Hydraulics | Hydrology | Geomorphology | Design

Efficacy of stream restoration as currently practiced

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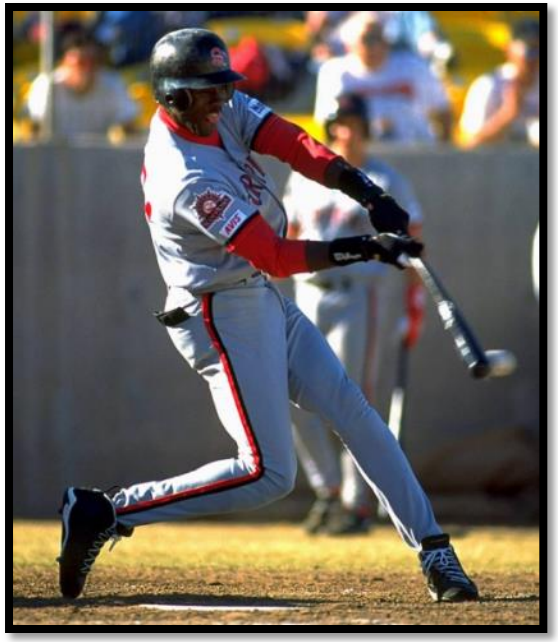
Environmentally sustainable solutions for the water resources industry

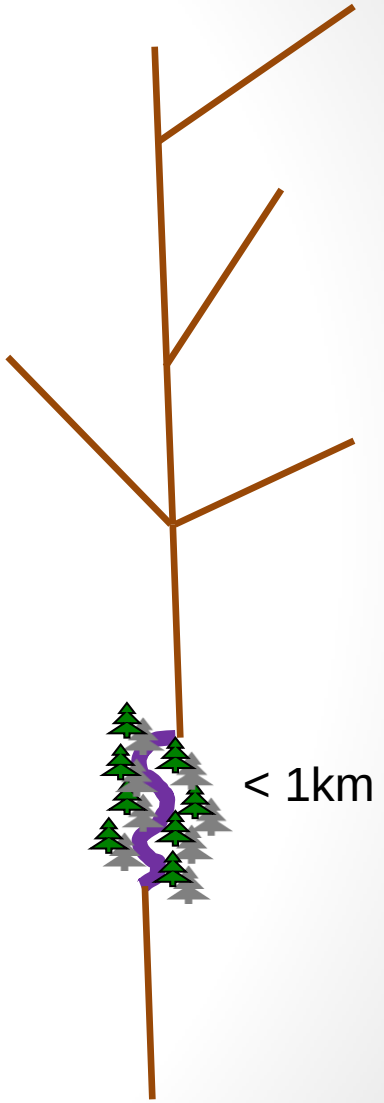
Assessment of stream restoration science

- Can we improve the ecological integrity of streams if we try really, really hard?
- What's your batting average?
- Only < 10% of stream restoration projects are monitored (Palmer et a. 2007, NRRSS)
- Your friends won't tell you. Telephone interviews of 317 stream restoration project managers revealed that 2/3 felt their project had been "completely successful." (Bernhardt et al. 2007)
- 89% of project contacts reported success, but only 11% ….because of the response of a specific ecological indicator (39 projects in Midwest, Alexander and Allan 2007)



Approach for this study

- A review of reviews and meta-reviews
- Reports of restoration > 9 sites
- Reports must be based on controlled (BACI, BA, or CI) study designs
- Reports must contain biological (fish or invertebrate) data
- Note: a separate and more sparse literature deals with effects of restoration on flood mitigation and nutrient retention services



Overview

1. Global review (1)
2. Instream structures and salmonids (2)
3. Invertebrates (4)
4. German study of “large” rivers (1)

Effects of stream habitat rehab—a global review

- 325 studies reviewed (1937 – 2006) , most in Western US and Canada—categories of interventions
  - ✓ Road improvement
  - ✓ riparian rehab
  - ✓ floodplain connectivity and rehab (dam and levee removal, beaver reintro, meander creation, flow modification)
  - ✓ instream habitat improvement (LW, rock, gravel)
  - ✓ nutrient addition
- Qualitative synthesis rather than quantitative meta-analysis
- Focused on fishes and to a lesser extent on macroinvertebrates
- Verbal synthesis for each major intervention category

Roni, P., K. Hanson, et al. (2008). Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. N Amer Jour Fish Mgt 28(3): 856-890.

Roni et al. (2008) results

- Reconnection of isolated habitats, floodplain rehab, and placement of instream structures were the most promising techniques
- "When implemented properly , these techniques can produce dramatic improvement of physical habitat and biota…."
- "Little positive benefit [of instream structure placement] has been documented for nonsalmonids"
- "The most successful projects…. create large changes in physical habitat and mimic natural processes…."

Instream structures and salmonids

- Two major meta-reviews (17 and 211 studies)
- Both used statistical techniques to combine data sets
- A wide range of typical interventions
  - ✓ Weirs
  - ✓ Deflectors, vanes, groins
  - ✓ Cover structures
  - ✓ Boulder placement
  - ✓ LW
  - ✓ Ramps, riffle creation
  - ✓ Re-meandering

Stewart, G. B., H. R. Bayliss, et al. (2009). Effectiveness of engineered in-stream structure mitigation measures to increase salmonid abundance: a systematic review. Ecological Applications 19(4): 931-941.

S. L. Whiteway, et al. (2010). Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Cana J Fish Aquat Sci 67: 831-841.

Instream structures and salmonids

- Widely variable results
- No control for confounding factors such as degraded water quality
- Structures associated with a statistically significant increase in salmonid abundance/biomass
- Structures appear to be more effective in smaller (i.e., narrower) streams

Instream restoration and macroinvertebrates

- Four major studies—a two meta-analyses, a European large scale study, an NC study of small streams
- Some overlap between the two meta-analyses
  - 24 studies (out of initial list of 53 papers)
    - 18 reported both density and richness estimates
    - 6 only richness or density
  - 78 projects, 18 different author groups
- 25 German sites (CI)
- 27 NC sites (CI)

Miller, S. W. et al. 2010. Quantifying Macroinvertebrate Responses to In-Stream Habitat Restoration: Applications of Meta-Analysis to River Restoration. Rest Ecol 18(1): 8-19.

Palmer, M. A. et al. 2010. River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice? Fresh Biol 55.s1: 205-222.

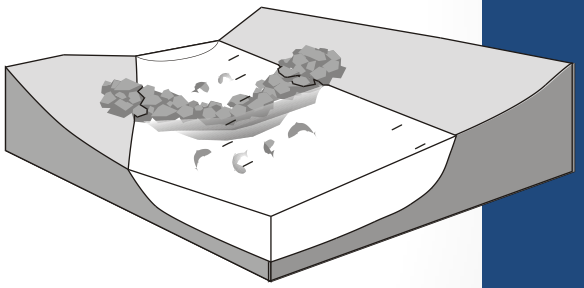
Sunderman, A. et al. 2011. Hydromorphological restoration of running waters: effects on benthic invertebrate assemblages. Fresh Biol 56.8 : 1689-1702.

Tullos, D. D. et al. 2006. Development and application of a bioindicator for benthic habitat enhancement in the North Carolina Piedmont. Ecol. Engrng 27.3 : 228-241.

Instream restoration and macroinvertebrates

- Reach –scale
  - half less than 300 m long
  - mean length 1.4 km; range 0.1 to 8.0 km

- Interventions
  - ✓ Boulder additions
  - ✓ Artificial riffles
  - ✓ Channel reconfiguration
  - ✓ LWD additions
  - ✓ Removal of bank fixation/bank re-grading
  - ✓ Creation of new water courses
  - ✓ Broadening to create braided reaches



Inverts and restoration results

- Palmer et al. 2009

  "….across the 78 independent restoration projects monitored by the 18 sets of studies we evaluated, only two of the 78 (.026) projects resulted in increases in invertebrate diversity sufficient for the authors to conclude that the project was a biological success."

  Increase in physical diversity (habitat heterogeneity) did not produce increase in biological diversity

- Miller et al. 2010
  - Results highly variable, but generally positive findings for both density and richness
    - Richness mean response = 2.3 genera or 10%
    - Density mean response = 660 individuals or 23%
  - Richness levels did not return to target or minimally impacted conditions
  - LW produced largest and most consistent responses
  - Boulder additions and channel reconfiguration were positive, yet highly variable

Inverts and restoration results

- Tullos et al. (2006 and 2008) NC studies
  - No difference in specialists between control and restored reaches
  - Taxa tolerant of disturbance were characteristic of restored reaches
- Sunderman et al. (2011)
  - 3/25 (.120) of the restored German sites showed "good ecological quality" Diversity, dominance and evenness did not vary between control and restored reaches No relationship between restoration success and costs, length of restored section or elapsed time since restoration
  - Later work showed distance from sources of potential colonists to be critical

“Large rivers” in Germany

- 24 stream restoration projects in Europe, 1-12 yr old
- 7 to 2,530 km^2 watersheds, average restored length 1.5 km
- CI design (unrestored control reach located upstream in each case)
- Compared macrophytes, invertebrates and fish

Haase, P. et al. 2013. The impact of hydromorphological restoration on river ecological status: a comparison of fish, benthic invertebrates, and macrophytes. Hydrobiologia 704(1), 475-488. doi 10.1007/s10750-012-1255-1

“Large rivers” in Germany

- ✓Removal of bank fixation
- ✓Wood placement
- ✓Installation of flow deflectors
- ✓Channel reconstructions
  - Elongation
  - Creation of new water course
  - Creation of multiple channels
- ✓Extensification of landuse
- ✓Re-connection of backwaters

Haase et al. (2012) results

- Habitat heterogeneity was enhanced
- "….the response of all taxa groups to restoration was weak"
- Positive restoration effects were observed only for fish (11 of 24 cases) (.458)
- No changes for macroinvertebrates (.000)
- Ecological Quality Class (EQC) improved in 7 restored reaches, declined in 1 reach, no change in 16 reaches, relative to unrestored comparison reaches. Only 1/24 restored sections reached a "good" EQC.(.042)
- "Our results indicate that stressors other than hydromorphological degradation still affect the biota in restored sections. We emphasize the need for advanced restoration strategies based on catchment analyses…."

Wish I had said that……

"….there has been little empirical evaluation of whether restoration projects individually or cumulatively achieve the legally mandated goals ……..New efforts to evaluate river restoration projects that use channel reconfiguration ….are ***finding little evidence for measurable ecological improvement****. While designed channels may have less-incised banks and greater sinuosity than the degraded streams they replace, these reach-scale* ***efforts do not appear to be effectively mitigating*** *the physical, hydrological, or chemical alterations that are responsible for the loss of sensitive taxa and the declines in water quality ……"*

Bernhardt and Palmer , *Ecological Applications*, 21(6), 1926-1931, 2011.

Actually, I almost did…

"Streams that have been degraded by poor watershed land use cannot be restored by focusing solely on instream conditions."

--Doyle and Shields 2012

Revised Title!

Grumpy old men and grumpier old women

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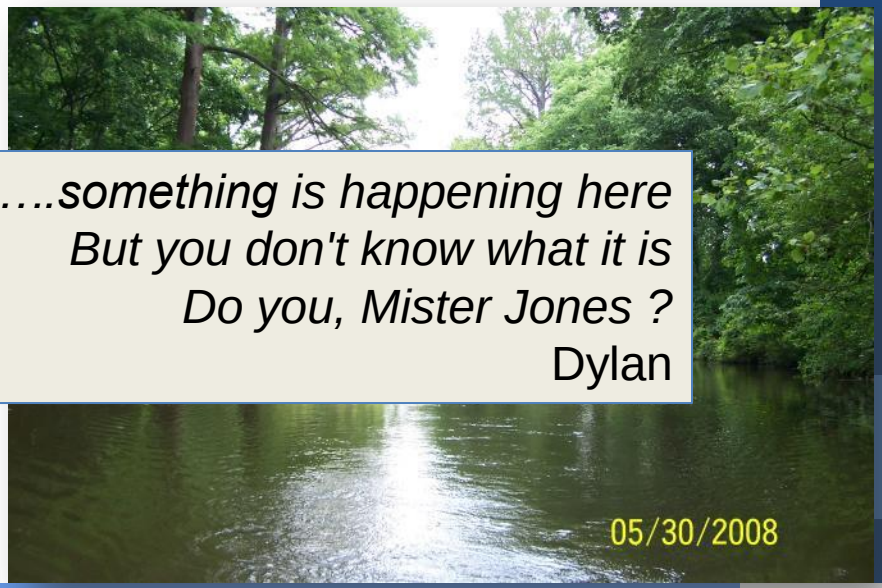
Why ruin a good thing?

- ✓We all feel good about restoration of streams
- ✓Restored streams look pretty
- ✓We can make money this way
- ✓Good for take your kid to work day



….something is happening here
But you don't know what it is
Do you, Mister Jones ?
Dylan

Does stream restoration work?

- $1 Billion/year not including mega-projects
- Logic behind compensatory mitigation
  - Working assumption by federal and state regulatory agencies is that stream restoration, as has been typically practiced, produces increased physical, chemical, and biological integrity of a formerly degraded stream system.
  - This assumption is necessary for current implementation of compensatory mitigation to be an option in the CWA 404 permitting program.

Two different stories ?

- East v. west
- Coldwater v. warm
- Gravel/cobble bed v. sand/fines
- Salmonids v. non salmonids
- Less developed watershed v. short reach urban ach urban
- Large stream v. small
- Process v. reach scale channel interventions

So what does all this mean?

- First, do no harm (keep earthmoving activities to a minimum, especially tree removal)
- Time for "moneyball"
  - Greater reliance on outcomes
  - Greater reliance on quantifiable results
  - Restore process, not form

More on, So what does all this mean?

- Work at scale of underlying problem
- Location, location, location
  - Site selection is key part of restoration
  - Proximity to potential colonists
  - Retention of high flows
  - Connection (or lack thereof)

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