"This paper shows that what constitutes a natural channel form must be re-examined…
… the first step in a river-restoration program should be to develop a solid understanding of what the targeted rivers were actually like before the changes that restorationists seek to undo or mitigate."

Dave Montgomery
ecological history provides baselines

Least impacted reference sites used

Novel design solution

Design for future conditions

Daniel Pauly. 1995. “accommodation of the creeping disappearance of resource species, and inappropriate reference points ….”

Poole et al. 2004

Palmer et al. unpub

Poole et al. 2003, Water quality regimes

Poole et al. 2004

Poole et al. 2004
Assume the **condition of non-stationarity** but predictable trajectory

non-stationarity defined  
• constantly changing  
• in a state of flux  
• a statistical trend in the data exist

### Designing the channel ….based on predictions

**Given**  
Water discharge and sediment supply

**Find**  
Channel slope, depth & width  
(& velocity & shear)

We have enough general relations to solve for all but one of these unknown variables  
If we specify channel width, we can solve for the rest of the variables  
What slope is needed to transport the supplied sediment with the available water?
But, do we have such *formulas* for ECOLOGICAL restoration?

I think not …
- it is a multi-variate problem
- not just a matter of balancing to opposing forces

Given this complexity… how do we approach restoration?

First ask: what do we want and is it possible?

Second, establish priorities.

Third: evaluate options for ‘getting’ the desired services while ….. doing the best you can with other functions
For some streams… certain services can simply not be supported

Flood control

Smith et al. 2006 Water Resources Res

R^2 = 0.52; p < 0.0001

Moore and Palmer 2005

Support insect diversity


Clearly identify desires and priorities

Service

- clean water – drinking, irrigation
- climate control – temperature regulation
- minimize floods – absorb storm energy
- water conveyance – flood control, irrigation
- biota – diverse plants & insects, fisheries
- aesthetics – angling, canoeing, hiking
Identify what needs to be managed or restored to get the desired services

Underlying supporting processes

**nutrient processing** - e.g., denitrification
**contaminate uptake** - plant/microbial processing
**water storage** - groundwater recharge
**heat capacity** - condensation, evaporation
**primary & secondary production** - photosynthesis, growth
**process & store carbon** - nutrient regeneration

What tools do we have to affect those processes?

- Alter floodplain connectivity
- Manipulate channel morphology & interaction with flow
- Enhance channel complexity & retentiveness
- Re-plant riparian vegetation
- Manage the energy "inputs" - organic matter, sunlight
- Alter the streambed D\textsubscript{50}, D\textsubscript{50}/D\textsubscript{84}
- Control sediment load
- Manage flow regime - frequency, intensity of floods & baseflows
- Establish connections to source populations
- Set limit to cumulative watershed impacts
Some key concepts to keep in mind

*Systems are variable*

... *there will always be some level of uncertainty*

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**Thresholds and hysteresis exist**

Non-Equilibrium dynamics
States, transitions, thresholds
Abiotic & stochastic control
Non-linearities
Restoration is NOT just about channel design

Dreams of Nature's Streams
David R. Montgomery