Lessons learned about the physical and aquatic response of rivers to dam removal, USA

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Marmot Dam, Sandy River, Oregon USA (1913 – 2007)
American Rivers (2016)
National Inventory of Dams (2000)
Why dam removal?

- Aging dams/dam safety
- Threatened and endangered species
- “Natural flow regime” paradigm
- River restoration
- Policy windows (i.e., FERC relicensing)
- Deregulation of energy industry
- Symbolic value

In 1981, Earth First! unfurls a 300ft plastic “crack” along the front of Glen Canyon Dam.

Bruce Babbitt takes a sledgehammer to Quaker Neck Dam in North Carolina, as U.S. Secretary of the Interior in 1997.
Key questions for dam removal

- **FLOW (Q)**
- **SEDIMENT (Qs)**
- **TEMP**
- **CHEMISTRY**

**Upstream:** how much sediment is eroded how quickly?

**Downstream:** where does it go?

- Channel morphology
- **Aquatic Biology**

what effect on ecology?
Geomorphologic lessons learned

• Response to removal of large versus small dams is different
Large dams ≠ Small dams

- >15 meters high
- >$10^5 m^3$ sediment volume
- Reservoirs usually partially filled with sediment
- Progressive/staged dam removal

- <15 meters high
- <$10^5 m^3$ sediment volume
- Reservoirs often filled with sediment
- Typically “blow & go” dam removal
Sediment released by dam removals

Reservoir sediment (m$^3$)

10^8
10^7
10^6
10^5
10^4
10^3
10^2


Previous small dam removals

Large dam removals

Edwards

Embrey

Savage Rapids

Milltown

Condit

Marmot

Big Rapids

Brownsville

Edwards Dams

Milltown Dams

Condit Dams

Savage Rapids Dams

Marmot Dams

Brownsville Dams

Grant & Lewis, 2015
Geomorphic lessons learned

• Response to removal of large versus small dams is different

• Rate of sediment transport from reservoir is a function of grain size, volume of sediment, and how dam was removed
Geomorphic lessons learned

- Response to removal of large versus small dams is different
- Rate of sediment transport from reservoir is a function of grain size, volume of sediment, and how dam was removed
- Downstream effect on channel form scales with volume and rate of sediment release, channel energy
Sediment Deposition below Brownsville Reservoir
(Zunka, 2012)
Geomorphic lessons learned

• Response to removal of large versus small dams is different

• Rate of sediment transport from reservoir is a function of grain size, volume of sediment, and how dam was removed

• Downstream effect on channel form scales with volume and rate of sediment release, channel energy

• Removal of small dams with limited storage has minimal physical effects on downstream rivers
Key questions for dam removal

- **Flow (Q)**
- **Sediment (Qs)**
- **Temp**
- **Chemistry**

**Upstream:**
- How much sediment is eroded?
- How quickly?

**Downstream:**
- Where does it go?

**What effect on ecology?**

**Channel morphology**

**Aquatic Biology**
Ecological lessons learned

- Response varies by stream reach relative to former dam and reservoir
Stream reaches influenced by dam removal

- Dominant processes affected by dam removal
  - (a) Upstream from dam & reservoir
    - Longitudinal connectivity
      - Fish recolonization
      - Nutrient subsidies
  - (b) Former reservoir & dam site
    - Lentic to lotic
      - Revegetation
      - Community structure
      - Channel and floodplain evolution
  - (c) Downstream of dam & reservoir
    - Physical fluxes
      - Sediment deposition
      - Turbidity
      - Wood/organic matter
      - Contaminants (if present)
      - Water temperature
Ecological lessons learned

• Response varies by stream reach relative to former dam and reservoir

• Reaches undergo different trajectories following dam removal
Ecological response trajectories following dam removal
Ecological lessons learned

- Response varies by stream reach relative to former dam and reservoir
- Reaches undergo different trajectories following dam removal
- In general, fish and other organisms respond rapidly to removal
Salmon recolonization above former Elwha dams

- Steelhead
- Chinook salmon
- Coho salmon

Year:
- 2011/12
- 2012/13
- 2013/14
- 2014/15
- 2015/16
- 2016/17
- 2017/18

Total redds above former Elwha dam
Some other lessons...

• Ask good questions that address both local issues and broader understanding.
• Build science around a few key removals. Focus on the ones most likely to answer critical questions.
• Build strong partnerships with scientists, NGOs, citizens, and governments.
Dam removal science occurs within a cultural context.

- Economic
- Social
- Historical
- Legal

- geomorphology
- engineering
- hydrology
- ecology
For more information and lists of publications please visit:

Watershed Processes Group
http://wpg.forestry.oregonstate.edu/

John Wesley Powell Center for Analysis and Synthesis
https://www.usgs.gov/centers/powell-ctr