Reconnecting ‘Disconnected Rivers’

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Why care about rivers?

- river as ecosystem
- ecosystem services (clean water, fisheries, recreation, esthetics, flood control, habitat)
- landscape integrator – links physical & biological variables
Rivers as Ecosystems & Landscape Integrators

- Atmosphere-channel
  - Wind-blown sediment
  - Insects
  - Nutrients & minerals

- Groundwater-channel
  - Dissolved contaminants

- Hillslope-channel
  - Nutrients, contaminants
  - Sediment
  - Organic matter

- Floodplain-channel
  - Contaminants
  - Sediment
  - Water
  - Fish, amphibians, reptiles

- Hyporheic-channel
  - Drift of larval insects
  - Nutrient flow
  - Water discharge
  - Sediment movement
  - Plant propagules
  - Contaminants

- Upstream-downstream
  - Migratory fish
  - Nutrient flow
  - Sediment movement
  - Plant propagules
  - Contaminants

- Grand Canyon
River Health

A healthy river exhibits physical diversity of flow and form, biological diversity of organisms and communities, and 3-dimensional connectivity with fluxes of energy, matter, and organisms.
Physical Diversity
- hydrology
- sediment
- hydraulics
- substrate
- geometry
temporal & spatial

Channel + Floodplain

Biodiversity
- biological characteristics
- connectivity (x, y, z)
temporal & spatial

Habitat

River health
Humans indirectly & directly alter rivers

Indirect alterations:
- changes in land cover (deforestation, afforestation, crops, urbanization)
- human-induced changes in climate

Direct alterations:
- flow regulation (dams, diversions, augmentation)
- channelization, bank stabilization
- levees
- removal of native species & introduction of exotic species

Reduced river connectivity and physical & biotic diversity
How extensive & intensive are these alterations?

- in the US, 75,187 large dams & > 2.5 million small dams
- all watersheds larger than ~ 2000 km$^2$ (excluding Alaska) have some dams

Minimum flows inflated or diminished in 74% of streams assessed
• USGS 1991-95 National Water Quality Assessment: streams & ground water in basins with significant agricultural and/or urban development almost always contain complex mixtures of nutrients & pesticides
• > 1/3 of the rivers in the US are listed as impaired or polluted by EPA
• almost half US waters fail to meet biological water-quality standards
• the conservation status of 15 of the 40 major watersheds in the US is rated critical, the highest category for a ranking based on degree of land-cover alteration within the catchment, degradation of water quality, alteration of hydrologic integrity, degree of habitat fragmentation, effects of introduced species, & impacts of direct species exploitation

Abell et al., 2000
Abell et al., 2000
Abell et al., 2000

Figure 4.5  Degree of habitat fragmentation.

Figure 4.6  Effects of introduced species.
• estimated 70-90% of riparian forests have been lost nationally
• wetland losses > 50%, and close to 90% in some portions of US

• at least 123 freshwater species became extinct in North America during 20th century

• 1/3 to ¾ of aquatic species nationwide are rare to extinct

• extinction rates of freshwater fauna are 5x those for terrestrial biota
Human-induced uniformity impairs river health

stabilized urban river, Hungary

stabilized urban river, Austria
channelized river, Colorado

tie-driven stream, Wyoming
Better to conserve physical & biodiversity of rivers

than to attempt to restore following human alterations
Use connectivity diagrams to conceptualize river trajectories (Kondolf et al., 2006)

- Deschutes River, Oregon: dam blocks fish migration, sediment feeding, little/no effect on flow regime.
- Isar River, Germany: dam traps sediment, regulates flow.
- Clear Creek, CA: small dam removed, regulates flow.
- Condamine River, Queensland: diversions reduce base flow, perennialization by urbanization, weirs, and wastewater.
- Torrens River, South Australia: ephemeral/intermittent.

Streamflow variability:
- low
- high
But ...
the worst effects of alterations can be reduced by restoring links between process and river form

- identify interactions among physical driver & physical & biotic response variables
- quantify changes in driver & response variables associated with human-induced alterations of rivers
- identify thresholds necessary to restore & maintain desired physical & biotic process and form
- modify human alterations (e.g., changing dam operations) to the river in order to exceed those thresholds
North Fork Poudre River, Colorado

900 km² drainage area
bedrock canyon; boulder-bedded, pool-riffle channel
summer snowmelt peak flow
upstream dam built 1910
concern about loss of bed mobility,
pool infilling,
lack of riparian vegetation recruitment,
drying of floodplain

(Rathburn et al. 2009)
Several studies indicate

- reduced base flow & extreme peak flows
- reduced sand & gravel transport – changes in periphyton, aquatic insects, & predators (fish, birds)
- clogging of spawning gravels
- aging & senescence of riparian forest
- encroachment on xeric plants on floodplain
Recommendations for flow thresholds to
mobilize interstitial sediment
mobilize majority of bed material
erode stream banks
inundate overbank areas

- interstitial fines flushed
  * grain size distribution
  * channel geometry
  * entrainment equation

- majority of bed material mobilized
  * grain size distribution
  * channel geometry
  * entrainment equation

- overbank flow occurs
  * valley geometry
  * channel geometry
  * hydraulic model

- lateral channel mobility
  * channel geometry
  * bank characteristics (incl. vegetation)
  * bank erosion model

threshold discharge
Advice from a River

Stay current
Be thoughtful of those downstream
Immerse yourself in nature
Follow the path of least resistance
The beauty is in the journey

Ilan Shamir
Thinking like a geomorphologist

History of river form

Changes from a reference condition that cannot be altered

Connectivity of river form & process across drainage basin

Evolution of rivers through time

Goals of management & restoration

Patience
Bibliography


