Restoration Outcomes and Uplift:
Physical Processes

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Streams are complex systems.

Where you are on the planet is important for this discussion.

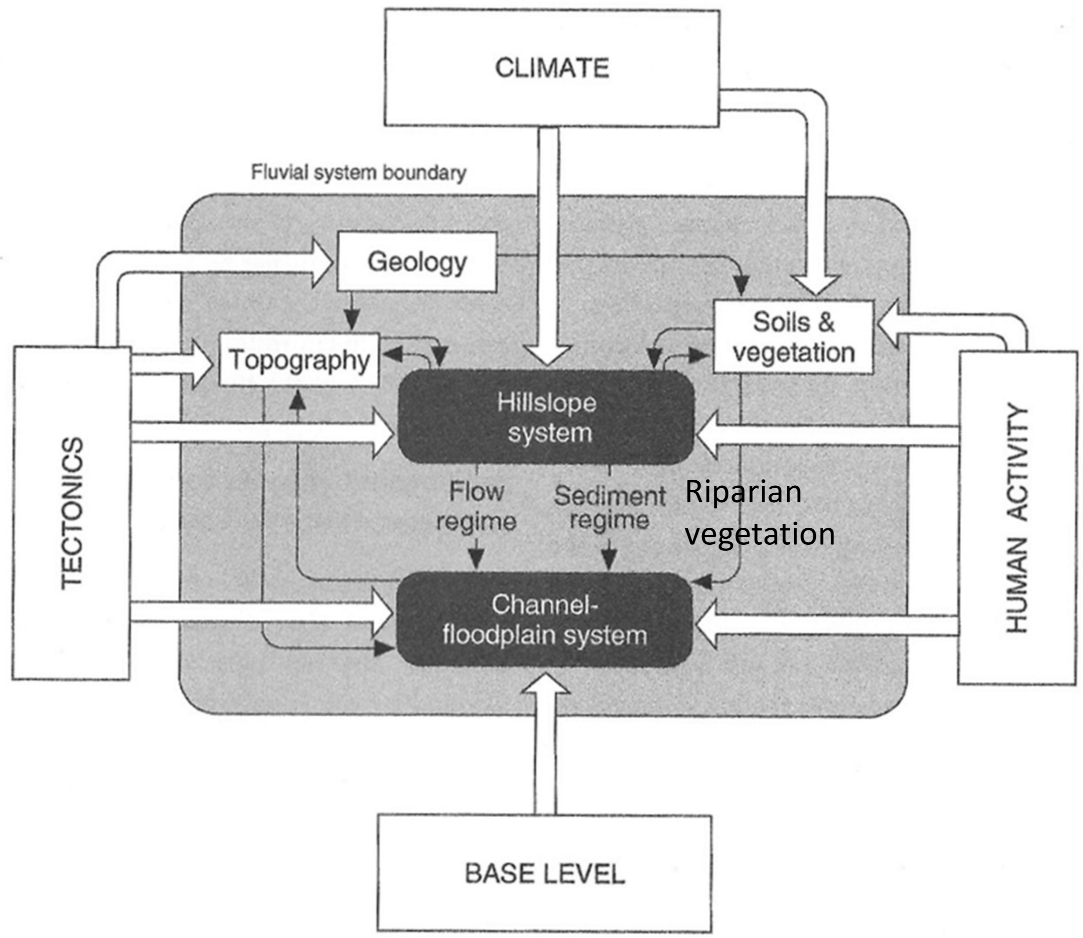
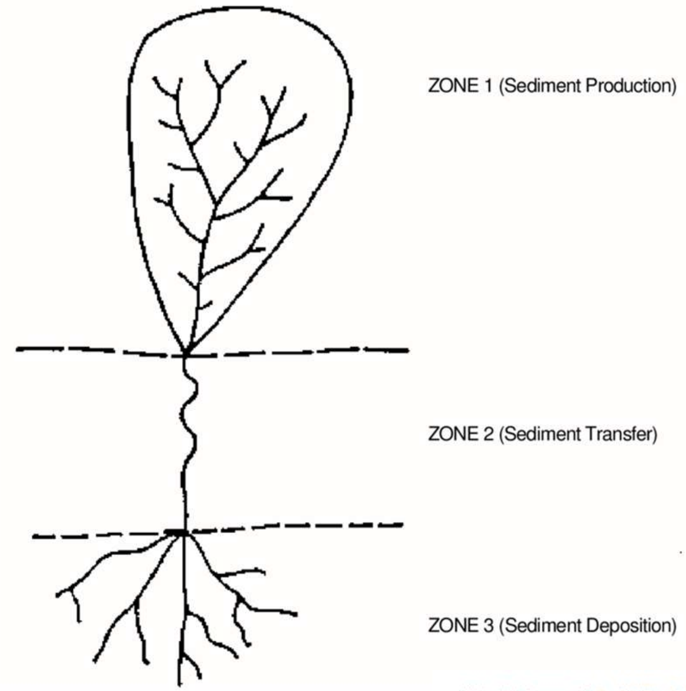


Figure 2.2 Simplified representation of the fluvial system.

Fundamentals of Fluvial Geomorphology. 2008. Ro Charlton

Let’s narrow the relevant research:

- Humid temperate climate
- Little tectonic activity
- Gravel-bed and sand-bed channels
- 1^{st}-3^{rd} order ***alluvial*** channels
- Sediment transfer zone (10^3+ years)
- Processes relevant for a time frame of 10^1-10^2 years



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Adapted from Schumm, 1977

Let’s define stream restoration:

“For the purposes of this workshop, stream restoration is broadly defined as an **intervention** to move a **degraded** ecosystem to a **trajectory of recovery** as informed by a **reference condition** considering local and global environmental change.”

Urban
streams??

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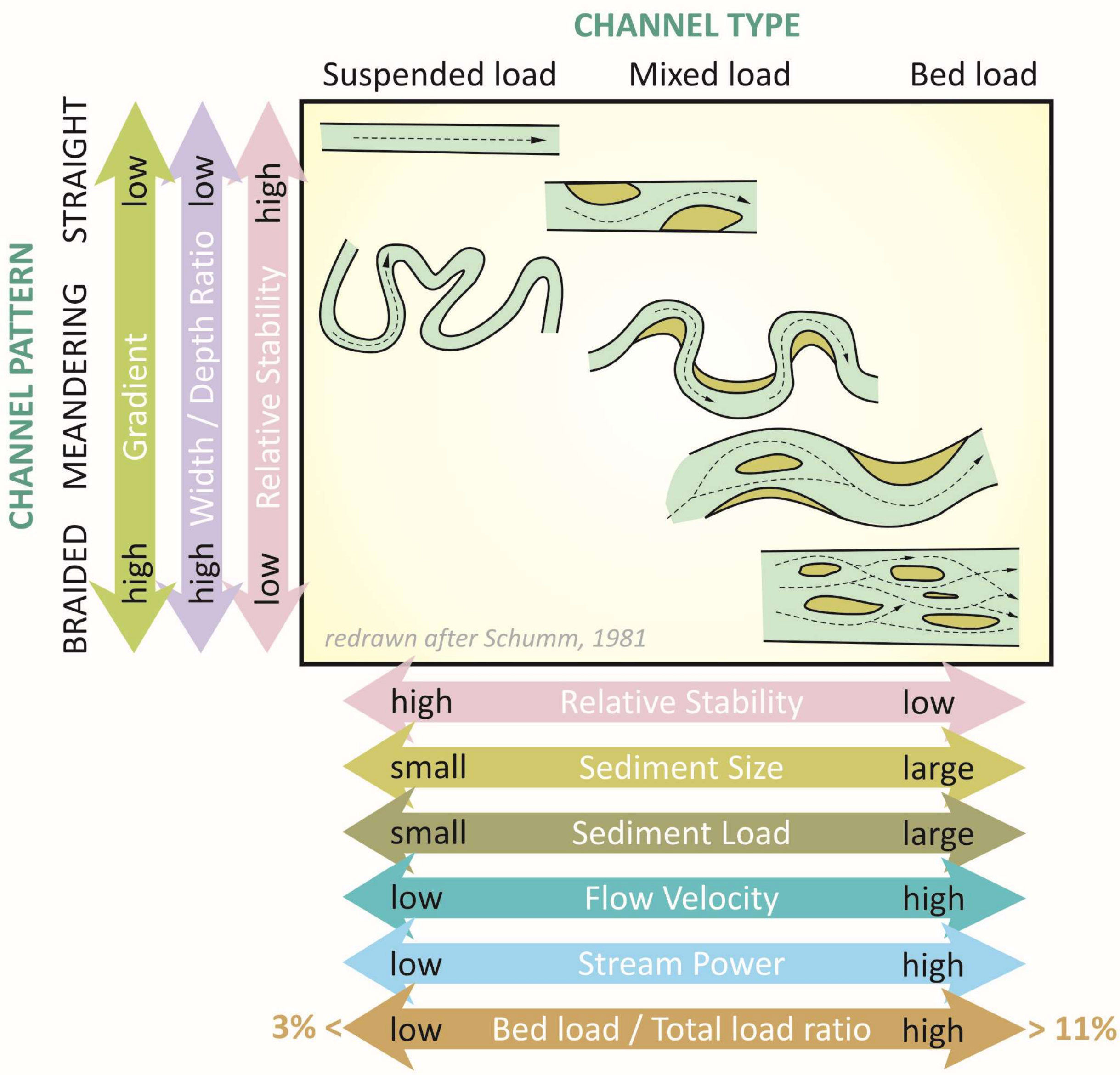
A geomorphic reference condition should be based on geomorphic processes.



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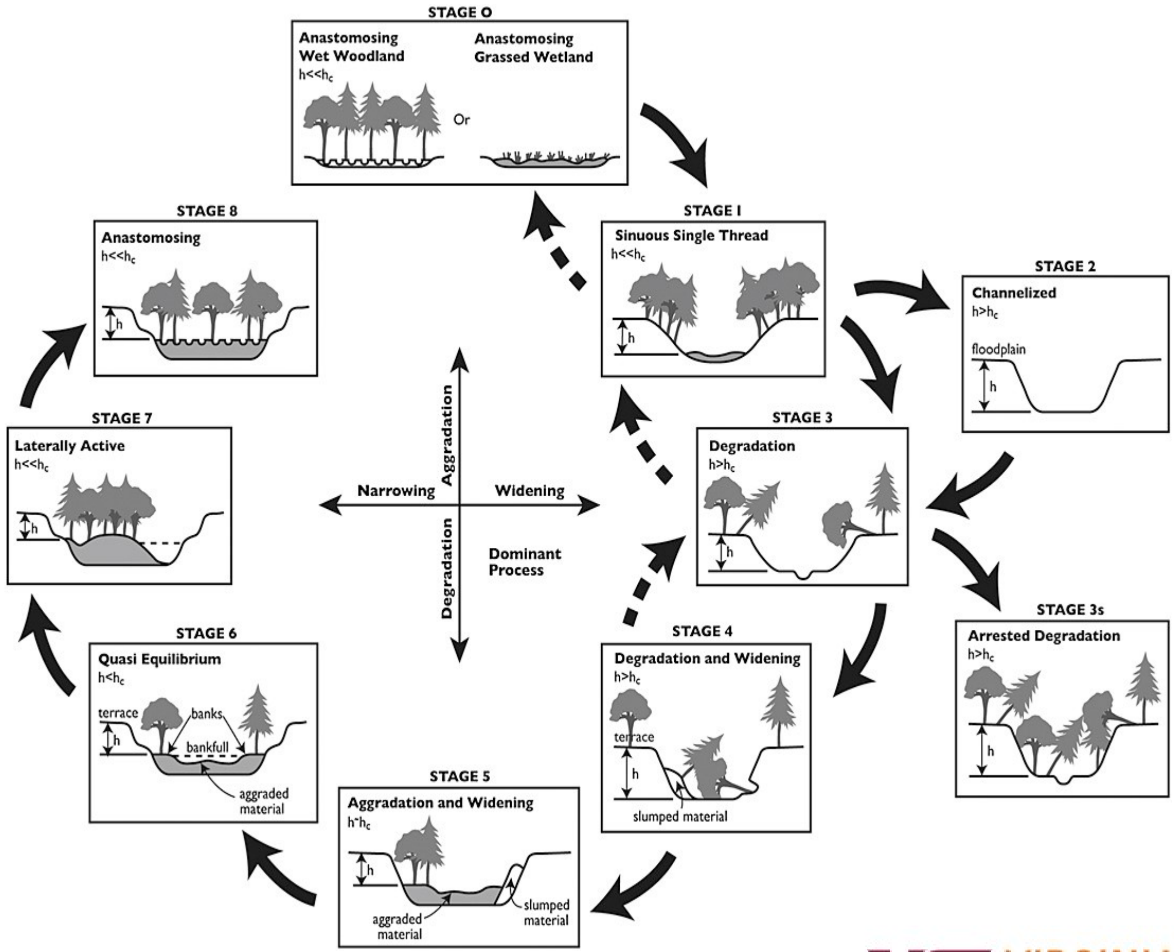
What is a "stable" stream?

"… a stable river, from a geomorphic perspective, is one that ***has adjusted its width, depth, and slope*** such that there is no significant aggradation or degradation of the stream bed or significant planform changes (meandering to braided, etc.) within the engineering time frame (generally less than about 50 years)."

- Commonly, the designer chooses the width, depth, and slope and holds the stream in that form using structures.

Biedenharn, D.S., C.M. Elliott, and C.C. Watson. 1997. "The WES Stream Investigation and Streambank Stabilization Handbook." U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, October, 436 p., URL: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.122.4798&rep=rep1&type=pdf.

Are there stable urban streams? Or are they “stuck” due to dense vegetation?



River Research & Apps, Volume: 30, Issue: 2, Pages: 135-154, First published: 10 January 2013, DOI: (10.1002/rra.2631)

Even if you estimate W, D, S correctly, as riparian vegetation matures, channel width will change

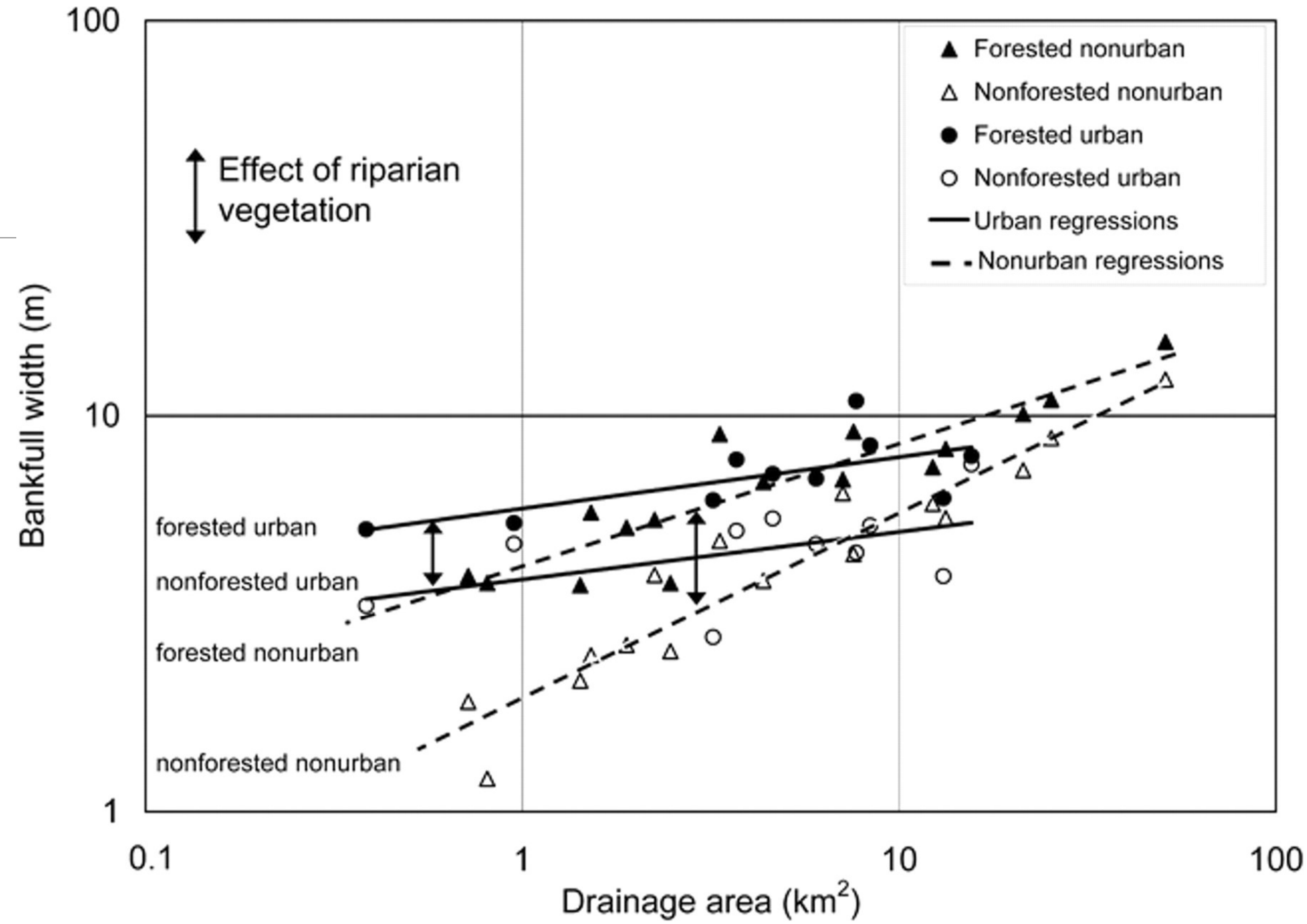


Figure 2. Bankfull width as function of drainage basin area. Separation between forested and nonforested regression lines, as illustrated by vertical arrows, indicates effect of riparian vegetation on bankfull width in urban and nonurban categories.

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Geology. 2003;31(2):147-150. doi:10.1130/0091-7613(2003)031<0147:IOBVOC>2.0.CO;2

The effects of bank vegetation on channel shape are scale-dependent

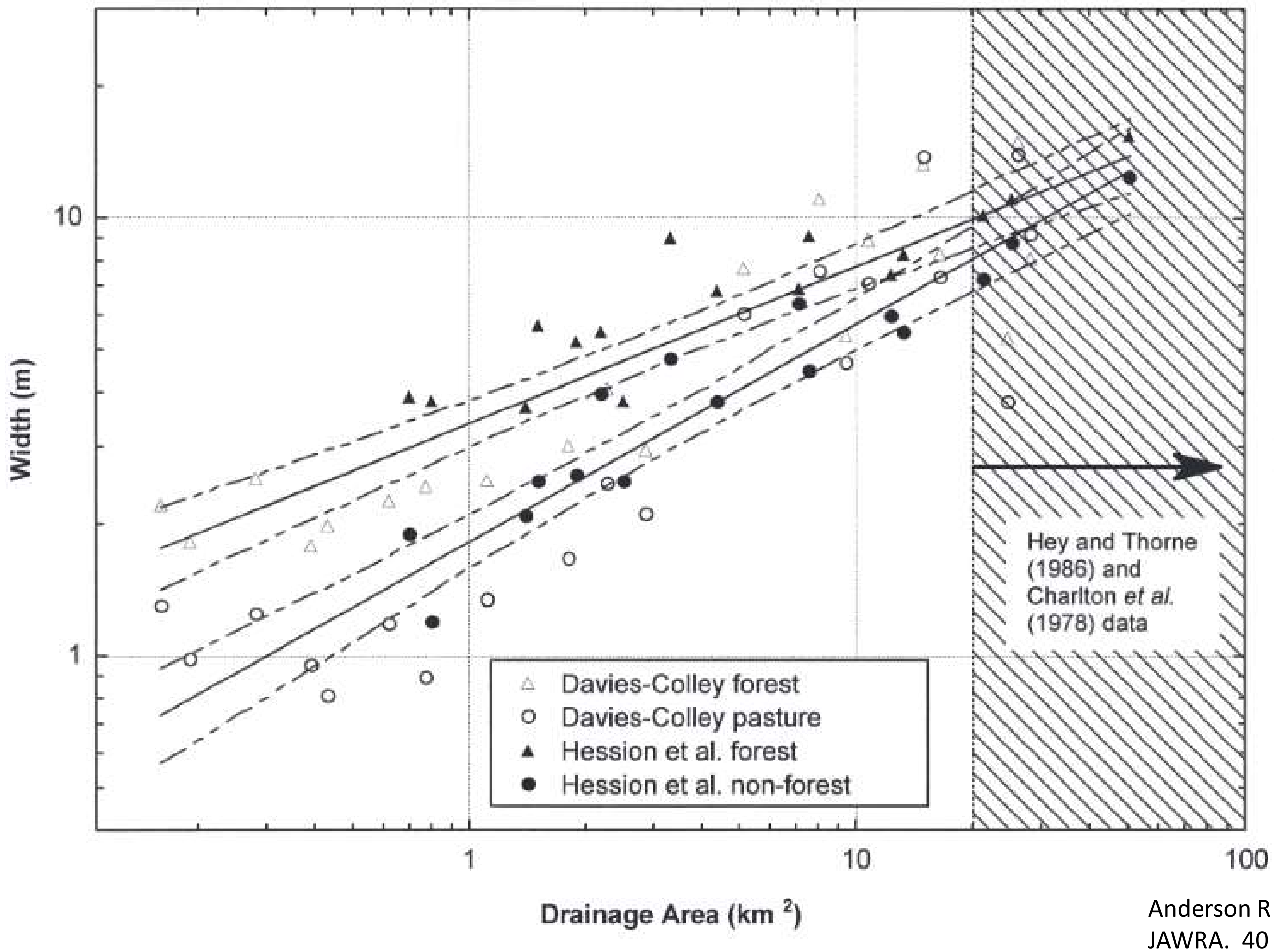

Figure 1b. Width Drainage Area Relationship by Bank Vegetation (Davies-Colley, 1997; Hession *et al.*, 2003). Regression lines are presented with the 95 percent confidence interval. Note the opposite trend where thick bank vegetation is associated with wider channels.

Anderson R Bledsoe B Hession W. 2004. JAWRA. 40 (5): 1159-1172

If you don't estimate the main channel dimensions correctly, it may be a long time until the channel becomes "stable"

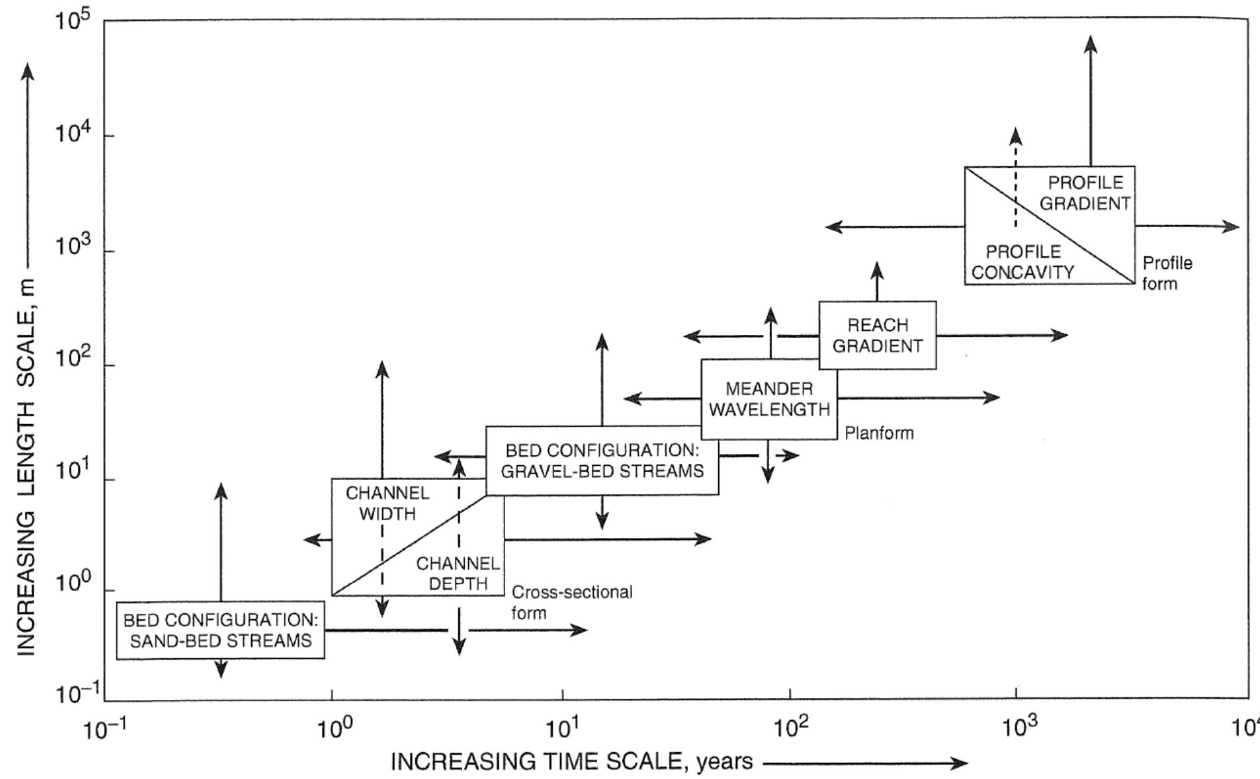

Figure 8.5 Schematic diagram of the time scales of adjustment of various channel form components with given length dimensions in a hypothetical basin of intermediate size. After Knighton (1998).

Can we restore “stability” to streams?

- Yes, we can.
- You have to wait for the trees to grow.
- Constraints in urban streams prevent development of stable alluvial channels.
- Current “success criteria” discourage it.

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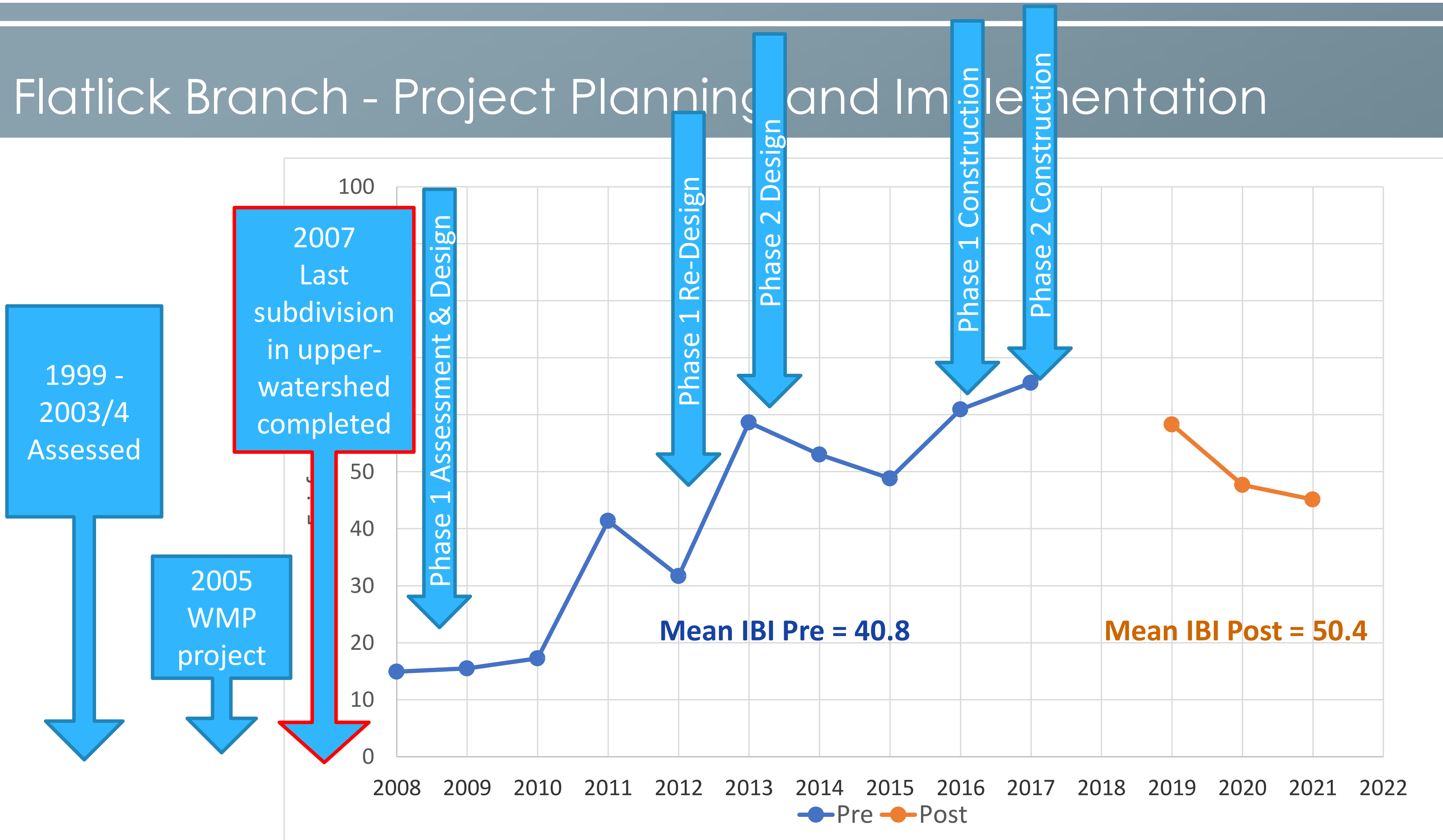
Flatlick Branch - Project Planning and Implementation



Buchanan et al. 2014
Mill Creek near Slaterville Springs, NY

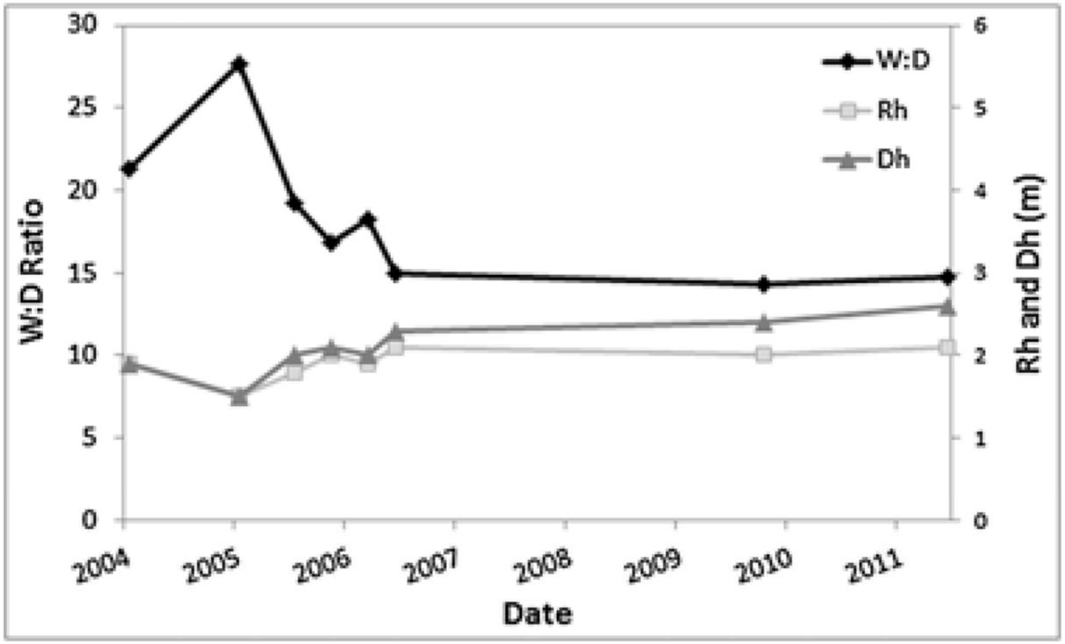


Figure 5. Chrono-sequence of average changes in bankfull geometry at the monumented cross-sections. W:D = width to depth ratio, Rh = hydraulic radius (m), Dh = hydraulic depth (m).

River Res. Applic. **30**: 245–258 (2014)

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CHARACTERIZING A MAJOR URBAN STREAM RESTORATION PROJECT: NINE MILE RUN (PITTSBURGH, PENNSYLVANIA, USA)[1]

Daniel J. Bain, Erin M. Copeland, Marion T. Divers, Marijke Hecht, Kr
Michael Koryak, Mary Kostalos, Lisa Brown, Emily M. Elliott, Jos
Brady Porter, Brenda Smith, Christopher Tracey, an

- "continual and substantial" improvement in fish community
- Healthier, more diverse benthic macroinvertebrate community
  - Removal of mine leachate
  - Sewer upgrades
  - Fish passage barriers
- Large amount of sediment eroded from reach (average of 44 cm)

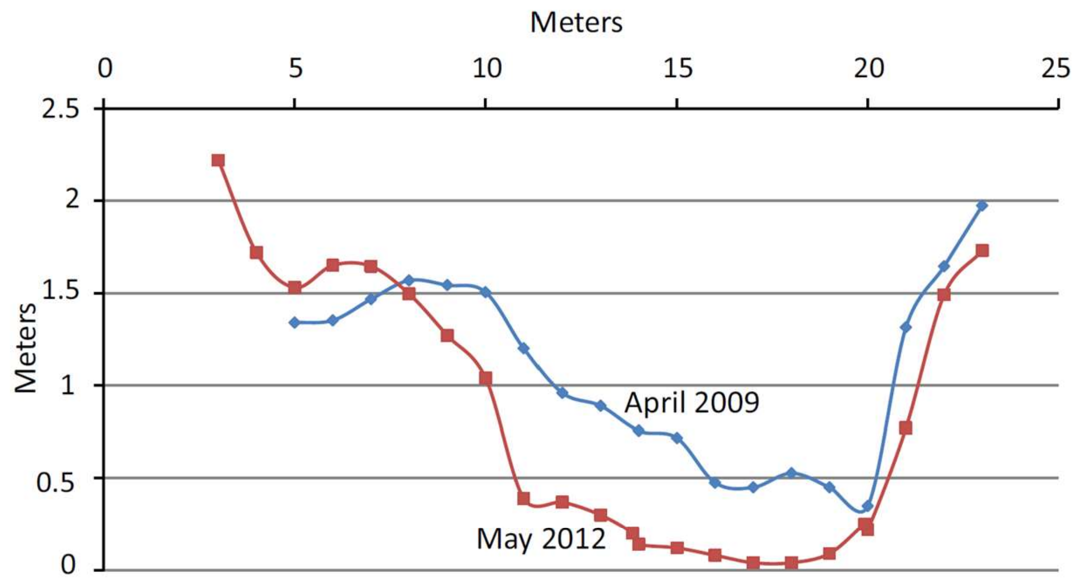

FIGURE 5. Changes in Nine Mile Run Channel Geometry Showing Post-Restoration Channel Incision. The upper line shows a cross-sectional survey taken between the Upper and Lower Station in April 2009. The lower line shows a return survey conducted in May 2012.

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EVALUATING THE ECO-GEOMORPHOLOGICAL CONDITION OF RESTORED STREAMS USING VISUAL ASSESSMENT AND MACROINVERTEBRATE METRICS[1]

Barbara A. Doll, Gregory D. Jennings, Jean Spooner, David L. Penrose, and Joseph L. Usset[2]

- Assessed 156 streams using SPA
- Restored streams similar geomorphic condition as reference streams
- Restored streams had greater range of bedform and habitat variability

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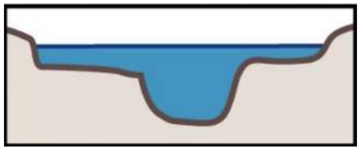
We developed three measures of project "success"



1. Field-based geomorphic function score
    - Floodplain access
    - Stable banks
    - Dense, native riparian vegetation
    - Region-appropriate bed material and bedforms

2. Field-based design score
    - Percentage of the original design still present
    - Are design features still functional

3. Monitoring report score – a mixture of function and design

Geomorphic function was correlated with land cover change, channel width:depth, bed sediment size, and stream power.

Channel W:D

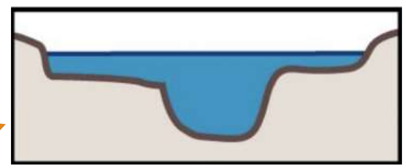
p = <0.0001

+

Decrease in agriculture 2001-2016

p = 0.004

−



D_{50}/depth

p = 0.007

−

Unit stream power

p = 0.106

−

Regression Equation

p=<0.0001

r^2 = 0.49

Adj. r^2 = 0.42

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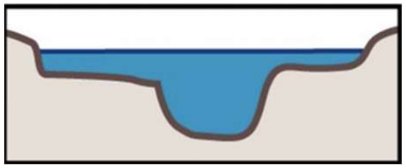
Research take-aways…



- Site selection is critical to restoring geomorphic function.
- Choose sites with…
  - Rural watersheds
  - Watersheds with stable landcover
  - No constraints to decreasing bank height (increasing floodplain access)

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New design techniques are being used

We just have to wait for the trees to grow before we can determine if they are "stable"…

Urban Ecosystems
https://doi.org/10.1007/s11252-022-01307-7

Is urban stream restoration really a wicked problem?

Christopher S. Herrington[1] · Kimberly Horndeski[2]


Questions?