River Restoration: Hydrology, Geomorphology and Ecology

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CRESS
Structure

- Justification
- Restoration principles
- Why restoration in Scotland
- Ecosystem based principles
  - Hydrological
  - Geomorphological
  - Ecological
- Scottish case studies
- Effective Monitoring
- Final thought
Justification

• Scientists
• Geomorphology, hydrology and ecology
• Monitoring and assessment of river projects from ground zero.
• Academic freedom
Restoration principles

**STAKEHOLDER SUCCESS**
- Aesthetics
- Economic Benefits
- Recreation
- Education

**ECOLOGICAL SUCCESS**
- Guiding image success
- Ecological Improvement
- Self-sustaining
- No lasting harm done
- Assessment completed

**LEARNING SUCCESS**
- Scientific contribution
- Management experience
- Improve methods

Palmer et al., 2006
Success of River Restoration

1. A guiding image
   an ecologically healthy river that could exist at the site

2. Improving ecosystems
   demonstrate that there is a measurable change

3. Increasing resilience
   create hydrological, geomorphological and ecological conditions for a resilient self-sustaining system

4. Doing no lasting harm
   e.g. avoid fish spawning season for construction works

5. Completing an ecological assessment

Palmer et al., 2005.
Standards for ecologically successful river restoration
Journal of Applied Ecology
Ecosystem based restoration principles

- Restore ecosystem functioning not targeted at single species.
- Restore longitudinal, lateral and vertical connectivity.
- Allow for dynamism and climate change.
- Need to consider restoration in context of whole catchment.
- Need to restore suite of limiting conditions not just one targeted problem.
- Need to give projects time
Why restoration?

R. Findhorn at Forres
Sadlar et al. (2005) show exposed river sediments are important for biodiversity in UK.
Spey at Laggan
Exposed bars

Embankment breach

Gilvear, 2003; River Science and Applications
“The biophysical complexity (heterogeneity) of rivers underpins their long-term vitality”  
Naiman, 2006

“Rivers should be viewed in 3D – the fluvial hydrosystem”  
Petts & Amoros, 1995
“Alluvial rivers are shifting habitat mosaics”
Stanford et al., 2006
“Fluvial processes, riverscape change and biological development takes time”
Hydrology

- River and floodplain. Inundation critical to functioning of riparian areas, river margins and floodplain evolution (flood pulse concept).
- Natural water quality: Require river basin management to deliver water relatively free of diffuse pollution and self-purification processes to be operating in the river.
Geomorphology

- Reinstate fluvial processes priority over morphological features (Avoid landscape gardening – not sustainable)
- Conveyors of sediment transport (not just flow conveyance)
- Allow for bank instability and channel migration
- Balance between erosion and deposition; net erosion in headwaters and net deposition in lowland reaches
- River typing for reference condition – based on underlying geomorphic controls
Controlling variables

River flow

Sediment load (and calibre)

Slope

Boundary materials (valley confinement)

Base level

Historical hangovers (memory)
Restoring process

- Roni et al (2005) reviewed use of habitat structures and concluded they work best when nested within wider catchment/geomorphological framework that targeted ability of the reach to sustain them (e.g., log jams).
- Failure of created riffles where processes not there to sustain them (Sear and Newson, 2004).
- “Restoration of watershed processes should precede or be conducted in conjunction with habitat restoration” (Roni et al., 2005)
Nith Diversion - physical habitat development
Sinderland Brook

Day of completion

1 year later
Ecology

- Physical template is basis for ecology so ecological structure will be self-creating
- Need a functional view of ecology focussing on energy sources and transfer of energy
- Without a good species pool will not end up with good community structure
- Hydromorphological modification can recruit alien species
Natural deciduous woodland along river margins produces

- Allochthonous organic input
- Debris dams
- Terrestrial/aquatic subsidies
- A mosaic of productivity (algal regulation)
- A mosaic of thermal patches
- Resistant and complex bank structure
- A dispersal corridor for species
Woody Debris introduction and fish

Gregory, 2006; Willamette River, USA
Woody Debris introduction and fish

*Gregory, 2006, Stirling hydroecology conference; research and applications*
Need linkage between disciplines

Ecosystems: the basis for effective restoration

Hydrology
Geomorphology
Ecology

SCIENCE

PEOPLE
Inchewan Burn – Do not consider reach restoration in isolation
Self recovery

Let dynamic rivers reinstate natural morphology and processes

Example of 100 years of self recovery on the River Tummel.
River Tummel
Physical habitat change with flood bank abandonment

Parsons and Gilvear (2000), River Science and Applications
Classified image of land cover types within the Tomdachoille reach of the River Tummel in 1994.
Bamff Beavers – nature’s ecosystem engineers

- Parker and Ronning (2007) Beavers insignificant impact on Sea trout and Atlantic salmon recruitment
- Jones (2007) Increase biodiversity
- Potential for flow attenuation and nutrient uptake
Monitoring River Restoration Success

• Need to monitor outside of restoration reaches as well as in them

• Monitoring environmental process not biological response

• Given that non-stationarity of climate (before-after post-project appraisal complex)
Best Practice River Restoration

- If it ain’t broke don’t fix it
- Old habits die hard
- Don't go near the water until you learn how to swim
- Appearances can be deceptive

- Let the saw do the work for you
- A chain is no longer than its weakest link
- A rolling stone gathers no moss
- Still waters run deep

- Keep your eye on the ball
- Rome wasn’t built in a day

Before

During

After