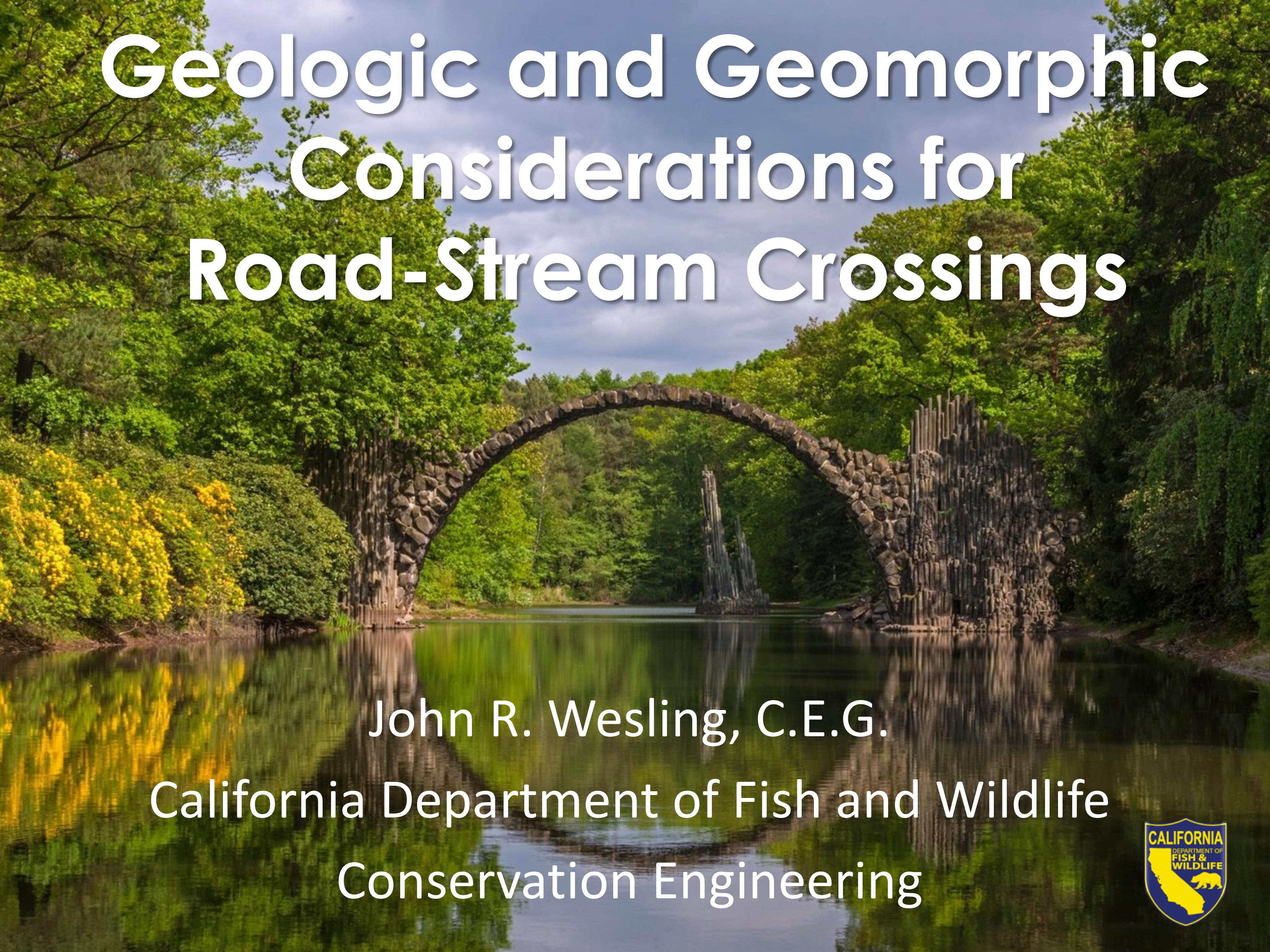


Geologic and Geomorphic Considerations for Road-Stream Crossings

John R. Wesling, C.E.G.

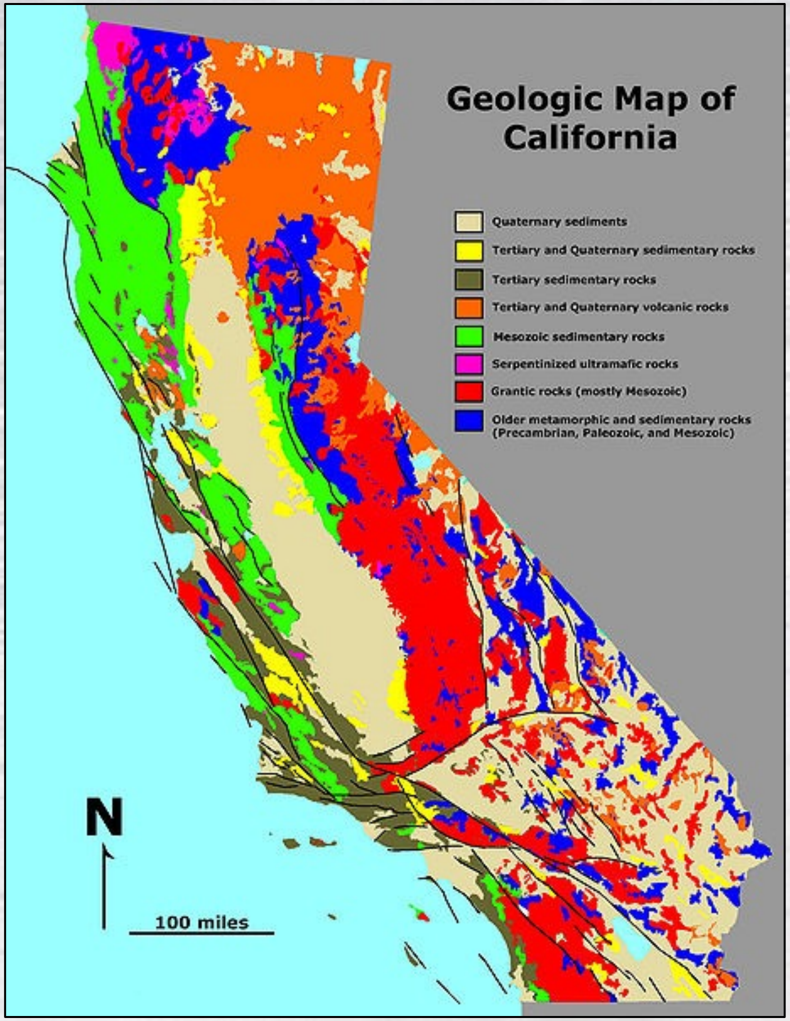
California Department of Fish and Wildlife

Conservation Engineering

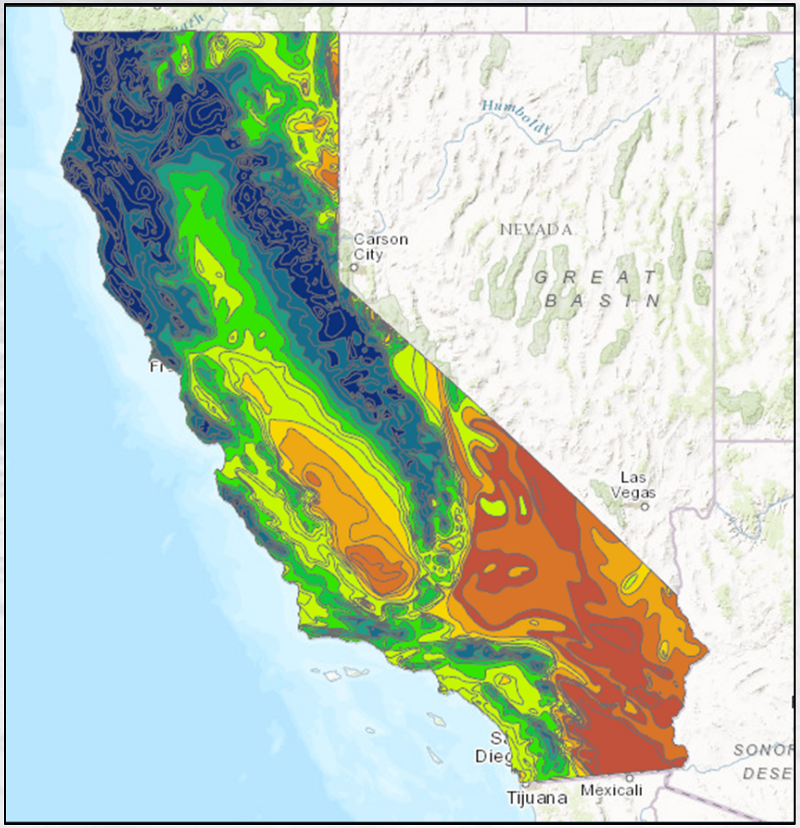
Presentation Overview

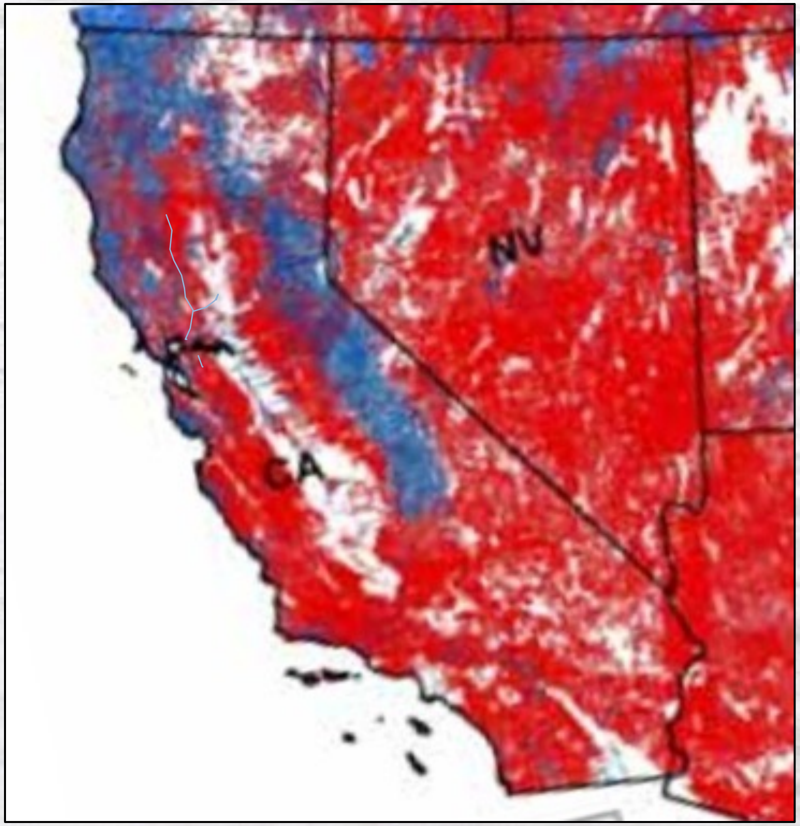
- Engineering Geology and Geomorphology
- Setting of CA Streams
- Fluvial Terminology, Process and Form
- Ecological Connectivity
- Crossing Controls and Fluvial Adjustments

Geology and Topography

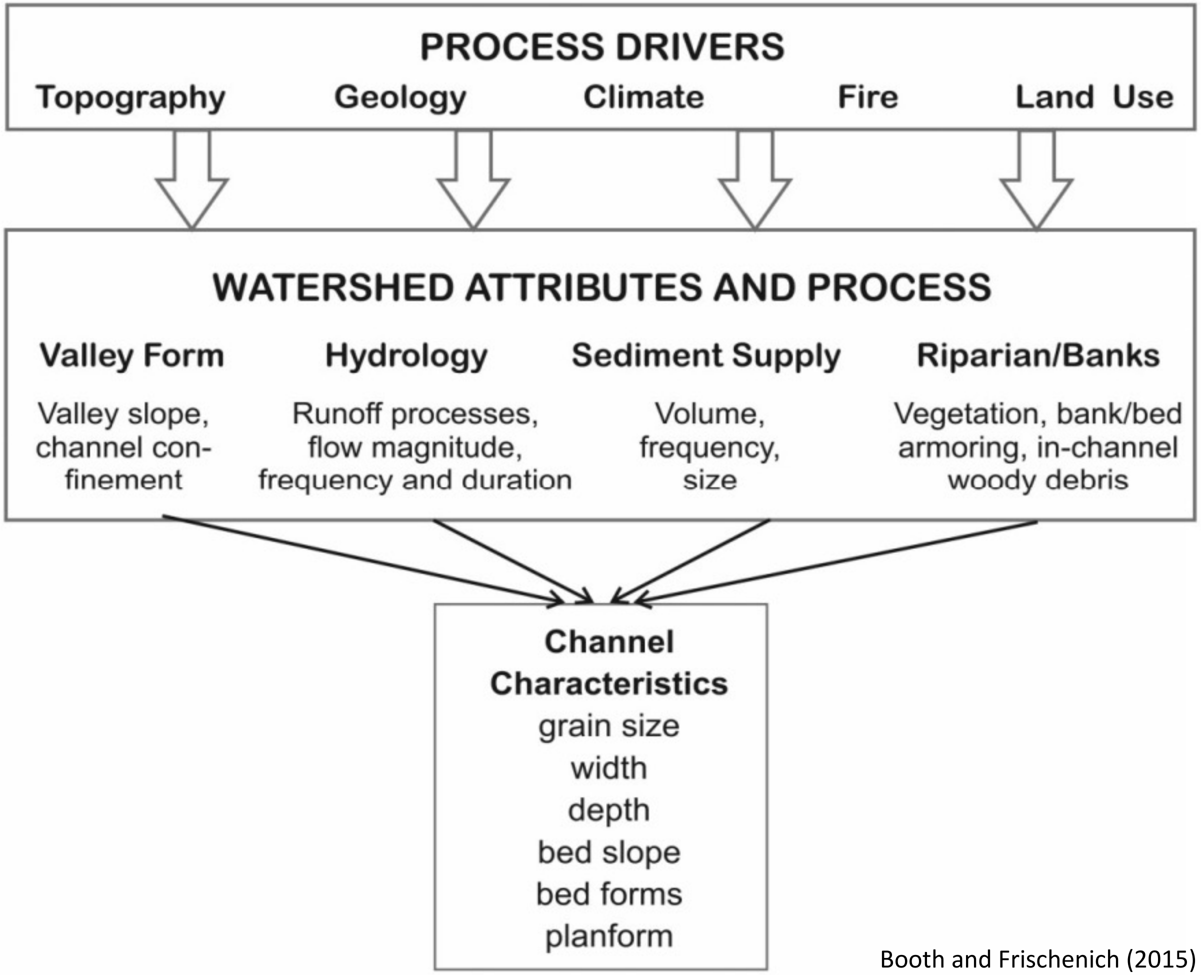


Climate & Hydrologic Flow Regime

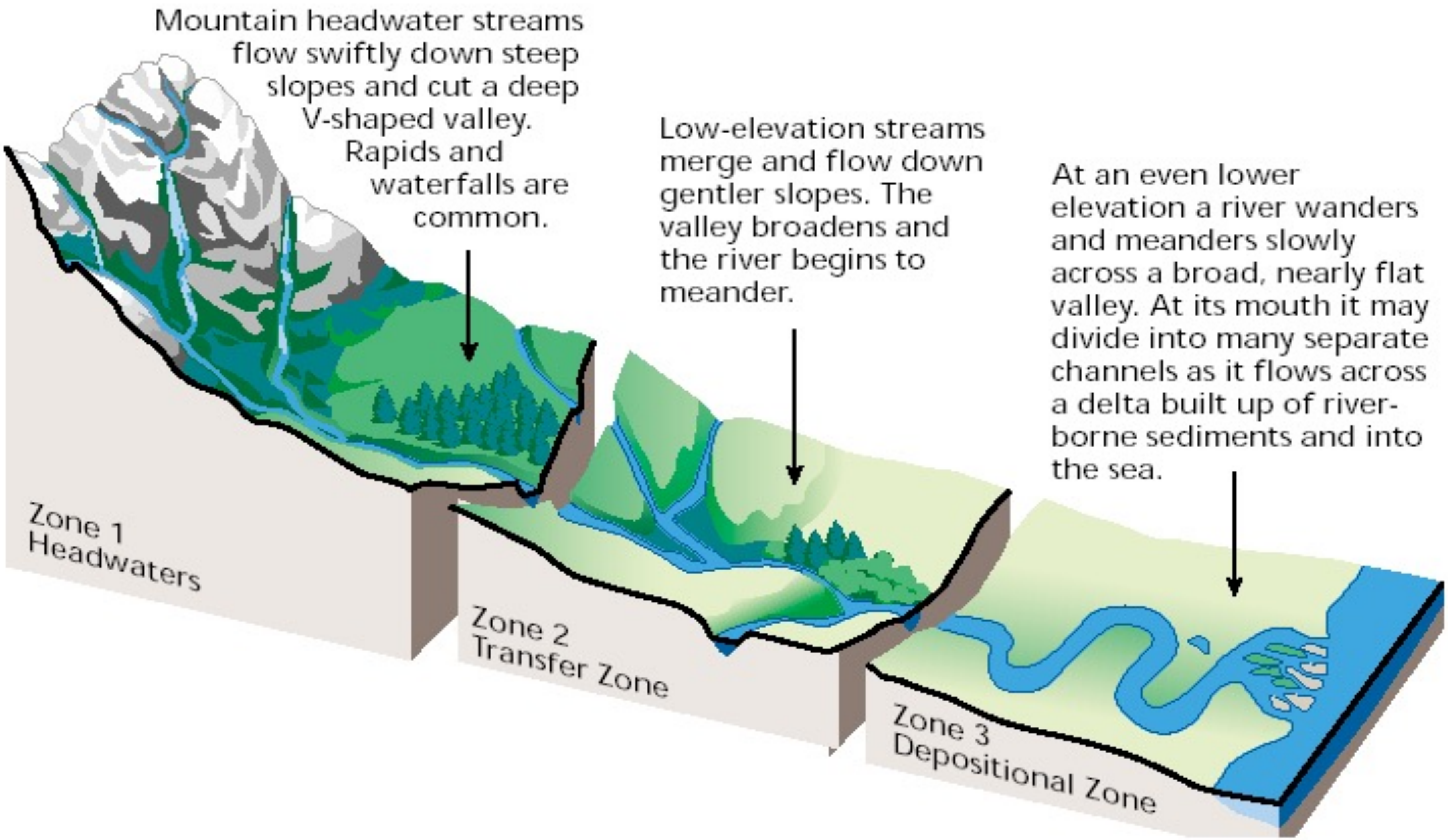


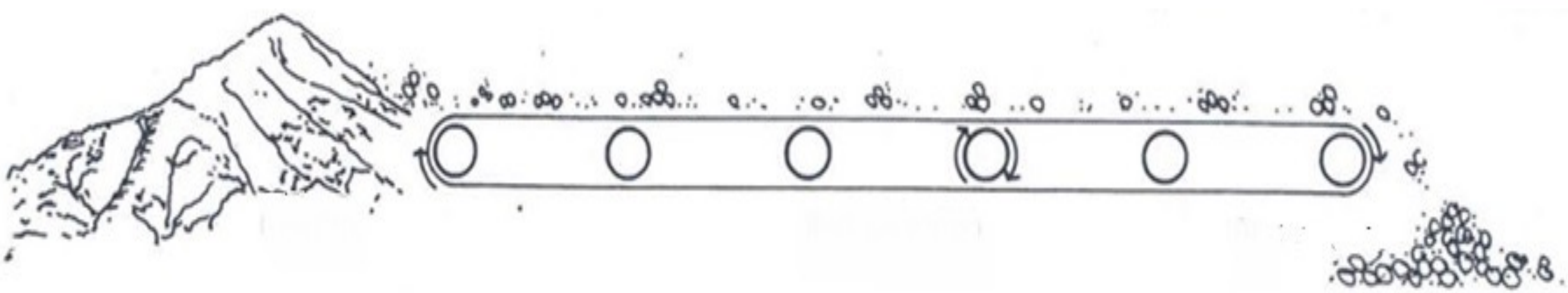


Process and Form

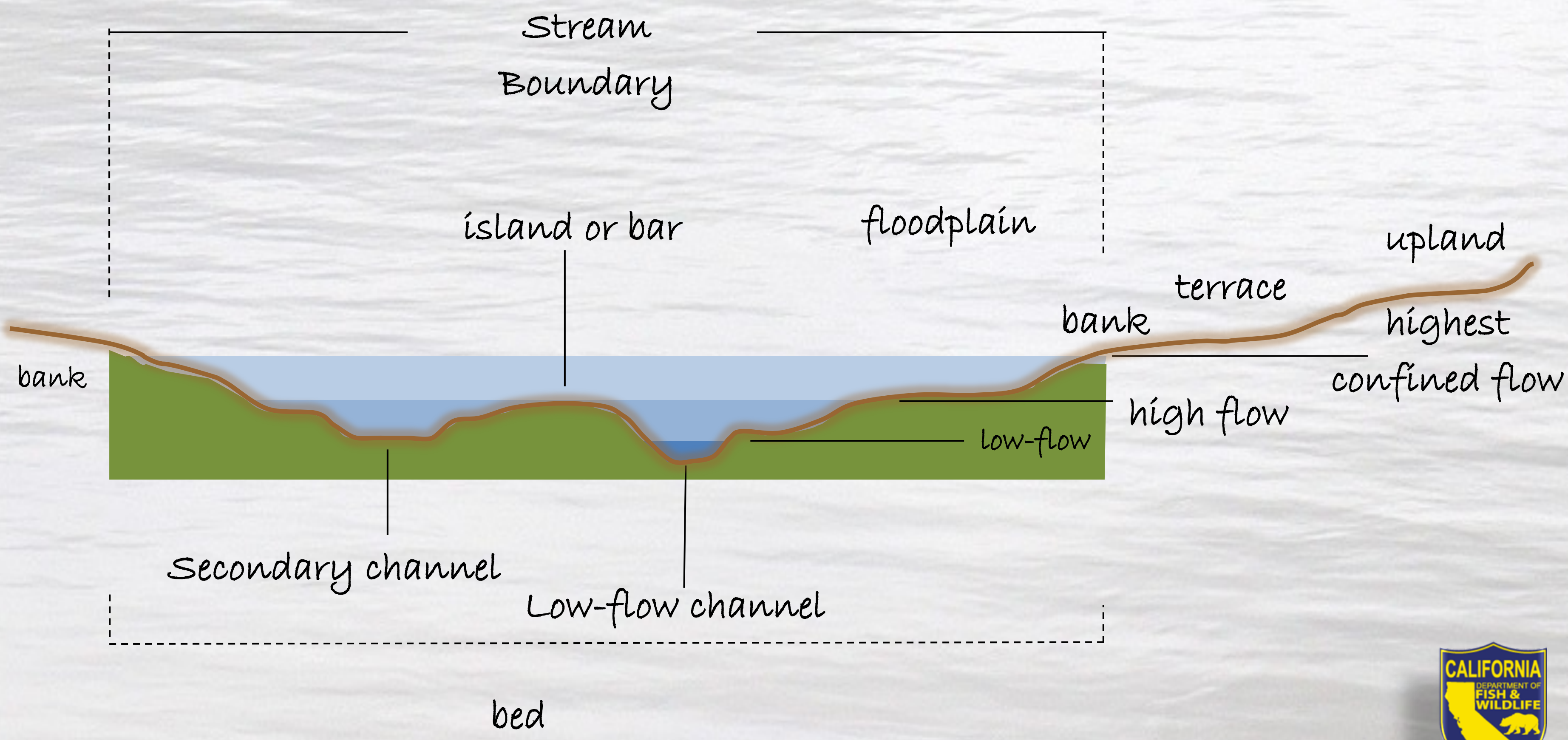


Booth and Frischenich (2015)


Mountain headwater streams flow swiftly down steep slopes and cut a deep V-shaped valley. Rapids and waterfalls are common.
Low-elevation streams merge and flow down gentler slopes. The valley broadens and the river begins to meander.
At an even lower elevation a river wanders and meanders slowly across a broad, nearly flat valley. At its mouth it may divide into many separate channels as it flows across a delta built up of river-borne sediments and into the sea.
Zone 1
Headwaters
Zone 2
Transfer Zone
Zone 3
Depositional Zone



Science-Based Terminology Stream & Landforms

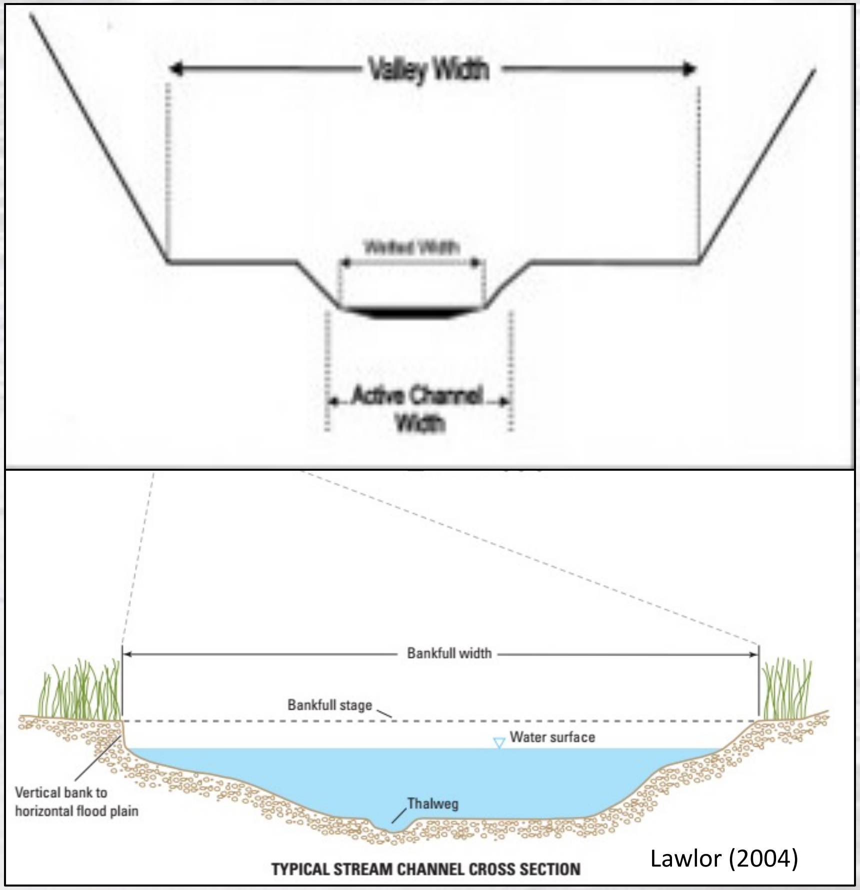


Science-Based Terminology

- **Stream/River**
- Floodplain
- Riparian
- Channel
- Bed
- Bank

Other Important Terms…

- Bankfull Stage
- Bankfull Width
- Active Width
- Valley Width
- Wetted Width



Lawlor (2004)

Road-Stream Crossings
It's All About Connections

- Connecting the road from one side of the stream to the other
- Connecting the stream from one side of the road to the other
- Connecting the stream ecosystem from one side of the road to the other

Basic Concepts…

- Streams are a continuum of upstream to downstream physical processes that collectively build, rejuvenate, and sustain headwater to terminus habitats and ecosystems

- Local stream processes may be critical to sustaining downstream as well as terrestrial non-stream habitats located elsewhere

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Basic Concepts…

- Species depend on the structure of their habitat and the physical processes that create and maintain the habitat

- Habitat protection begins with science-based application of terminology to describe structure, its inextricable link with process, ecosystem function, and the well-being of our riparian resources

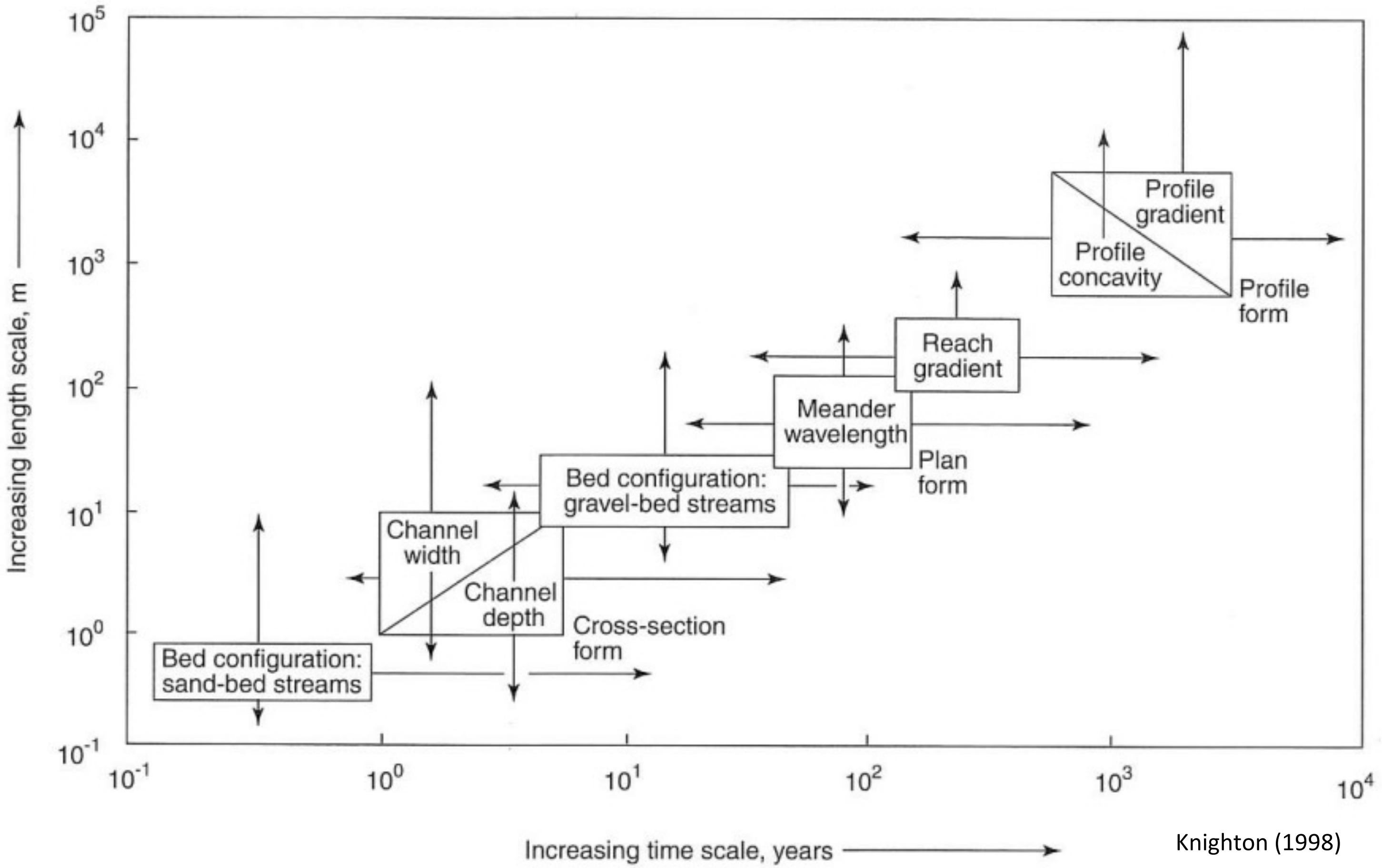
Ecological Connectivity

"For habitat protection, ecological connectivity should be a goal of stream-road crossing designs. The narrowest scope of crossing design is to pass floods. The next level is requiring fish passage. The next level includes sizing the crossing for sediment and debris passage. For ecosystem health, "ecological connectivity" is necessary. Ecological connectivity includes fish, sediment, debris, other organisms and channel/floodplain processes."

Ken Bates - WDFW

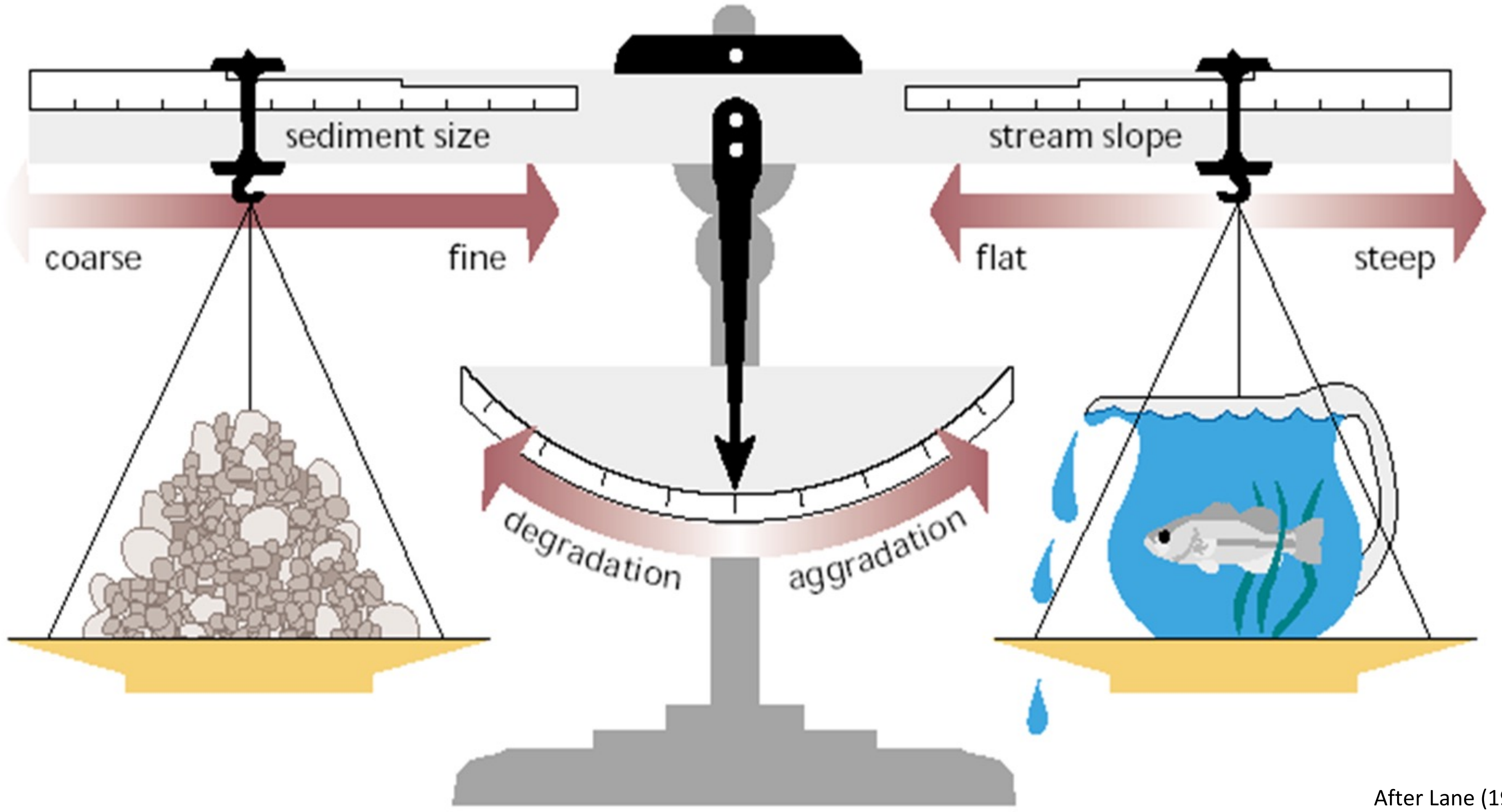
- Water
- Fish
- Sediment & Debris
- Other Organisms
- Channel Processes
- Floodplain Processes

Change is Expected



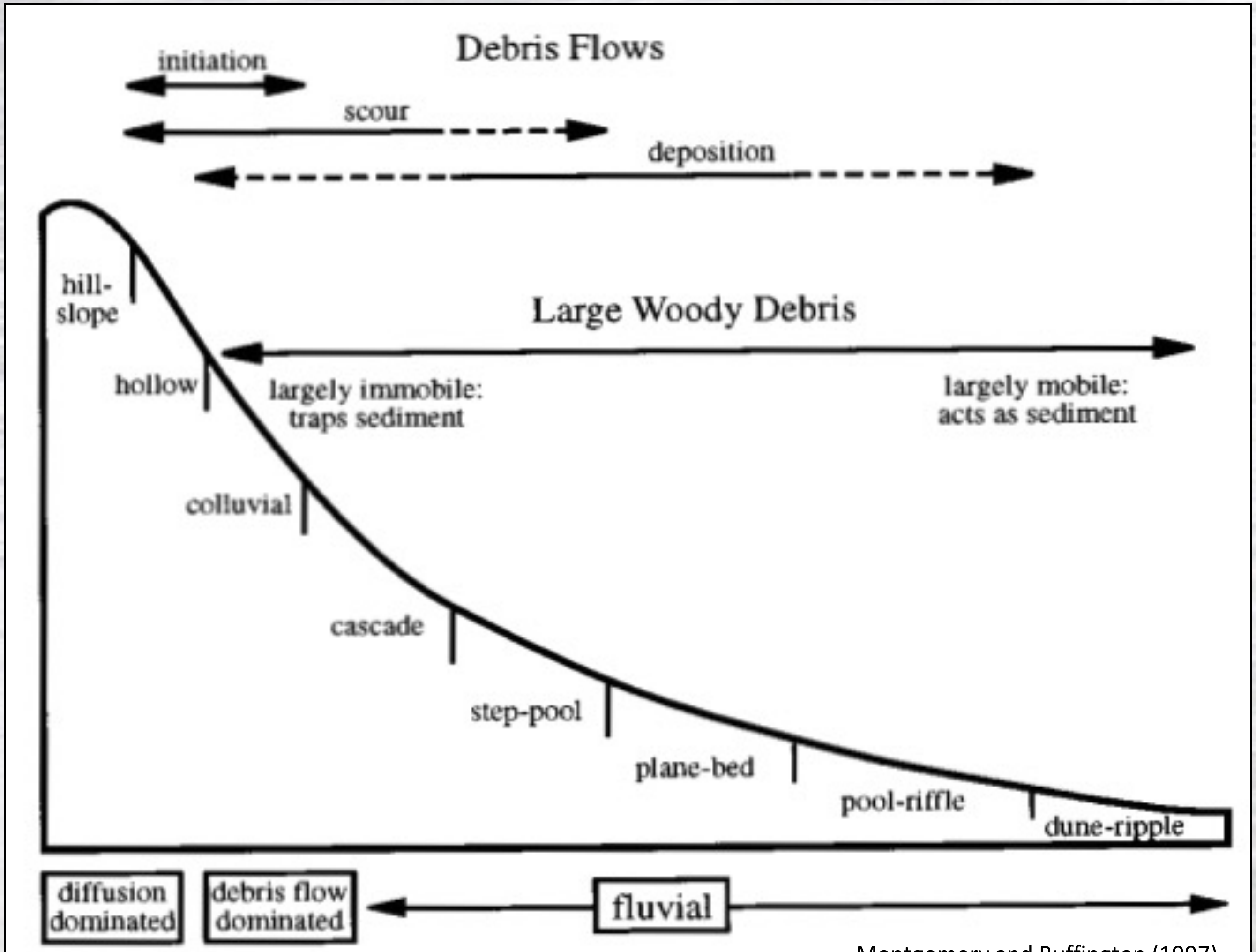
Knighton (1998)

Lane's Balance



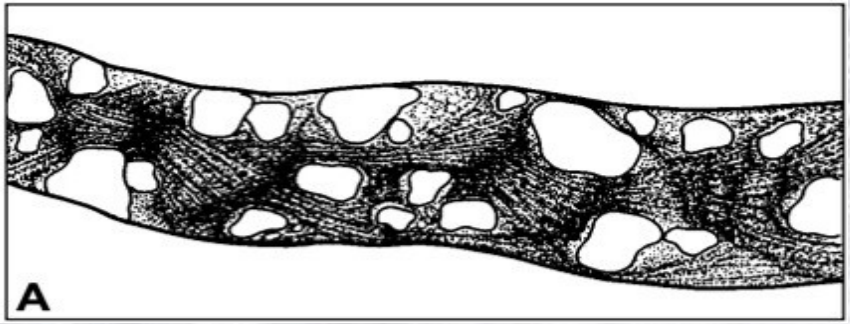
After Lane (1955)

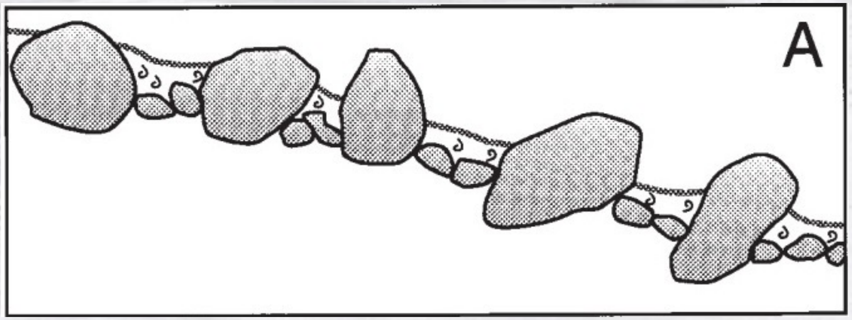
Channel Classification



Montgomery and Buffington (1997)

Cascade Channel

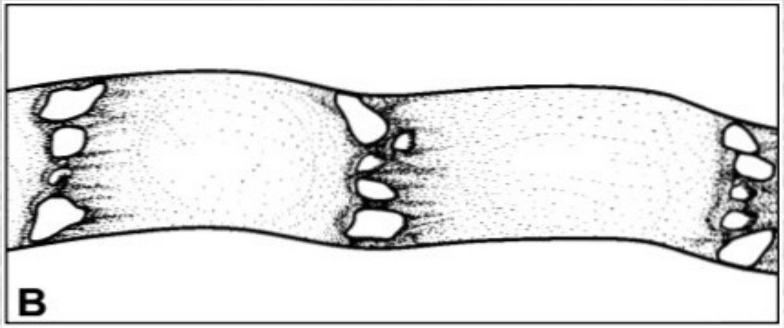


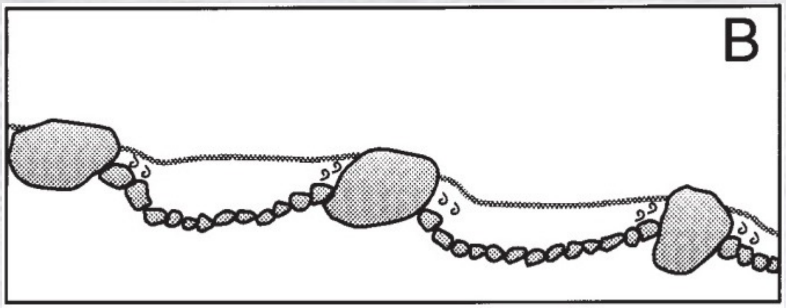


- **Stream Gradient**: >0.065
- **Pool Spacing**: <1
- **Bed Material**: Boulder
- **n**: Grains, Banks
- **Sed. Storage**: Lee/Stoss of obstructions

Adapted from Montgomery and Buffington (1997) and Buffington and Montgomery (2013)

Step-Pool Channel

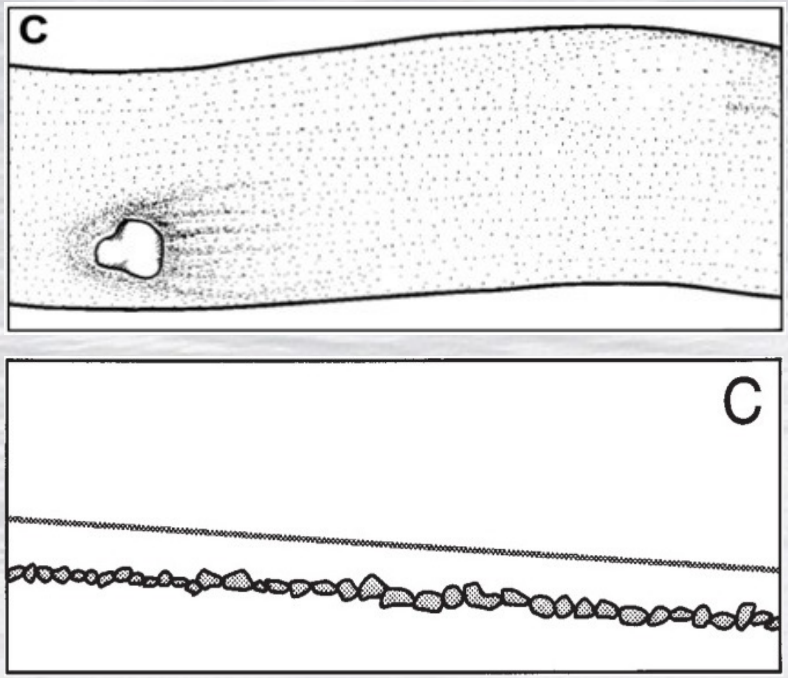




- **Stream Gradient**: 0.03 to 0.065
- **Pool Spacing**: 1 to 4
- **Bed Material**: Cobble-Boulder
- **n**: Bedforms, Grains, Banks
- **Sed. Storage**: Bedforms

Adapted from Montgomery and Buffington (1997) and Buffington and Montgomery (2013)

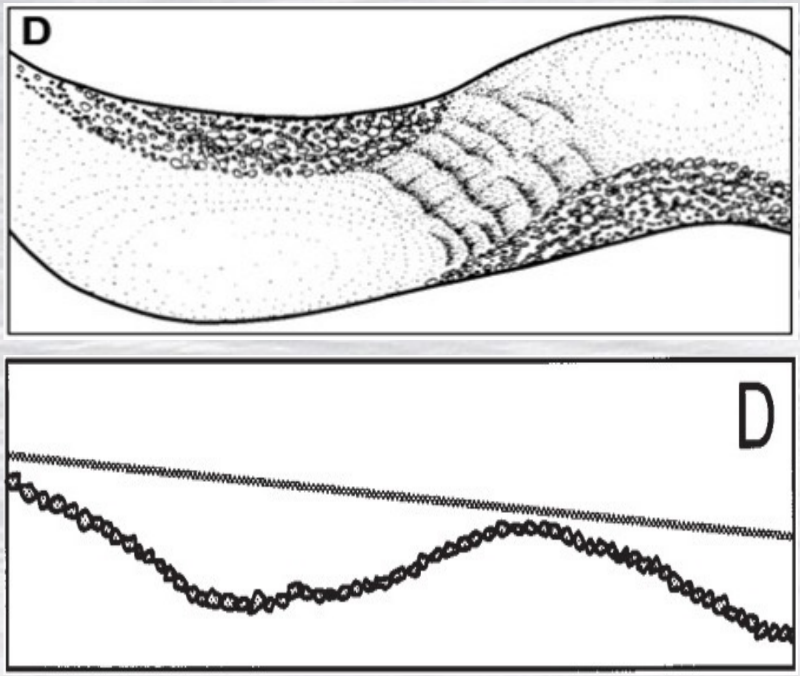
Plane-Bed Channel



Adapted from Montgomery and Buffington (1997) and Buffington and Montgomery (2013)

- **Stream Gradient**: 0.015 to 0.03
- **Pool Spacing**: None
- **Bed Material**: Gravel-Cobble
- **n**: Grains, Banks
- **Sed. Storage**: Overbank

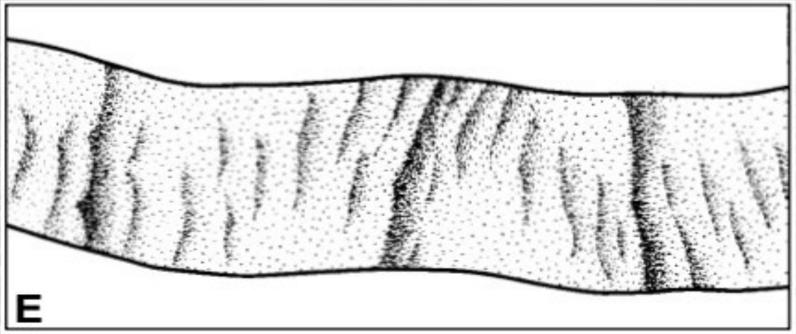
Pool-Riffle Channel

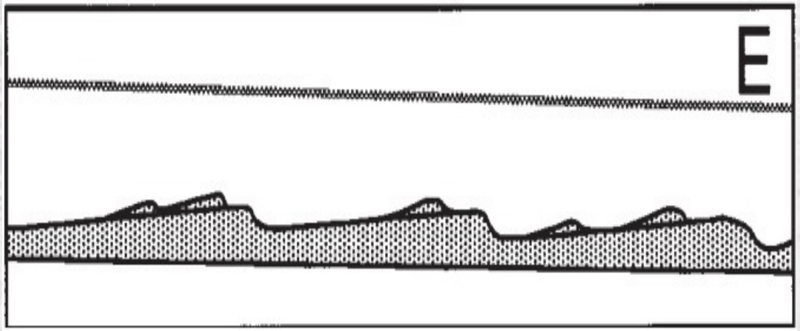


- **Stream Gradient**: <0.015
- **Pool Spacing**: 5 to 7
- **Bed Material**: Gravel
- **n**: Bedforms, grains, sinuosity, banks
- **Sed. Storage**: Overbank, bedforms

Adapted from Montgomery and Buffington (1997)
and Buffington and Montgomery (2013)

Dune-Riffle Channel





- **Stream Gradient**: Low Gradient
- **Pool Spacing**: 5 to 7
- **Bed Material**: Sand
- **n**: Sinuosity, Bedforms, Grains, Banks
- **Sed. Storage**: Overbank, Bedforms

Adapted from Montgomery and Buffington (1997) and Buffington and Montgomery (2013)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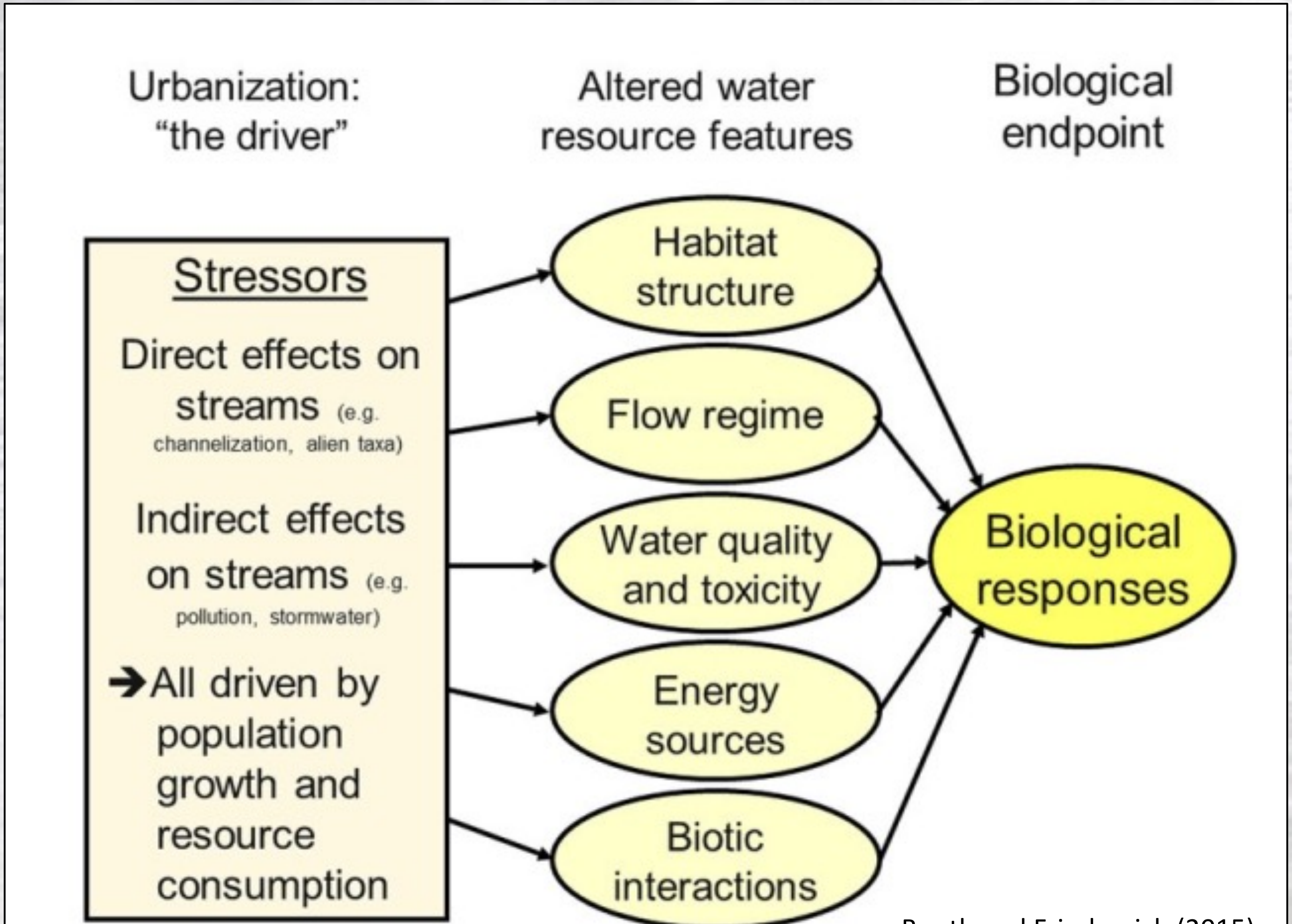
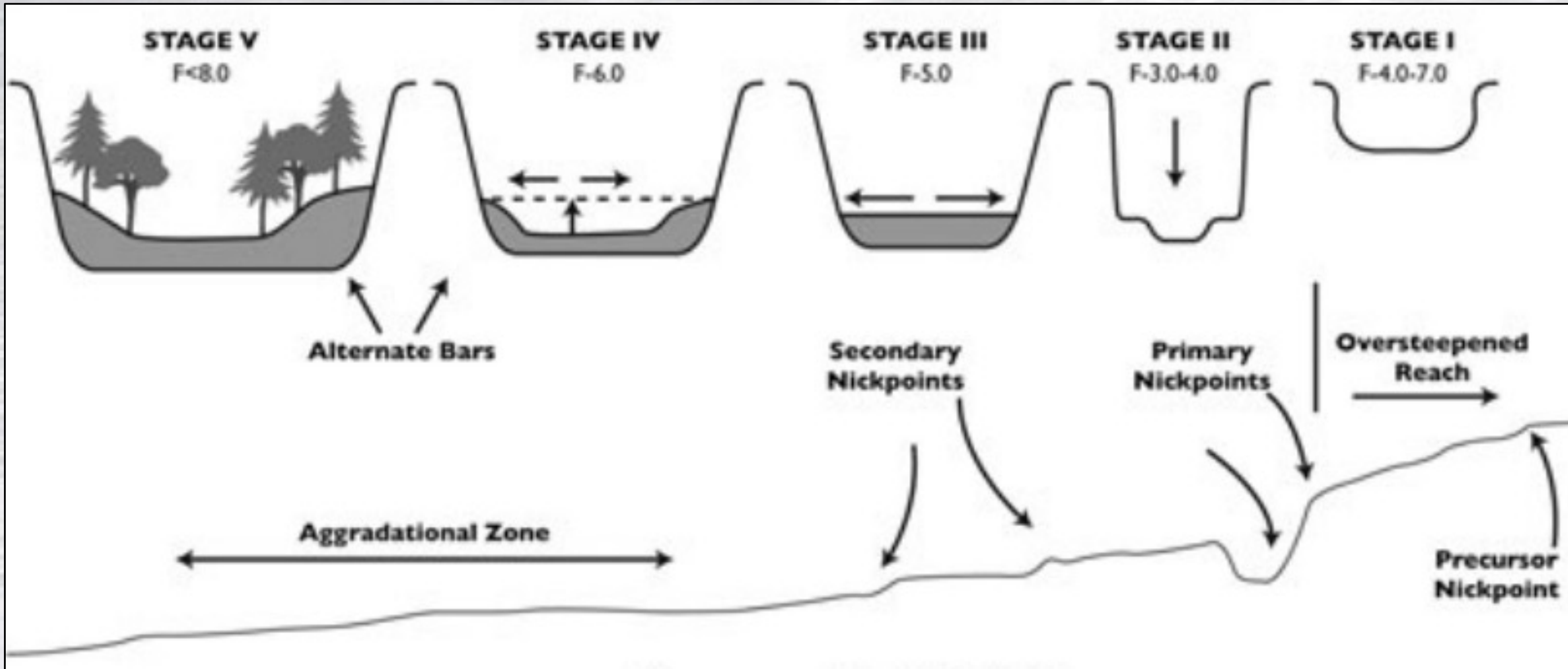
Drivers of Rapid Change



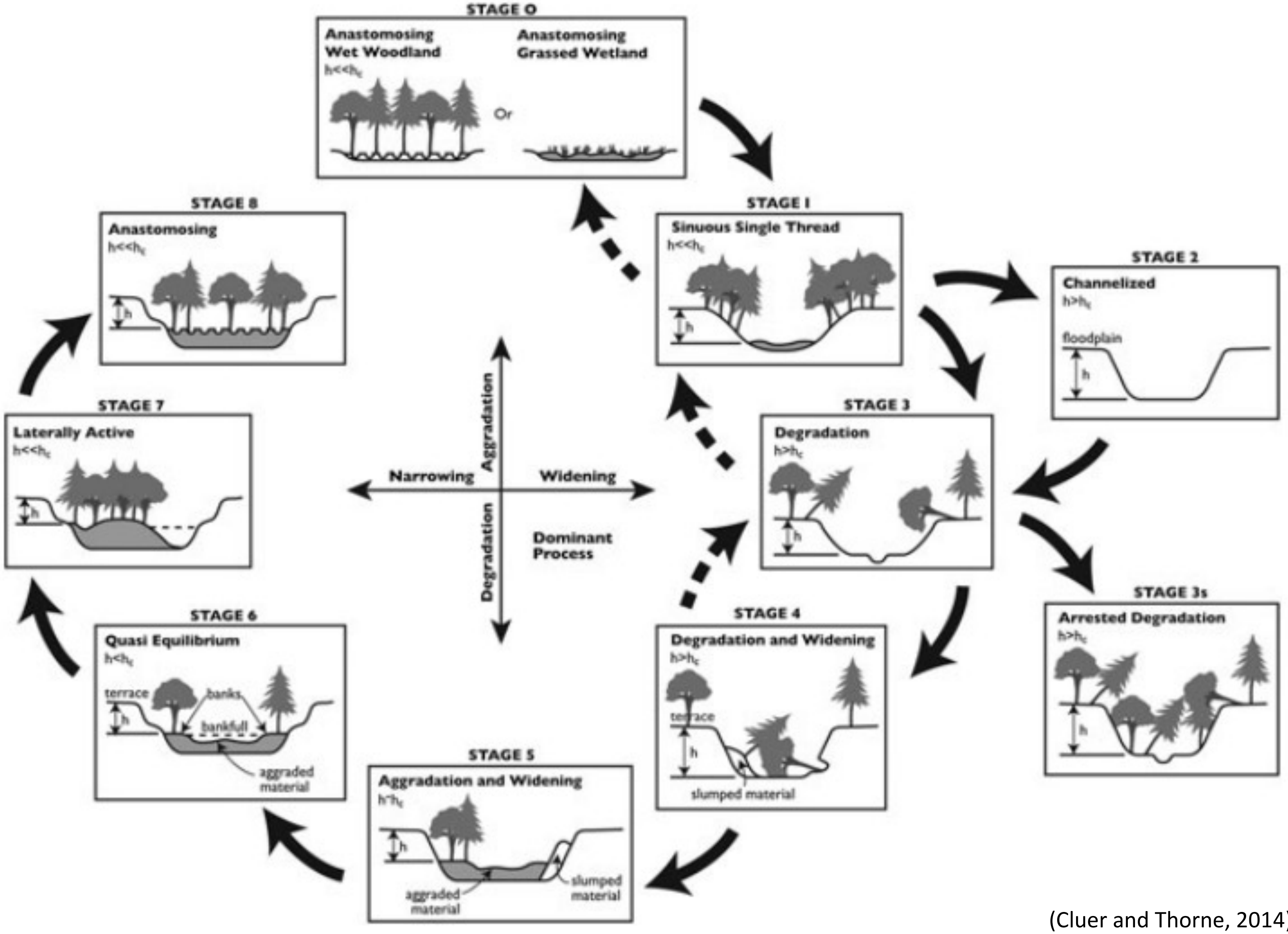
Booth and Frischenich (2015)

1984 Channel Evolution Model



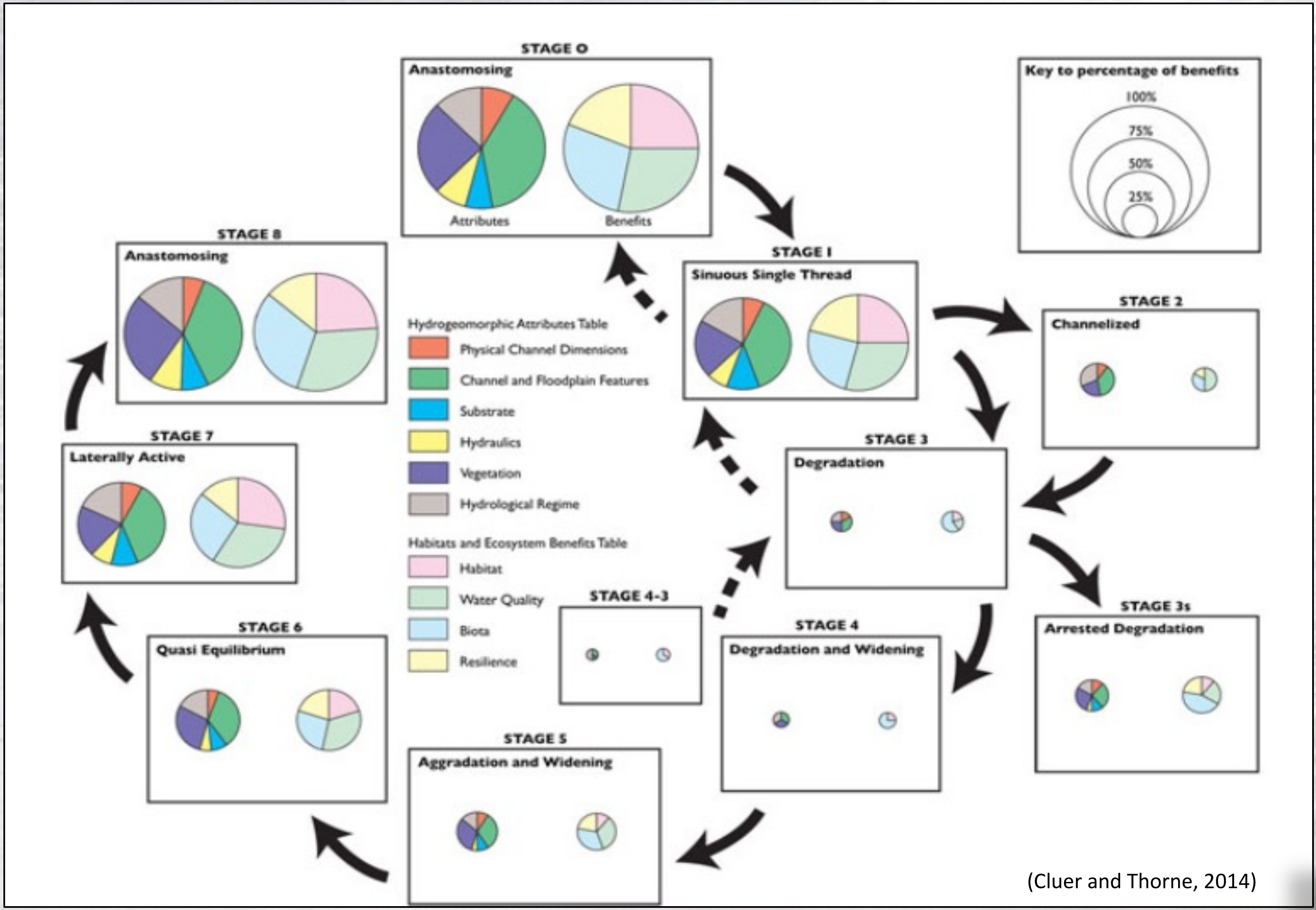
(Schumm et al., 1984)

2014 Channel Evolution Model



(Cluer and Thorne, 2014)

2014 Channel Evolution Model



(Cluer and Thorne, 2014)

Modifications at Crossings

- Reshape and realign channel
- Modified channel roughness
- Channel confinement
- Storm water runoff and tributary alterations
- Bed/Bank Armoring/Grade Control
- Riparian vegetation removal
- Others…

Potential Stream Responses

- Loss of channel complexity
- Scour/headcutting
- Undesirable hydraulic conditions
- Form knickpoint
- Bank & erosion collapse
- Sedimentation & aggradation
- Channel incision
- Bed armoring

Example #1

- Adverse hydraulics
- Excessive scour
- Loss of floodplain continuity
- Fine sediment input
- Loss of channel complexity
- Bank erosion/collapse

Example #2

- Multithread channel with frequent shifts
- Q ~ 60,000 cfs
- Presence of fully protected species
- Geomorphic input into construction issues

Conclusions

- Encourage early geologic and geomorphic input in design process
- Importance of science-based terminology and understanding of fluvial processes
- Ecosystem connectivity benefits engineering and biological elements of crossing

Thoughts or Questions…?

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