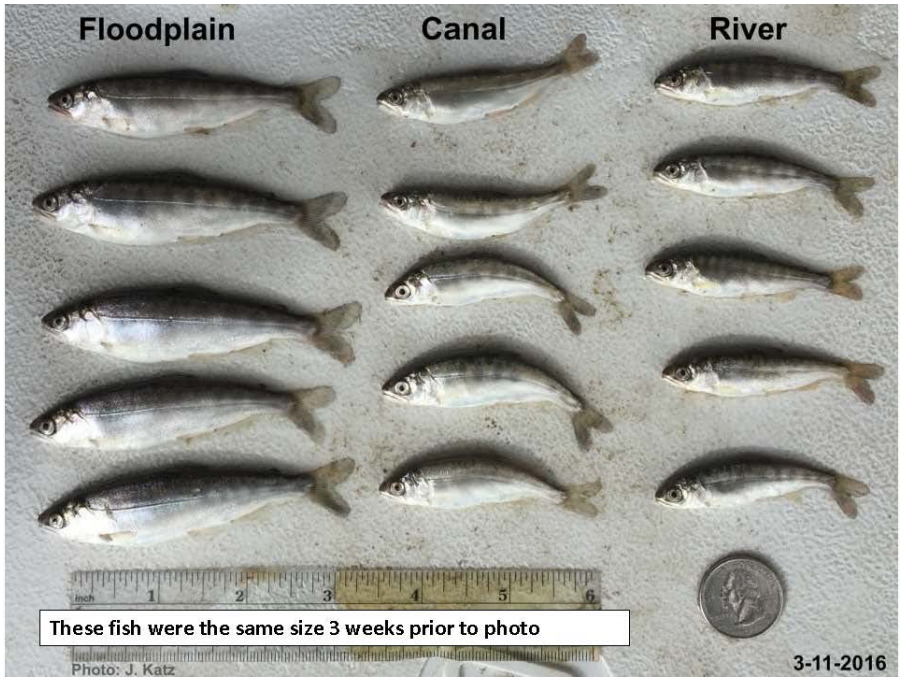
Biota

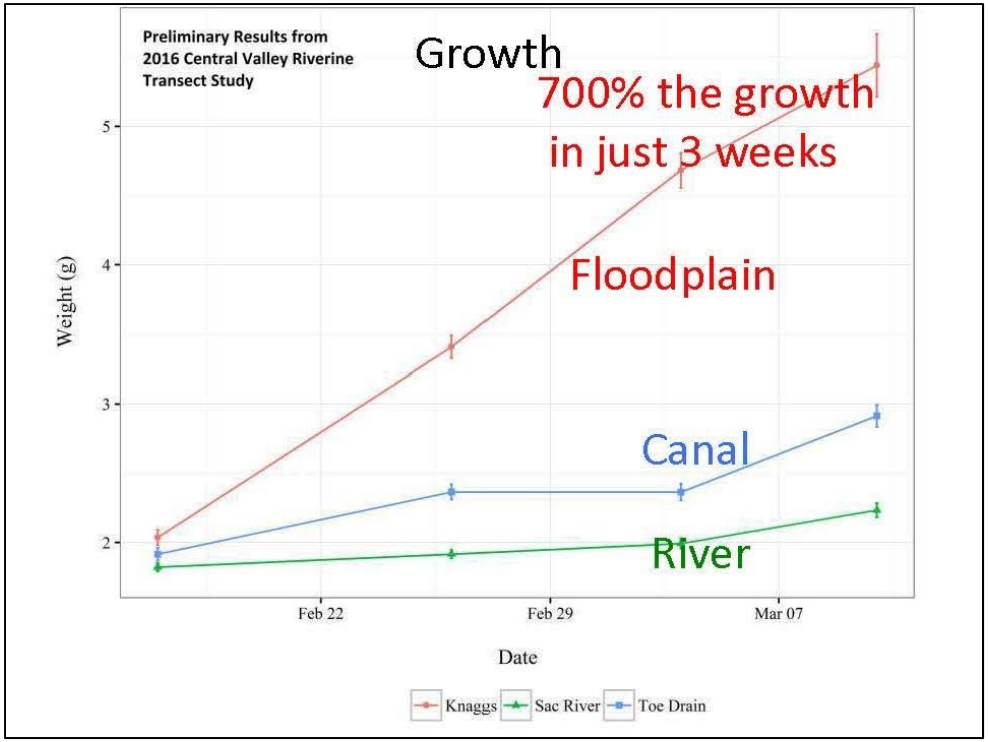
- Highest possible biodiversity (species richness and trophic diversity) and proportion of native species.
- 1st and 2nd order productivity in quiet shallow water.
- Highest productivity across maximal space.









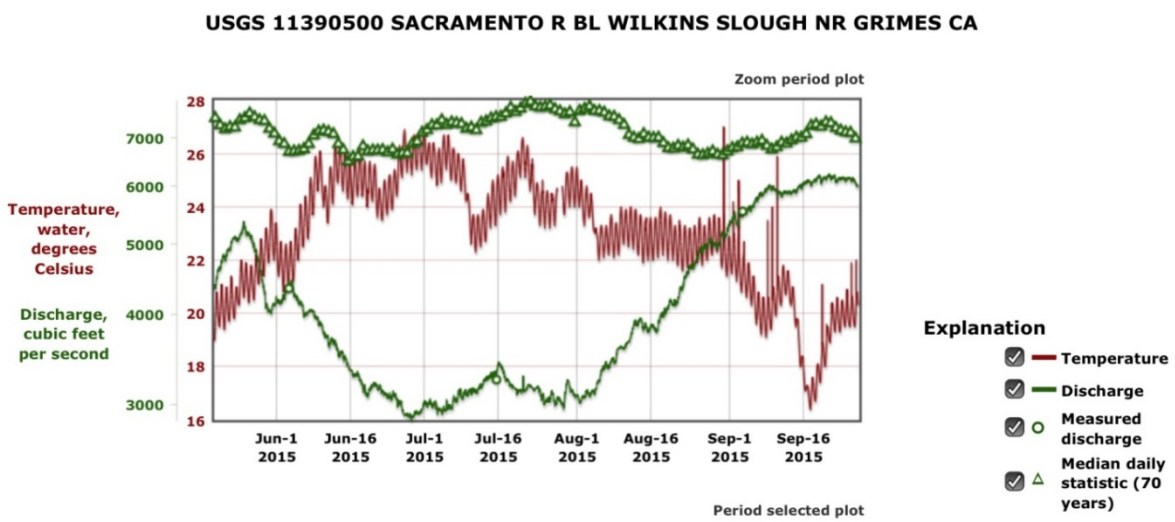


Higher growth rate
and
Higher abundance

J. Katz 2016

High water quality

- Capacity to store sediment and other suspended solids.
- Cycle nutrients.
- Dense, diverse vegetation - abundant shade.
- Together with efficient hyporhesis, effective in ameliorating high and low temperatures.



Stage 0 sessions:

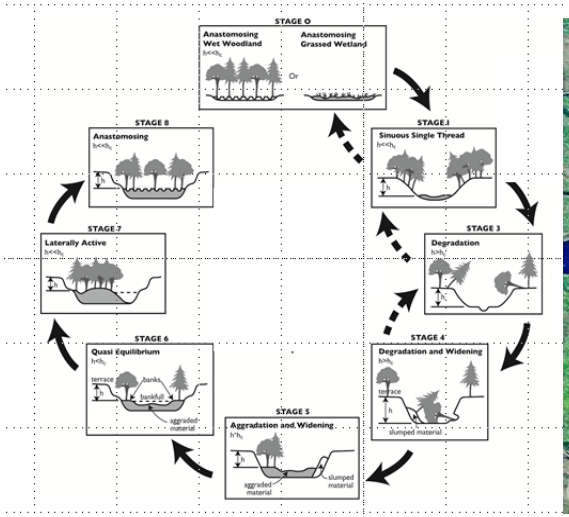
SESSION 1, Science Base, Historical Perspectives & Natural Functions

- **Brian Cluer - geomorphic and ecological basis for restoring Stage 0**
- **Robin Grossinger - historical basis for restoring to Stage 0**
- **Mark Beardsley - restoring historic widespread Stage 0 in the Southern Rocky Mountains**
- **Jenny Mant – Flood management and ecological benefits? Fact or fiction British perspective**
- **Johan Hogervorst – A 10 minute history of National Forest restoration of depositional areas.**

Stage 0 sessions:

SESSION 2, HOW: Design and Case Studies

- **Paul Powers - A Proposed Stage 0 Restoration Approach, Design, and Construction**
- **Kate Meyer - Case Study - Cascades, Deer Creek OR**
- **Paul Burns - Case Study - Coastal, Five Mile Bell OR**
- **Lauren Hammack – Natural development of Stage 0 wetland complex, coastal Willow Creek CA**
- **General Discussion and Q+A**



Stage 0 related posters:

- **Castro and Thorne - Stream Evolution Triangle: accounting for geology, hydrology and biology in understanding stream morphology and evolution**
- **Kurian and Squires – Restoring Staley Creek OR to Stage 0**
- **Pollock et al. - Stage 0 concepts applied to mountain meadow restoration**
- **Press - Restoring high desert Whychus Creek OR to Stage 0**
- **Tanaka et al. - Functional secondary channels**

Thank you.

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