Large-Scale Experiments Demonstrating the Effectiveness of Process-based Low-tech Restoration

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Acknowledgements

Funding
• NOAA, Pacific Coastal Salmon Recovery Fund
• NOAA, Pacific States Marine Fisheries Commission
• Salmon Recovery Funding Board
• Oregon Watershed Enhancement Board
• Bonneville Power Administration

Collaboration and Support
• Snake River Salmon Recovery Board
• Integrated Status and Effectiveness Monitoring Program
• US Forest Service
• Washington Department of Fish and Wildlife
• Oregon Department of Fish and Wildlife
• Utah State University
Outline/Message

Intensively Monitored Watershed
• What and Why
• Lessons

Bridge Creek IMW
• Beavers
• Incision

Asotin Creek IMW
• Large woody debris
• Channelization
Intensively Monitored Watersheds (IMWs)

Keogh
Strait Juan de Fuca
Potlatch
Lemhi
MF John Day
Bridge
Alsea
Tenmile
L. Columbia
Elwha
Hood Canal
Skagit
Methow
Entiat
L. Columbia
Wind
Asotin
MF John Day
Bridge
Pudding, CA
Columbia River
Snake River
Bennett et al. 2016. Fisheries
Bridge Creek IMW
Beaver dam analogs (BDAs)
Problem

Incision

Incised Channel

$10^3$ years

Incision Recovery

• Simplified habitat
• Limited riparian

• Complex & dynamic channel
• Healthy riparian
Restoration Approach
Beaver Dam Analog Structures (BDAs)

- Mean Annual Flood Height: 30 - 50 cm
- Incision Trench
- Disconnected Terrace
Oregon

John Day Basin

Bridge Creek Watershed

Bear Creek

Bridge Creek

Gable Creek

Bridge Creek

Murderers Creek

Mitchell, OR

Oregon

John Day Basin

Bridge Creek

Murderers Creek

Control

Treatment

Murderers Creek – Watershed Control

Summer steelhead
Monitoring Fish

- Abundance
- Age
- Growth
- Movement
- Survival
- Carrying Capacity
- Smolts/Spawner

Mark-recapture (summer, fall)

Mobile PIT tag detection (all seasons)

PIT tag arrays (continuous)

Fish In-Fish Out (Brood year)
Monitoring Habitat

Columbia Habitat Monitoring Protocol (CHaMP)

Topographic survey of channel

Digital Elevation Model (DEM)

Invertebrate Drift

Stream Temperature & Discharge

Champmonitoring.org
Restoration Response (treatment scale) pre-treatment
Mimic beaver - beaver dam analogs (BDAs)

Crooked River, OR
Mimic beaver - but NOT like this!!!

Silvies Ranch, OR
BDA treatment & Beaver Response

Number of Beaver Dams and BDAs

Restoration

Bridge Creek

Treatment reaches

Control reaches

Restoration Response (treatment scale)
Floodplain Connection (+200%); Deposition (1 m)
Restoration Response (treatment scale)
Floodplain Connection (+200%); Deposition (1 m)
Restoration Response (treatment scale)
Floodplain Connection (+200%); Deposition (1 m)
Restoration Response (treatment scale)
Floodplain Connection (+200%); Deposition (1 m)
Restoration Response (treatment scale)
Compressed Summer Temperature Range

- Treatment reach - Dam influenced
- Control reach - No dams

Weber et al. 2017 PLoS ONE
Restoration Response (site scale)
Temperature refugia

Treatment

Control

Restoration Response (treatment scale)

Fish
Restoration Response (treatment scale)

Fish

- 168% increase in abundance
- 52% increase in survival
- 172% increase in production
Error bars = 90% CI.

Bouwes et al. 2016. Scientific Reports
2016
Post-restoration

164 Beaver Dams

29% Passage
The whole enchilada?
Asotin Creek IMW, Washington
High Density Large Woody Debris (_{HD}LWD)
## Setting Landscape

<table>
<thead>
<tr>
<th>Stream</th>
<th>Basin Area (km²)</th>
<th>Bankfull width (m)</th>
<th>Gradient (%)</th>
<th>Average Discharge (cfs)</th>
<th>Peak Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charley</td>
<td>58</td>
<td>4.8</td>
<td>3.0</td>
<td>9.5</td>
<td>100</td>
</tr>
<tr>
<td>North Fork</td>
<td>165</td>
<td>9.8</td>
<td>1.7</td>
<td>60.0</td>
<td>1000</td>
</tr>
<tr>
<td>South Fork</td>
<td>104</td>
<td>6.3</td>
<td>2.6</td>
<td>11.5</td>
<td>800</td>
</tr>
</tbody>
</table>

- **Blue Mountains**
- **Dissected Highlands**
- **Dissected Loess Uplands**
- **Mesic Forest**
- **Lower Snake Canyons**
- **Charley Creek**
- **Flow**
Experimental Design
Staircase

(Walters 1988, Loughin 2006)
Wood
Scope of the Problem

Young forest, minimal wood input & efficient transport
Restoration Approach
High Density Large Woody Debris ($_{HD\text{LWD}}$)

• Soft-engineering
• Let water do the work\(^1\)
• Large extent
• High density (3-5/100m)
• Lower cost/km (~25%)

\(^1\) (Zeedyk and Clothier 2009)
High Density Large Woody Debris (HD-LWD)

- Density over stability
- Strength in numbers
- Many types of structures – but focus on density!
Approach Construction prior to high flows
Effectiveness
Floodplain connection first high flow
Mean frequency of pools in treatment and control sites across all streams and years.
Effectiveness
Geomorphich change
Geomorphic Units Post Restoration

![Geomorphic Units Post Restoration](image)

- Chute
- Pocket Pool
- Pond
- Pool
- Margin Attached Bar
- Mid-Channel Bar
- Riffle
- Cascade
- Rapid
- Run
- Transition
- Bank

- Concavities
- Convexities
- Planar

Area (ft²)
Effectiveness
Bar development
Effectiveness
Bar development
Effectiveness
Erosion – defining good vs bad outcomes
Effectiveness
Tree recruitment
Survey of condition of structures 5 years (South Fork), 4 years (Charley), and 3 years (North Fork) after construction (n = 580).
Change in abundance of juvenile steelhead in treatment sites relative to control sections within each study creek within the Asotin Creek IMW: 2008-2017. Error bars = 90% confidence intervals.
Take Home Messages

• BDAs and LWD
  • increase geomorphic diversity
  • Initiate processes (site and reach)
• BDAs reconnect floodplain; LWD if aggressive
• BDAs can significantly increase fish production
• LWD still analyzing
Conclusion
Bridge Creek IMW

- Testing BDA Assisted Incision Recovery
- Benefits to Fish Populations and Habitat

Adapted from Pollock et al. 2014
Background
Wadeable Streams

Charley Creek ~ 4-5 m bankfull: stream order 2

Low summer flows: 5-25 cfs
Large floods: 5000-6000 cfs

South Fork Asotin Creek ~ 6-7 m bankfull: stream order 3

North Fork Asotin Creek ~ 9-10 m bankfull: stream order 4
Smolts/female (colored bars) by stream and brood year, and total female escapement (black line): 2010-2015.
Background - impairments
Floodplain/riparian function

- Degraded Riparian
- Decreased LWD/Dams
- Decreased Overbank Flow
- Disconnected Floodplain
- Upland Encroachment
Response
Net Rate of Energy Intake (Reach Carrying Capacity)

Inputs

Hydraulic Model

Drift

Temperature

Fish Information

LWD

Foraging and Swim Costs Models

Hughes and Dill (1990)

NREI Calculation

Gross Rate El − Swim Costs = Net Rate El