Suburban stream erosion rates in northern Kentucky exceed reference channels by an order of magnitude and follow predictable trajectories of channel evolution

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Introduction

Conventional stormwater management amplifies erosive power in suburban streams.

Hypothesis

Suburban streams (> 5% Total Impervious Area, TIA) will experience greater rates of erosion than rural streams.

Methods

- ~Annually repeated surveys at 61 sites over ~10 years (Figures 1 and 2)
- Systematic measures of "bankfull" geometry
- Average rates of deepening and widening at each site via linear regression (Figure 3)

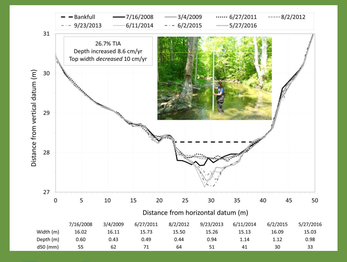


Figure 1 – Site experiencing incision (Stage 2)

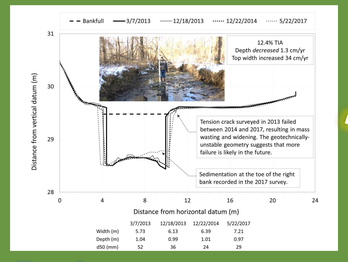


Figure 2 – Site experiencing widening and aggradation (Stage 4)

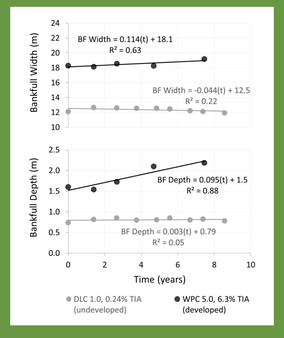
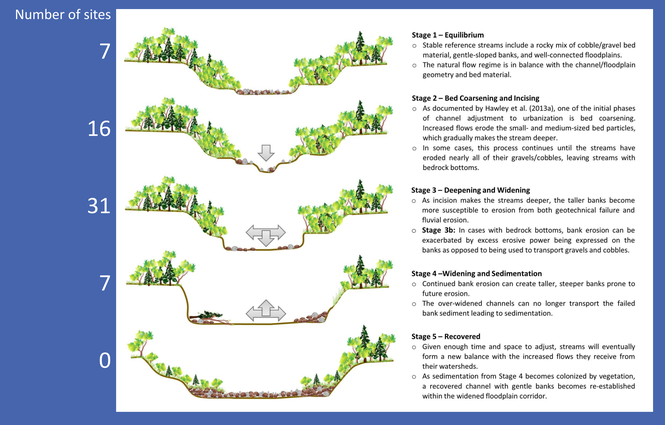


Figure 3 – Linear regression of changes in width and depth at two representative sites

Erosion rates of suburban streams exceed rural streams by ~ 10x

✓ Over a **10-yr study**, the average widening rate of 45 suburban streams (>5% TIA) was **9.4 cm/yr** compared to **1.0 cm/yr** for rural streams

✓ Suburban streams follow predictable patterns of evolution, consistent with the "classic" **Channel Evolution Model** (CEM) of Schumm et al. (1984)



✓ Only **one suburban site** showed signs of a potential **recovery** (transition from Stage 4 to 5), which was attributable to an upstream **stormwater retrofit**

Results

- Widening rates between rural (-58 to 20 cm/yr, avg 1.0 cm/yr) and suburban (-11 to 61 cm/yr, avg. 9.4 cm/yr, Figure 4) were statistically notable (p = 0.11)
- **Widening** rates between **Stage 2** (-58 to 61 cm/yr, avg. 0.3 cm/yr) and **Stage 4** (-10 to 50 cm/yr, avg. 17 cm/yr, Figure 5) were statistically different per an LSD test
- **Deepening** rates between **Stage 2** (-5.8 to 36 cm/yr, avg. 5.2 cm/yr, Figure 5) were statistically higher than all other CEM stages except Stage 4 per an LSD test

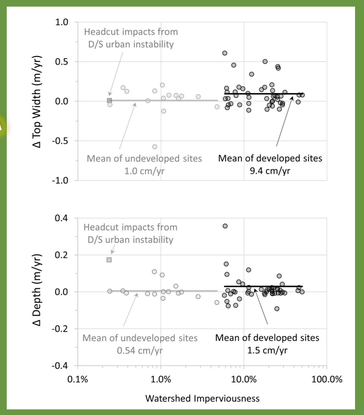


Figure 4 – Rates of widening and deepening by watershed TIA

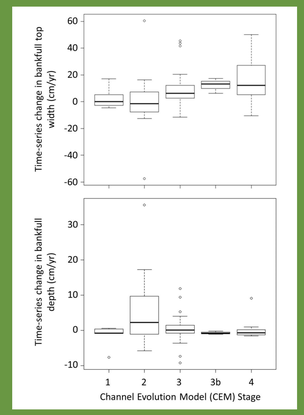


Figure 5 – Rates of widening and deepening by CEM Stage

Discussion

- **Historical data** (e.g. 21 to 34 cm/yr of widening at one suburban site over 44 years) are consistent with widening rates over that last decade
- Streams in suburban watersheds are also **significantly wider** than rural streams after accounting for drainage area ($W = 7.18 * DA^{0.36} * TIA^{0.08}$)

  → *a stream with 30% TIA would be* ***~25% wider*** *than a stream with 2% TIA*
- Stormwater management that **restricts erosive discharges** can help to facilitate a geomorphic recovery (transition from Stage 4 to 5, Figure 6)

Figure 6 – Looking downstream at the same site from Figure 2 in July 2019, ~5.5 yrs after a stormwater retrofit was installed upstream (see Hawley et al., 2017)

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References

Hawley, R.J., Goodrich, J.A., Korth, N.L., Rust, C.J., Fet, E.V., Frye, C., MacMannis, K.R., Wooten, M.S., Jacobs, M., and Sinha, R. 2017. Detention outlet retrofit device improves the functionality of existing detention basins by reducing erosive flows in receiving channels. Journal of the American Water Resources Association, 53(5): 1032-1047.

Schumm, S.A., Harvey, M.D., and Watson, C.C. 1984. Incised Channels: Morphology, Dynamics, and Control. Water Resources Publications, Littleton, Colorado.