PARTNERING WITH BEAVER IN RESTORATION DESIGN

HAILEY, IDAHO 2018 WORKSHOP FIELD NOTEBOOK

Prepared by:

Utah State University
ECOGEOMORPHOLOGY & TOPOGRAPHIC ANALYSIS LABORATORY

FHC THE FLUVIAL HABITATS CENTER

Department of Watershed Sciences, 5210 Old Main Hill, Logan, UT 84322-5210

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USDA United States Department of Agriculture
Natural Resources Conservation Service

SAGE GROUSE INITIATIVE

The Nature Conservancy Idaho

WOOD RIVER LAND TRUST

PHEASANTS FOREVER

June 2018
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syllabus &amp; Web Resources</td>
<td>5</td>
</tr>
<tr>
<td>Workshop Webpage:</td>
<td>5</td>
</tr>
<tr>
<td>Design Manual</td>
<td>5</td>
</tr>
<tr>
<td>Where to Get More Help:</td>
<td>5</td>
</tr>
<tr>
<td>Your Instruction team</td>
<td>8</td>
</tr>
<tr>
<td>Geomorphology Exercise</td>
<td>9</td>
</tr>
<tr>
<td>Incised streams – channel evolution models &amp; Stage 0</td>
<td>12</td>
</tr>
<tr>
<td>Rock Creek Ranch</td>
<td>15</td>
</tr>
<tr>
<td>Assessing Beaver Activity Exercise</td>
<td>17</td>
</tr>
<tr>
<td>Beaver Activity</td>
<td>18</td>
</tr>
<tr>
<td>Beaver Dam Monitoring</td>
<td>19</td>
</tr>
<tr>
<td>Assessing Beaver Dam Building Capacity</td>
<td>20</td>
</tr>
<tr>
<td>Exercise</td>
<td>20</td>
</tr>
<tr>
<td>Modeling Capacity at Rock Creek</td>
<td>24</td>
</tr>
<tr>
<td>Mitigating some undesireable beaver activity.</td>
<td>26</td>
</tr>
<tr>
<td>Living with Beaver Strategies</td>
<td>26</td>
</tr>
<tr>
<td>Building a Beaver Dam Analogue – Day 1</td>
<td>31</td>
</tr>
<tr>
<td>Notes</td>
<td>31</td>
</tr>
<tr>
<td>Safety</td>
<td>32</td>
</tr>
<tr>
<td>Post Pounders</td>
<td>33</td>
</tr>
<tr>
<td>Post-Assisted Beaver Dam Analogue Recipe</td>
<td>36</td>
</tr>
<tr>
<td>Ingredients:</td>
<td>36</td>
</tr>
<tr>
<td>Instructions:</td>
<td>36</td>
</tr>
<tr>
<td>Notes</td>
<td>37</td>
</tr>
<tr>
<td>Other Diagrams OF BDAs</td>
<td>37</td>
</tr>
<tr>
<td>Adaptive management options – DAY 2</td>
<td>41</td>
</tr>
<tr>
<td>Examples of Adaptive Management Plans</td>
<td>41</td>
</tr>
<tr>
<td>Rock Creek Stream Bed Alteration Permit</td>
<td>42</td>
</tr>
<tr>
<td>Transparent, repeatable, hypothesis driven design</td>
<td>82</td>
</tr>
<tr>
<td>Simple BDA Design Form</td>
<td>83</td>
</tr>
<tr>
<td>Logistics &amp; Staging</td>
<td>86</td>
</tr>
<tr>
<td>Design Manuals</td>
<td>88</td>
</tr>
<tr>
<td>Beaver Restoration Guidebook</td>
<td>88</td>
</tr>
<tr>
<td>Hand-Built Structures for Restoring Degraded Meadows in Sagebrush Rangelands</td>
<td>88</td>
</tr>
</tbody>
</table>
Good Books on Beaver …………………………………………………………………………………………………………………………………………………… 90
References ………………………………………………………………………………………………………………………………………………………………………… 93
SYLLABUS & WEB RESOURCES

This handout only contains copies of supplemental information we will use during the workshop in the field for exercises and reference. Participants should refer to the workshop webpages for complete information, including:

Workshop Webpage:

http://beaver.joewheaton.org/nrcs--idaho.html

Design Manual
Available later this summer!


Where to Get More Help:
http://beaver.joewheaton.org/need-help-planning-designing--building.html
Partnering with Beaver in Restoration Design

Field Workshop
(June 20-21, 2018 - Hailey, Idaho)

Primary Learning Outcomes
This workshop will bring together NRCS conservationists and partners in Idaho interested in how to use beaver, and beaver dam analogues, as low-cost tools to restore riparian areas to benefit wildlife and working lands. Participants will come away with:

1. An appreciation of beaver ecology and the complex feedbacks between beaver activity, hydrogeomorphic responses, riparian vegetation and ecology;
2. Exposure to ways in which beaver and beaver dam analogues can be used as restoration tool to mitigate specific impairments;
3. Introduction to considerations in planning, permitting, design and building such restoration projects;
4. Knowledge of how to use adaptive management in managing expectations about beaver as a restoration agent and/or nuisance impacts;
5. First-hand experience designing and building some beaver dam analogues;
6. A chance to interact with experienced practitioners & share perspectives

Day 1 - Restoring Process and Function in Riparian Areas 8:00 to 5:00 with Evening Social

Early Morning
● 8:00 - 10:00 : Background & Context
● 10:00 - 10:15 : Break
● 10:15 - 10:30 : Reading Riparian Riverscapes

Late Morning to Afternoon - Field Trip - Rock Creek Ranch Beaver Dams
● 10:30 - 3:00 - Field Trip - Reading Riverscapes, Understanding what beaver do and why, Building your first Beaver Dam Analogue

Afternoon - Classroom - Restoring Process & Function in Riparian Areas
● 3:00 - 5:30 - Lectures & Discussion
● 6:30 - 9:00 - Evening Social / Dinner @ 6:30-9:00 (TNC Headquarters)
  ○ 7:00 - 8:00 - Reintroducing Beaver to Bring Back Perennial Flow - Jay Wilde
Day 2 - Implementing BDAs as Low-Cost Restoration Tool, 8:00 to 5:00
All of day 2 will be spent in the field at Rock Creek Ranch (Idaho) learning about various ways in which low-cost structures can be used.

Early Morning - Classroom
- 8:00 - 8:15 - Overview of Day 2 & Clarifications from Day 1
- 8:15 - 9:00 - Adaptive Management, Pilots, Maintenance & Expectation Management

Morning to Mid Afternoon Field Trip - Rock Creek Design & Implementation
- 9:00 - 3:30 - BDA Design & Construction

Late Afternoon Wrap Up in Field
- 3:30 - 5:00 - Discussions
  - Permitting & Regulatory Considerations in Idaho
  - Workshop Synthesis & Where to Turn for Help
  - Next steps for Idaho
- 5:00 - Depart from Rock Creek

Resources
This workshop is not meant to turn you into an expert, but instead to expose you to the concepts and principles of 'cheap and cheerful' restoration of riverscapes (streams, rivers and their riparian areas). The course pages will be a resource for you to come back to in the future.

See [http://beaver.joewheaton.org/nrcs--idaho.html](http://beaver.joewheaton.org/nrcs--idaho.html) for slides, handouts, links, literature.

The design manual will be made available at: [http://beaver.joewheaton.org/restoration-manual.html](http://beaver.joewheaton.org/restoration-manual.html) later this summer & hard copies available in the Fall.

All Times are Approximate & Subject to Change
YOUR INSTRUCTION TEAM

For bios, see links from http://beaver.joewheaton.org/nrcs--idaho.html

The above is your cheat sheet for pretending you remembered all our names.
The valley bottom consists of the areas that could plausibly flood (i.e. floodplain). The building blocks of the valley bottom include the floodplain, and where present the channel(s) flowing through them, standing water bodies (ponds, lakes, etc.) and wetlands (Fryirs et al., 2015). By contrast, valleys can include not just the valley bottom, but fans (alluvial and colluvial), terraces (inactive floodplain), moraines (lateral and terminal). The hillslopes bound the valley, and can bound the valley bottom but don’t always. Being able to identify these landforms, and in particular the valley bottom, helps build realistic expectations for the maximum extent of plausible riparian habitat (e.g. including mesic habitat and wet meadows that occupy valley bottoms).

We will do an exercise in class to help you identify these features on a map, and then attempt to apply that same lens out in the field.

For more information see:

- Design Manual: Chapter
EXERCISE 2 - VALLEY SETTING

South Fork Asotin Creek
Reach SF_01
River Mile 1.5 to 2.2
INCISED STREAMS – CHANNEL EVOLUTION MODELS & STAGE 0

From Cluer and Thorne (2012) we get a series of conceptual channel evolution models helpful for understanding how streams incise and typical geomorphic responses, and how those can be used in process-based restoration.

Figure 1. Schumm et al. (1984) Channel Evolution Model with typical width-depth ratios (F). The size of each arrow indicates the relative importance and direction of the dominant processes of degradation, aggradation and lateral bank erosion. (Redrawn with permission from Water Resources Publications)

Figure 4. Stream Evolution Model based on combining the Channel Evolution Models in Figures 1–3, inserting a precursor stage to better represent pre-disturbance conditions, adding two successor stages to cover late-stage evolution and representing incised channel evolution as a cyclical rather than a linear phenomenon. Dashed arrows indicate ‘short-circuits’ in the normal progression, indicating for example that a Stage 0 stream can evolve to Stage 1 and recover to Stage 0, a Stage 4–3–4 short-circuit, which occurs when multiple head cuts migrate through a reach and which may be particularly destructive. Arrows outside the circle represent ‘dead end’ stages, constructed and maintained (2) and arrested (3a) where an erosion-resistant layer in the local lithology stabilizes incised channel banks.

Figure 1 - Stream Evolution Models from Cluer and Thorne (2012).
In Pollock et al. (2014) we adapted these concepts to look at how both natural beaver dams, and beaver dam analogues could accelerate this ‘recovery’ process in incised streams.
Figure 3 - Examples on left of acceleration of aggradation and recovery of incised channel with beaver dams and on right with BDAs. The big difference is who does the maintenance and when its done.
Figure 4 - Big Wood HUC showing valley bottoms, roads, railroads and canals.
Figure 5 – Rock Creek Ranch (boundary shown in black) with perennial valley bottom, canals and roads shown.
ASSESSING BEAVER ACTIVITY EXERCISE

In the Chapter 4 of the Riverscapes Restoration Design Manual, we provide a series of basic and advanced forms for monitoring beaver activity, beaver dams, and beaver dam complexes. These are fully described there and word documents also exist.

These forms are straight forward to modify and build into useful field Apps with database applications like FileMaker (Camp and Wheaton, 2014), or GIS data collectors like ESRI’s Survey 123.

Figure 6 – Screen shots from Survey 123 Apps.
## BEAVER ACTIVITY MONITORING FORM

### OBSERVATION INFO
- **Observer Name:** ____________________________
- **Site ID:** ____________________________
- **Observation Date:** ____________________________

### OBSERVATION TYPE:
- □ Beaver Dam
- □ BDA
- □ Beaver Activity (no dam)

### OBSERVATION CHRONOLOGY
- □ New Observation of New Feature
- □ First Observation of Existing Feature
- □ First Observation of Relic Feature
- □ Repeat Observation of Existing Feature

### POSITIONAL ATTRIBUTES
- **GPS UTM Easting:** ____________________________
- **GPS UTM Northing:** ____________________________
- **Stream Name:** _________________________________

### BEAVER ACTIVITY LOCATIONS RELATIVE TO CHANNEL(s)
- □ On Main Channel
- □ On Right Side Channel(s)
- □ On Left Side Channel(s)
- □ On Left Floodplain
- □ On Right Floodplain

### OBSERVATION CHRONOLOGY
- □ New Observation of New Feature
- □ First Observation of Existing Feature
- □ First Observation of Relic Feature
- □ Repeat Observation of Existing Feature

### RECENT (PAST 3 MONTHS) BEAVER ACTIVITY:

#### Dam Expansion
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Dam Construction
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Dam Maintenance
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Scents Mound
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Canal Digging
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Pond Excavation
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Dam Notching
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

#### Drainage/Flushing
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

### Corn on the Cob (Foraging)
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

### Felling of Trees
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

### Harvesting of Branches
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

### Skid Trail Usage
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

### Primary Wood Harvested
- □ Aspen
- □ Cottonwood
- □ Willow
- □ Other Hardwoods
- □ Conifers
- □ No active harvesting

### Above Ground Lodge Maintenance or Construction
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity

### Bank Lodge Maintenance or Construction
- □ Certain - Documented Evidence  □ Probable - Strong Evidence
- □ Possible - Anecdotal or Inconclusive Evidence
- □ Unsure - Just a guess  □ No Evidence of Activity
BEAVER DAM COMPLEX MONITORING FORM - BASIC

OBSERVATION INFO

Observer Name: ____________________________
Site ID: ____________________________
Observation Date: ____________________________

BEAVER BUILT DAMS?

○ Beaver-only Built Dams
○ Beaver Dam Analogue (manmade)
○ Mix of beaver-built and manmade

COMPLEX TYPE:

○ Single Dam only
○ Primary + One or More Secondary
○ Multiple Possible Primaries + One or More Secondary

STATUS

○ Active
○ Abandon
○ Historic/Relic

CONFIDENCE IN STATUS

○ Certain - Documented Evidence
○ Probable - Strong Evidence
○ Possible - Anecdotal or Inconclusive Evidence
○ Unsure - Just a guess

POSITIONAL ATTRIBUTES

LOCATION OF PRIMARY DAM

GPS UTM Easting: ____________________________
GPS UTM Northing: ____________________________

COMPLEX SIZE

Number of Primary Dams: ____________________
Number of Secondary Dams: ____________________

POSITION OF DAMS

Primary Dam Location: □ Top □ Bottom □ In-between
Number of Secondary Dams Upstream of Primary: _______
Number of Secondary Dams Downstream of Primary: _______

NOTES & / OR SKETCH
ASSESSING BEAVER DAM BUILDING CAPACITY

In Macfarlane et al. (2015) we presented a method for modelling the capacity of a riverscape to support dam building activity by beaver. In other words, the model predicts the upper limit of how many dams can be built in a reach.

This model is part of the BRAT – Beaver Restoration Assessment Tool. It is part of a family of open-source tools our lab built and are available through the Riverscapes Consortium. See: http://brat.riverscapes.xyz

BRAT is currently being run for the entire state of Idaho, thanks to a grant from Idaho Department of Fish and Game. Results will be made publicly available in 2019 to support beaver management, conservation and restoration planning and prioritization.

EXERCISE

In the field, we will ask the same questions that the BRAT capacity model asks, and use the inference system (a rule table) to assess capacity. The actual model uses GIS data to provide approximate quantitative answers to the same questions and a fuzzy inference system to do the math. Fill out the form on the next page and answer use the look up tables.

We will stick to a simple version of this form here, but in Chapter 4 of the Riverscapes Restoration Design Manual, we provide a series of basic and advanced forms and full description of how to use them. There is also a field Survey 123 App that allows you to do the same thing on a tablet or phone, or from a browser.
OBSERVATION INFO

Observer Name: ____________________________
Reach ID: ____________________________

LOCATION OF ASSESSMENT REACH

GPS UTM Easting: ____________________________
GPS UTM Northing: ____________________________

STRENGTH OF VEGETATION TO SUPPORT DAM BUILDING ACTIVITY

SUITABILITY OF STREAMSIDE VEGETATION
- Unsuitable
- Barely Suitable
- Moderately Suitable
- Suitable
- Preferred

Vegetation within 30 m of water’s edge

What vegetation types are abundant?
- Desirable woody (e.g. Aspen, Willow, Cottonwood)
- Other woody (e.g. conifers, sagebrush)
- Grasses
- Crops
- Ornamentals
- Developed

SUITABILITY OF RIPARIAN/UPLAND VEGETATION
- Unsuitable
- Barely Suitable
- Moderately Suitable
- Suitable
- Preferred

Vegetation within 100 m of water’s edge

What vegetation types are abundant?
- Desirable woody (e.g. Aspen, Willow, Cottonwood)
- Other woody (e.g. conifers, sagebrush)
- Grasses
- Crops
- Ornamentals
- Developed

DAM DENSITY CAPACITY ASSESSMENT BASED ON SUITABILITY OF VEGETATION ONLY (USE TABLE 1)

- None (no dams)
- Rare (0-1 dams/km)
- Occasional (1-4 dams/km)
- Frequent (5-15 dams/km)
- Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASEFLOWS?

- Probably can build dam
- Can build dam
- Can build dam (saw evidence of recent dams)
- Could build dam at one time (saw evidence of relic dams)
- Cannot build dam (streampower really high)

HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?

- So steep they cannot build a dam (e.g. > 20% slope)
- Probably can build dam
- Can build dam (inferred)
- Can build dam (evidence or current or past dams)
- Really flat (can build dam, but might not need as many as one dam might back up water > 0.5 km)

IF BEAVERS BUILD A DAM, CONSIDER WHAT HAPPENS TO THE DAM(S) IN A TYPICAL FLOOD (E.G. MEAN ANNUAL FLOOD)?

- Blowout
- Occasional Blowout
- Dam Persists

COMBINED DAM DENSITY CAPACITY ASSESSMENT BASED ON ALL (USE TABLE 2)

- None (no dams)
- Rare (0-1 dams/km)
- Occasional (1-4 dams/km)
- Frequent (5-15 dams/km)
- Pervasive (15-40 dams/km)

Maximum Dam Density (dams/km)
### INFERENCE SYSTEM OF CAPACITY BASED ON VEGETATION ONLY:

Table 1. Rule table for two input inference system that models the capacity of the reach to support dam building activity (in dam density) using the suitability of streamsid vegetation and suitability of riparian/upland vegetation as inputs.

<table>
<thead>
<tr>
<th>Rules</th>
<th>Inputs</th>
<th>Suitability of streamside vegetation &amp; Suitability of riparian/upland vegetation</th>
<th>Output Dam density capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Unsuitable &amp; Unsuitable</td>
<td>then None</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Unsuitable &amp; Barely suitable</td>
<td>then Rare</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Unsuitable &amp; Moderately suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Unsuitable &amp; Suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Unsuitable &amp; Preferred</td>
<td>then Occasional</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>Barely suitable &amp; Unsuitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Barely suitable &amp; Barely suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>Barely suitable &amp; Moderately suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Barely suitable &amp; Suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Barely suitable &amp; Preferred</td>
<td>then Occasional</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>Moderately suitable &amp; Unsuitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Moderately suitable &amp; Barely suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>Moderately suitable &amp; Moderately suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>Moderately suitable &amp; Suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>Moderately suitable &amp; Preferred</td>
<td>then Occasional</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>Suitable &amp; Unsuitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>Suitable &amp; Barely suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>Suitable &amp; Moderately suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>Suitable &amp; Suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>Suitable &amp; Preferred</td>
<td>then Occasional</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>Preferred &amp; Unsuitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>Preferred &amp; Barely suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>23</td>
<td>1</td>
<td>Preferred &amp; Moderately suitable</td>
<td>then Occasional</td>
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<tr>
<td>24</td>
<td>1</td>
<td>Preferred &amp; Suitable</td>
<td>then Occasional</td>
</tr>
<tr>
<td>25</td>
<td>1</td>
<td>Preferred &amp; Preferred</td>
<td>then Occasional</td>
</tr>
</tbody>
</table>
Table 2. Rule table for four input inference system that models the capacity of the reach to support dam building activity (in dam density) using the vegetation dam density capacity (output of Table 1 model), the two-year flood stream power, baseflow stream power and reach slope.

<table>
<thead>
<tr>
<th>Rules</th>
<th>Vegetation dam density capacity</th>
<th>2-Year flood stream power</th>
<th>Baseflow stream power</th>
<th>Reach slope</th>
<th>Output: Dam density capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1</td>
<td>None</td>
<td>&amp; -</td>
<td>&amp; -</td>
<td>&amp; -</td>
<td>then None</td>
</tr>
<tr>
<td>2/2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>then None</td>
</tr>
<tr>
<td>3/3</td>
<td>Rare</td>
<td>&amp; Dam persists</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>4/4</td>
<td>Rare</td>
<td>&amp; Dam persists</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>5/5</td>
<td>Rare</td>
<td>&amp; Dam persists</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>6/6</td>
<td>Rare</td>
<td>&amp; Num occasional breach</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>7/7</td>
<td>Rare</td>
<td>&amp; Num occasional breach</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>8/8</td>
<td>Rare</td>
<td>&amp; Num occasional breach</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>9/9</td>
<td>Rare</td>
<td>&amp; Num occasional breach</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>10/10</td>
<td>Rare</td>
<td>&amp; Blowout</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Rare</td>
</tr>
<tr>
<td>11/11</td>
<td>Rare</td>
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<td>&amp; Can build dam</td>
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<td>then Rare</td>
</tr>
<tr>
<td>12/12</td>
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<td>&amp; Dam persists</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Occasional</td>
</tr>
<tr>
<td>13/13</td>
<td>Occasional</td>
<td>&amp; Dam persists</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Occasional</td>
</tr>
<tr>
<td>14/14</td>
<td>Occasional</td>
<td>&amp; Occasional breach</td>
<td>&amp; Can build dam</td>
<td>&amp; NOT Cannot build dam</td>
<td>then Occasional</td>
</tr>
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<td>15/15</td>
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<td>16/16</td>
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<td>&amp; NOT Cannot build dam</td>
<td>then Occasional</td>
</tr>
<tr>
<td>17/17</td>
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<td>then Occasional</td>
</tr>
<tr>
<td>18/18</td>
<td>Occasional</td>
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<td>then Occasional</td>
</tr>
<tr>
<td>19/19</td>
<td>Occasional</td>
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<td>then Occasional</td>
</tr>
<tr>
<td>20/20</td>
<td>Frequent</td>
<td>&amp; Dam persists</td>
<td>&amp; Can build dam</td>
<td>&amp; Really flat</td>
<td>then Occasional</td>
</tr>
<tr>
<td>21/21</td>
<td>Frequent</td>
<td>&amp; Dam persists</td>
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</tr>
<tr>
<td>22/22</td>
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</tr>
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<td>23/23</td>
<td>Frequent</td>
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<td>24/24</td>
<td>Frequent</td>
<td>&amp; Dam persists</td>
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<td>then Occasional</td>
</tr>
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<td>then Occasional</td>
</tr>
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<td>then Occasional</td>
</tr>
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</tr>
<tr>
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<td>then Occasional</td>
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<tr>
<td>44/44</td>
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</tr>
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<td>46/46</td>
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</tr>
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<td>47/47</td>
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<td>54/54</td>
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</tr>
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<td>59/59</td>
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<td>60/60</td>
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</tr>
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<td>61/61</td>
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<td>then Occasional</td>
</tr>
<tr>
<td>62/62</td>
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<td>&amp; Can build dam</td>
<td>&amp; Really flat</td>
<td>then Occasional</td>
</tr>
<tr>
<td>63/63</td>
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<td>&amp; Blowout</td>
<td>&amp; Can build dam</td>
<td>&amp; Really flat</td>
<td>then Occasional</td>
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<tr>
<td>64/64</td>
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<td>&amp; Can build dam</td>
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<td>then Occasional</td>
</tr>
<tr>
<td>65/65</td>
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<td>&amp; Can build dam</td>
<td>&amp; Really flat</td>
<td>then Occasional</td>
</tr>
<tr>
<td>66/66</td>
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<td>&amp; Really flat</td>
<td>then Occasional</td>
</tr>
<tr>
<td>67/67</td>
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<td>&amp; Blowout</td>
<td>&amp; Can build dam</td>
<td>&amp; Really flat</td>
<td>then Occasional</td>
</tr>
</tbody>
</table>
Figure 7 – Prediction from BRAT (http://brat.riverscapes.xyz) of existing capacity to support beaver dam building (in dams/km) in Rock Creek.
Figure 8 - Prediction from BRAT (http://brat.riverscapes.xyz) of historic capacity to support beaver dam building (in dams/km) in Rock Creek.
MITIGATING SOME UNDESIREABLE BEAVER ACTIVITY

While the threats to infrastructure within Rock Creek are limited, there are some areas where roads, diversions, canals and critical infrastructure are either in the valley bottom or directly adjacent to the channel and beaver could cause problems.

Once beaver activity has been determined to be sufficiently damaging or threatening as to require management intervention there are a number of tools that can be used. All management decisions require resources, whether financial or temporal.

Living with Beaver Strategies

Traditionally, beaver management has relied on lethal trapping to prevent threats to infrastructure posed by beaver dam building activity. The increased awareness of the ecosystem benefits provided by beaver activity and their ability to help achieve a number of restoration goals has spurred the development of approaches capable of mitigating the negative results of beaver activity in order to retain the benefits such activity produces. Here we summarize a number of ‘living with beaver’ strategies. Perhaps the most authoritative resources on living with beaver strategies can be found at the Beaver Institute: [https://www.beaverinstitute.org/](https://www.beaverinstitute.org/)
Breach Dam
Breaching or partial breaching (i.e., notching) a dam is an effective way to mitigate the risk of flooding due to a specific dam, if that dam is no longer being actively maintained by beaver. Breaching, rather than full removal, allows managers to effectively control the water height of the dam while retaining the ecosystem services provided by such a dam. Breaching a dam is not an effective strategy if the dam is being actively maintained, given beavers’ ability to repair breaches within short periods of time (i.e., hours to days).

Figure 9 – Flow chart illustrating a monitoring and evaluation protocol for potential risk posed by beaver activity. Chart highlights decisions and evaluations in diamonds, and recommends management actions in CAPITALS. Figure from (Wheaton, 2013).
Notch Dam and Install Beaver Deterrent

In areas where an actively maintained dam is posing a threat of flooding but has not reached a critical level, notching the dam to reduce the pond height and installing a beaver deterrent may reduce the threat of flooding. A beaver deterrent is simply a white sheet that is strung between two fence posts and placed just upstream of the notched dam, such that it can move freely in the wind. The sheet is cut vertically to create strips that can blow in the wind. The movement of the sheet deters beaver from repairing the notched dam. This approach is very inexpensive and an excellent first approach to dealing with potentially threatening pond heights.

![Diagram of a beaver deterrent](image)

**Construction Details: Beaver Deterrent**

(View looking upstream from below dam)

- **Metal T-Posts** (6-8 FT)
- **White Sheet**
- **Wire**
- **Cut Notches in Sheet**
- **~ 2FT**
- **~ 1-2in**
- **Beaver Dam**
- **DAM NOTCHED**
- **Beaver Dam**

**Construction Notes**

1. Notch dam to desired pond level height.
2. Pound 6-8 ft. metal fenceposts just upstream of dam notch. Fencepost length depends on depth of pond/height of dam.
3. Attach 11-gauge or baling wire between the tops of fenceposts.
4. Affix white sheet or Tyvek house wrap to wire between fenceposts ~1-2 inches above pond water level. Clamps, clothespins, or sewing a sleeve can all be used to attach the sheet to wire.
5. Cut slits into the sheet spaced ~2ft.

*Figure 10 – Schematic of a beaver deterrent used to control pond height.*

Install Pond Leveler to Control Pond Height

Pond levelers are another way managers and land owners can mitigate the risk of flooding due to beaver activity while allowing beaver to remain in a given area. Pond levelers installation typically requires a half-day of labor for 2-3 people and materials cost approximately $600 – 1000 depending on site-specific conditions. A pond leveler consists of a flexible, perforated plastic pipe that has an inflow protected by a large metal cage and is anchored to the bottom of the pond, and runs through the dam, and is set at the desired water level height. It may be necessary to notch the dam in order to set the pipe at the desired pond height. Following installation, we recommend placing additional material over the end of the pipe in order to prevent beaver from clogging the outflow. Examples of a pond leveler installation performed by Anabranch Solutions personnel are shown in Figure 11.
Figure 11 – Pond leveler installation. From left: securing flexible pipe in cage to protect inflow from being clogged; placing pipe into beaver pond; rebuilding beaver dam after setting pipe into notched dam at desired water height.

Beaver Deterrent to Prevent Culvert/Irrigation Diversion Clogging

As shown above beaver deterrents (Figure 10) can be used pre-emptively in order to prevent beaver from becoming active in areas that are determined to be high risk. In Grouse Creek, we recommend using beaver deterrents where streams are diverted for irrigation.
Figure 12 – A conservative estimate of where potential conflicts between beaver activity and human infrastructure, based solely on proximity to roads, infrastructure, stream crossings, etc.
BUILDING A BEAVER DAM ANALOGUE – DAY 1

COMPLEX 1 - ROCK CREEK – NEAR HATTY GULCH & IRRIGATION DIVERSION (MAINSTEM)

On day one of the workshop, our first activity will be to have participants build post-assisted BDAs according to the traditional recipe (i.e. post line, with wicker weaver). We will do this in an area with successful beaver activity already and in attempt to attract the beaver upstream from an existing beaver dam that is interfering with the design of recent restoration efforts to build a new irrigation diversion structure into the canal. We will notch their existing dam and install a beaver deterrent (Figure 22). The BDAs as part of this complex will promote the expansion of riparian area and hopefully encourage opportunistic beaver to focus their activities further upstream (Figure 13).

Figure 13 – Aerial oblique photo of Rock Creek looking downstream showing location of and extent of complex 1.

NOTES
Safety
Partnering with Beaver in Restoration Design

Summary
Projects that 'partner with beaver' often take place in remote settings, where definitive care is not immediately available. Implementing stream restoration projects incorporates risks of working with traditional hand and power tools, such as shovels, loppers, chainsaws and hydraulic post pounders, with risks unique to working in stream environments. This section addresses safety concerns that need to be addressed for all restoration projects.

Equipment
- Hard hats
- Ear protection
- Eye protection
- Gloves
- Chaps (chainsaw operator and swampers)
- Waders

Construction Hazards
- Post driver weight ~ 90 lbs
- Many people working in small area

Stream Hazards
- Swift and/or deep water during high flow conditions
- Steep, unstable banks
- Poor footing
- Introduced tripping hazards

Managing Risk
- Pre-project and daily safety meetings
- Proper Personal Protective Equipment (PPE)
- Project foreman/safety officer to provide oversight
- 3-4 people are necessary to safely operate the post-pounder
- DO NOT lift post-driver above your shoulders
- All chainsaw operators must have proper training
- Ensure that medically trained personnel are on-site

Many agencies have their own safety procedures, trainings and certifications. Be familiar with agency-specific requirements.

Limiting the number of people working on any structure reduces the chances of an accident.
### Atlas Copco

**Brand:** Atlas Copco  
**Cost:** $9000

**Minimum Crew:** 2  
**Maximum Post Diameter:** 3.8

**Driver**  
Type: Hydraulic  
Weight lbs.: 75  
Example Model: LPD-T HBP

**Power Supply**  
Type: Gas Generator  
Weight lbs.: 250  
Example Model: LP-13-30 P

**Application**
Largest and most powerful system that has worked in most situations. Can be challenging to move in heavily vegetated or steep systems.

**Comments**
in larger streams a cheap plastic canoe ($100) can be used to transport the system and posts downstream; Larger tires and handles can also be added to the power pac to make it easy to move/carry

**URL** [https://www.atlascopco.com/en-us](https://www.atlascopco.com/en-us)

### Skidrill

**Brand:** Skidrill  
**Cost:** $5000

**Minimum Crew:** 2  
**Maximum Post Diameter:** 4

**Driver**  
Type: Hydraulic  
Weight lbs.: 70  
Example Model: HP 20

**Power Supply**  
Type: Gas Generator  
Weight lbs.: 100  
Example Model: P38

**Application**
Will drive most posts in most situations except in difficult situations such as large embedded cobble and hard clay

**Comments**
in larger streams a cheap plastic canoe ($100) can be used to transport the system and posts downstream; Larger tires and handles can also be added to the power pac to make it easy to move/carry

**URL** [http://skidril.com](http://skidril.com)
### BDA Post Pounder Summary

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<th>Brand</th>
<th>Cost</th>
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<tr>
<td><strong>Rhino</strong></td>
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**Driver**
- Type: Pneumatic
- Weight lbs.: 50 - 100
- Example Model: PD 55

**Power Supply**
- Type: Compressor
- Type: None

**Application**
- Pneumatic units require air compressor

**Comments**
- We have not used these but could be useful in some situations such as with larger posts in easy access situations.

**URL** [https://www.airpostdrivers.com/air-post-driver-parts.htm](https://www.airpostdrivers.com/air-post-driver-parts.htm)

<table>
<thead>
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<th>Cost</th>
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</table>

**Driver**
- Type: Gas
- Weight lbs.: 40
- Example Model: Redi Classic

**Power Supply**
- Type: Gas Engine
- Type: None

**Application**
- Good for small projects in relatively easy situations; very portable but does NOT have the power for difficult sites or driving hundreds of post/day

**Comments**
- Handy for T-posts and maintenance of structures.

**URL** [https://redidriver.com/all-about-redi-driver-inc/](https://redidriver.com/all-about-redi-driver-inc/)
### BDA Post Pounder Summary

<table>
<thead>
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<table>
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**Application**

*Good for tough jobs when road access is available*

**Comments**

**URL** [http://www.kencove.com/fence/Post+Drivers_products.php](http://www.kencove.com/fence/Post+Drivers_products.php)
POST-ASSISTED BEAVER DAM ANALogue RECIPE

For more information on BDAs, see:
- Chapter 11 – Beaver Dam Analogues of Design Manual

Cross Section View
(Generic BDA Structure)

Plan View
(Convex Primary Dam)

Figure 13 – One of the original BDA figures (drawn by Nick Weber)

Ingredients:
- Untreated wooden fence posts (as many as needed to space 30 – 50 cm apart and staggered)
- Willow weave material (long (i.e. > 1 m), limbed branches of ¼” to 2” diameter willow branches
- Cobble, gravel, sand and mud

Instructions:
1. Decide location of BDA dam crest, configuration (e.g. straight or convex downstream), and crest elevation (use landscape flags if necessary). Position yourself with your eye-level at proposed crest elevation of dam (make sure it is < 1.5 meters in height), and look upstream to find where the pond will backwater to. Adjust crest elevation as necessary to achieve desired size of pond, inundation extent, and overflow patterns. If concerned about head drop
over BDA, build a secondary BDA downstream with a crest elevation set to backwater into base of this BDA (and lessen head drop or elevation difference between water surface in pond and water surface downstream of BDA).

2. Install posts with hydraulic post pounder into stream bed and banks in configuration as shown.

3. Trim (with chainsaw) posts to level, desired crest elevation

4. Weave willow branches in between the posts across the channel. Pack stream substrate from area to be ponded against upstream face of dam to ‘plug’ up.

5. Work a willow mattress (laying branches parallel to flow) into dam on downstream side and build to provide energy dissipation to overtopping flows.

6. If desired and time permits, attempt to plug up BDA with mud and organic material (small sticks and turf) in order to flood pond to crest elevation. Optionally, you can leave this for maintenance by beaver or for infilling with leaves, woody debris and sediment.

Notes

- Resist the temptation to overbuild the BDA.
- A BDA that ‘breaches’ or ‘blows out’, just like natural beaver dams do, is not a ‘failure’ if you’ve designed to accommodate such a response. Often, BDAs that blow out or breach provide improved and more complex habitat.
- Design life: < 1 year (note actual life may last many years or even decades).

OTHER DIAGRAMS OF BDAS

These are from Chapter 6 of the Beaver Restoration Guidebook:
https://www.fws.gov/oregonfwo/Documents/2018BRGv.2.01.pdf
Figure 14 – Part of Figure 26 from Beaver Restoration Guidebook… Showing BDA as a wall. Figure 26 from Pollock et al. (2018).
Figure 28: Side view of beaver dam analogues designed to aggrade a bed within an incision trench. (top) Year one placement. The downstream BDA backs up water to the upstream BDA, forming a water “pillow” that helps prevent overtopping scour below the upstream structure. Willow branches can be placed parallel to the stream flow on the downstream side of a BDA to help reduce scour. The post should be placed deep enough in the ground to prevent structure failure as a result of downstream scour, although multiple posts woven together with willows can hold some scourcd posts in place. (bottom) After sediment accumulates and aggradation occurs upstream of the BDAs, another round of BDAs is placed upstream of the existing BDAs, on the aggraded bed. Placement should be upstream such that the downstream sediment scourcd is deposited against the BDAs installed in Year One; this helps to reinforce and strengthen the BDAs. The process can be repeated until the stream bed has aggraded sufficiently to reconnect it to its former floodplain.

Figure 15 – Example of staged, implementation of BDAs on top of an old BDA complex once the ponds aggrade. Figure 28 from Pollock et al. (2018).
Figure 16 – There are lots of ways to drive posts into a streambed, but hydraulic assistance is typically used. Hand operated post pounders like we use in this workshop are far lower impact and don’t require a track-mounted excavator or backhoe with access. In addition to the downsides of riparian and instream disturbances, there can be a tendency to over-build and ‘over engineer’ with too much focus on ‘structure stability’ presumably by using larger material posts. Figure 27 from Pollock et al. (2018).

Figure 27: Hydraulic post pounder options. Options include, clockwise, starting from upper left: (a) a hand-held pounder attached to hydraulic power pack, (b) a post pounder attached to bulldozers, (c) a handheld pneumatic post pounder attached to an excavator and (d) a modified excavator with a vibrating pad. Options (a) and (b) take approximately 5 to 10 minutes per post, depending on substrate, and it can be difficult to get to the desired depth. Option (d) takes less than 1 minute per post and can drive posts as deep as needed. All pounders have a metal cylindrical cap that holds the post in place while pounding. Each option has pros and cons to consider, including cost, maximum depth the posts can be pounded, substrate type, operator strength and expertise, and the amount of likely riparian and instream disturbance. Photo credits: (a) Nick Weber, Ecological Research, (b) Mark Cookson, USFWS, (c) Peter Thamer, Siskiyou County Resource Conservation District, and (d) Julie Ashmore, Okanogan Highlands Alliance.
Asotin IMW Overview

**Focal Species:** Steelhead trout (bull trout and Chinook likely to benefit too)

**Limiting factors:** Riparian condition, habitat complexity, floodplain connectivity, temperature

**Restoration strategy:** protect/restore riparian in long-term; add LWD in short-term to promote creation of habitat complexity, interaction between channel and floodplain

Experimental Design

Asotin IMW study includes the lower 12 km of Charley Creek, North Fork, and South Fork of Asotin Creek. Hierarchical-staircase design where one 4 km section of stream was restored each year from 2012-2014. An additional treatment was applied in 2016 to increase the area restored.

Monitoring Approach

Within each restoration and control Section we are PIT tagging juvenile steelhead to estimate abundance, growth, movement, survival, and smolt production. We are also monitoring fish habitat, invertebrates, discharge, and temperature across the watershed. WDFW operate fish-in fish-out monitoring for the entire Asotin mainstem.

Experimental and monitoring design. Locations of fish and habitat sample sites, PIT tag arrays, discharge and temperature sites, smolt trap and adult weir.

Restoration Approach

Hand built low cost wood structures at high density, using logs held in place with wooden fence posts driven into the streambed with a post driver. This approach was applied to protect the recovering riparian areas, reduce costs, and increase applicability to steelhead streams.
Asotin IMW Washington – Accomplishment Report

**Restoration Accomplishments**
- 39% of study area restored (14/36 km)
- installed 658 LWD structures in 14 km
- 4.8 structures/100m

**Riparian/Habitat/Floodplain Responses**
- ~70% of riparian fenced/protected
- significant increase in LWD, pool, habitat diversity
- limited floodplain connection due to below average floods from 2012-2016

**Fish Population Responses**
- seasonal estimates of abundance, growth, movement, survival, production, and productivity
- 26% increase in abundance across study area

**Future Direction**
- validate estimates of smolts/spawner and NREI capacity estimates pre and post treatment section
- determine factors that cause variation in population parameters
- model carrying capacity using net rate of energy intake
- develop IMW specific life cycle model
- develop tools to extrapolate Asotin IMW results to other similar watersheds
THE ISSUE

Throughout the Columbia Watershed, habitat for steelhead trout has been simplified and degraded. In streams where high volumes and densities of large woody debris (LWD) once forced numerous pools and bars and provided critical predation and energy refugia, highly simplified channels dominated by armored substrate and homogenous planebeds are now the norm. Although restoration efforts for the past thirty years have focused on adding LWD back into streams to promote complexity, many of these efforts are over-engineered, lack an appreciation of fluvial processes that recruit and rework wood in streams, and are so expensive that only short reaches (i.e. <0.5 km) are typically treated. Given the threats limiting steelhead production, the widespread simplification and degradation of their habitats, and the chronically low levels of LWD left in these streams we urgently need more cost-effective ways of getting LWD back in streams and letting the streams do the work to maintain these conditions.

BACKGROUN

The Asotin Intensively Monitored Watershed (IMW) in the southeastern corner of Washington (Map 1) is part of a larger group of IMWs throughout the Pacific Northwest with the broader goal of testing the effectiveness of stream restoration at increasing the production of salmon and steelhead. Data gathered from the Asotin IMW will be used to improve planning and implementation of restoration in other similar watersheds. We are adding high densities of large woody debris (HDLWD) to tributaries of Asotin Creek because wood can help create pools and other habitats required by salmon and steelhead. Since 2008, 400 LWD structures have been added within 12 km of stream length to maximize our ability to detect if the production of steelhead increases. The project will run through 2018 and involve a total of 600 LWD structures to capture the life cycle of several generations of steelhead.

APPROACH

We are using a non-invasive, inexpensive method to add wood at high densities to Asotin Creek. Logs and branches left over from nearby timber harvest operations are being placed in the creek and temporarily held in place with wooden fence posts that are driven into the streambed with a hydraulic post driver (Figure 1). HDLWD structures are placed to invoke specific hydraulic and geomorphic responses, which carve forced pools, promote forced bars and build riffles. A high density of structures are built so that if a structure is mobilized by a flood, the LWD from that mobilized structure has a high probability of accumulating on other intact structures downstream, hence maintaining a high degree of habitat heterogeneity within the treatment reach. This restoration method also promotes regular exchanges with the adjacent riparian forest by creating new surfaces to be colonized by riparian vegetation and recruiting wood from the existing riparian forest.

KEY QUESTIONS

- Can we develop inexpensive techniques for getting HDLWD back into these streams?
- Will restoring HDLWD in these streams kick start self-sustaining fluvial processes, which will maintain high-quality fish habitat and increase the production of wild steelhead?

Figure 1. Top Photos: Wooden posts are driven into the streambed to hold logs and branches in place long enough to create fish habitat. Bottom photo: Wood structures help to create new pools, fish cover, spawning areas, and resting places for steelhead and other species. Wood will naturally fall into the streams as the riparian forests bordering the creeks mature.
Cheap & Cheerful Steelhead Restoration with HDLWD: Asotin Creek IMW

RESULTS & DISCUSSION

After installing over 400 structures we have documented increases in pools, spawning areas, and fish cover. Observations during spring floods also indicate the structures are providing energy refugia for young steelhead to rest from fast water. Determining if restoration is increasing steelhead production in Asotin Creek has just begun and data will be reported annually from 2013 to 2018.

TAKE AWAY

• HDLWD structures are a cheap alternative to traditional methods of installing LWD (e.g. engineered large woody debris) in streams and is cheerful in that it appears effective at invoking the desired physical habitat responses.
• Within a few flood events of adding LWD to Asotin Creek, the amount and the quality of pools, spawning areas, and fish cover have all significantly increased.
• Ongoing monitoring efforts will be compared with intensive monitoring of steelhead populations and habitat from five years prior to the restoration that began in 2008 to determine how steelhead production changes.

FOR MORE INFORMATION:

etalfhc.org or scan this QR Code with your phone

The mission of the ET-AL lab is to illuminate and understand ecogeomorphic feedbacks and dynamics in rivers and streams through state-of-the-art monitoring and modeling analyses. To learn more about us, visit etaljoewheaton.org

Citation: Asotin Intensively Monitored Watershed ET-AL Factsheet: Ecogeomorphology & Topographic Analysis Laboratory, Utah State University, Logan, UT. Available at: http://etal-fhc.org.
ISEMP and CHAMP PRODUCT SUMMARY

Bridge Creek Intensively Monitored Watershed

RESTORATION EFFECTIVENESS OF BEAVER DAM ANALOGS AND BEAVERS TO RECOVER INCISED STREAMS

PROJECT DESCRIPTION

Beaver have been referred to as ecosystem engineers because of the large impacts their dam building activities have on the landscape; however, the benefits they may provide to fluvial fish species have been debated. We conducted a watershed-scale experiment to test how increasing beaver dam and colony persistence in a highly degraded incised stream affects the freshwater production of steelhead (Oncorhynchus mykiss). Four years after the installation of beaver dam analogs (BDAs), we observed a 168% increase in the density, a 52% survival, and a 172% in production of juvenile steelhead without impacting upstream and downstream migrations. The steelhead response occurred as the quantity and complexity of their habitat increased (Figure 1). This study is the first large-scale experiment to quantify the benefits of beavers and BDAs to a fish population and its habitat. Beaver mediated restoration may be a viable and efficient strategy to recover ecosystem function of previously incised streams and to increase the production of imperiled fish populations. Further monitoring is needed to see if these benefits are long-term or if they start to change the environment in favor of native (e.g., dace and suckers) and non-native fishes (e.g., smallmouth bass) other than steelhead. Also, while we are seeing recruitment of willow and cottonwood, exotic vegetation such as reed canary grass, which is also quite prevalent in Bridge Creek, could expand as ponds mature into wet meadows.

QUICK FACTS

POC: Nick Bouwes, Eco Logical Research
Development Team: Nick Bouwes, Chris Jordan, Michael Pollock, Carol Volk, Joe Wheaton, Nick Weber, Gus Wathen, Jake Wirtz
Status: Current Status- Application.
September 2017 status- Application/Analyses
Funding source: ISEMP

Figure 1. Expected changes following the installation of beaver dam analogs (BDAs). Beaver-made dams and BDAs slow and increase the surface height of water upstream of the dam. Beaver ponds above, and plunge pools below dams change the plane bed channel to a reach of complex geomorphic units providing resting and efficient foraging opportunities for juveniles. Deep pools allow for temperature stratification and greater hydraulic pressures forcing downwellings to displace cooler groundwater to upwell downstream, increasing thermal heterogeneity and refugia. Dams and associated overflow channels produce highly variable hydraulic conditions resulting in a greater diversity of sorted sediment deposits. Gravel bars form near the tail of the pond and just downstream from the scour below the dam, increasing spawning habitat for spawners and concealment substrates for juveniles. Complex depositional and erosional patterns cause an increase in channel aggradation, widening, and sinuosity and a decrease in overall gradient, also increasing habitat complexity. Frequent inundation of inset floodplains creates side channels, high-flow refugia and rearing habitat for young juveniles, and increasing recruitment of riparian vegetation. Flows onto the floodplain during high discharge dissipates stream power, and the likelihood of dam failure. The increase in pond complexes and riparian vegetation increases refugia for beavers, their food supply and caching locations, resulting in higher survival, and more persistent beaver colonies. Beaver will maintain dams and the associated geomorphic and hydraulic processes that create complex fish habitat.
This project has developed a novel and relatively inexpensive restoration approach to greatly improve salmon and steelhead habitat in incised streams. The number of miles of incised streams is enormous and therefore having a restoration approach that costs order(s) of magnitude less per mile, in part because beavers do much of the work, could be a very important tool in the recovery of listed salmonid species. Based on the results of Bridge Creek, this restoration approach has been widely implemented and is now being tested in several other degraded streams beyond incised conditions. While the restoration approach appears to provide many benefits shortly after restoration, the long-term benefits still need to be quantified as these effects are far more uncertain.


With ‘Cheap and Cheerful’ restoration, where you are working with fluvial and ecological processes, we always advocate using Adaptive Management. For an overview of affordable adaptive management options, see: http://www.anabranchsolutions.com/adaptive-management.html

In Bouwes et al. (2016) we lay out our vision for how adaptive management can move beyond something only the biggest projects with the healthiest budgets can afford, to something we can and should as routine practice on almost every restoration project.


EXAMPLES OF ADAPTIVE MANAGEMENT PLANS

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ROCK CREEK – NRCS PARTNERING WITH BEAVER IN RESTORATION DESIGN WORKSHOP - PILOT / DEMONSTRATION RESTORATION

SUPPLEMENT TO
STREAM BED ALTERATION PERMIT APPLICATION

Prepared by:
Joe Wheaton & Scott Shahverdian

Department of Watershed Sciences, 5210 Old Main Hill, Logan, UT 84322-5210

Prepared for:
The Nature Conservancy Idaho & Wood River Land Trust

May 2018
**Recommended Citation:**

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## CONTENTS

List of Figures ................................................................................................................................................................ 4

Background & Purpose .................................................................................................................................................. 6
  Rock Creek Restoration ........................................................................................................................................ 7

Proposed Pilot / Demonstration Complexes .................................................................................................................. 7
  Structure Types ........................................................................................................................................................ 9
    Post-Assisted ...................................................................................................................................................... 10
    Woody Debris Structures .................................................................................................................................... 11
    Postless Structures ............................................................................................................................................. 12

Complex Locations .................................................................................................................................................. 17
  Complex 1 - Rock Creek – Near Hatty Gulch & Irrigation Diversion (Mainstem) .................................................... 19
  Complex 2 - Smith Creek (Perennial Tributary) ...................................................................................................... 19
  Complex 3 - Rock Creek @ East Fork & West Fork Confluence ............................................................................. 20
  Complex 4 - West Fork Rock Creek ........................................................................................................................ 21
  Complex 5 - Ephemeral Tributary to West Fork Rock Creek ................................................................................... 21

Existing Conditions ...................................................................................................................................................... 22
  Riparian Conditions ................................................................................................................................................. 22
  Ability to Support Dam Building Activity by Beaver .................................................................................................. 25

Adaptive management ................................................................................................................................................ 27
  Monitoring............................................................................................................................................................. 27
  Management Options to mitigate undesirable impacts of constructed structures ................................................. 27
  Management Options to mitigate nuisance beaver problems ................................................................................. 29
    Living with Beaver Strategies .............................................................................................................................. 30

Recommended Future Work ........................................................................................................................................ 33

References ................................................................................................................................................................... 34
LIST OF FIGURES

Figure 1 – Picture of NRCS Workshop in Southeast Idaho where workshop participants are building beaver dam analogues. All the proposed work will be done by hand, with hand-tools and the manual labor of workshop participants. ....................................................................................................................................................................................... 6

Figure 2 – Example conceptual cartoon of a ‘complex’ and how multiple structures designed to achieve different specific objectives are intended to work in concert with each other to function as a ‘unit’. .............................................................................................................................................. 8

Figure 3 – Example of a BDA ‘complex’ consisting of three structures, with a larger primary dam at the top, and two secondary dams downstream, which both extend the forage range for beaver that might colonize and use the complex, but also reduce the head drop upstream and downstream of the primary dam, by backing water up from the secondary dams to the primary dam. .............................................................................................................................................. 9

Figure 4 – A ‘text-book’ example of a post-assisted BDA from the Crooked River in Oregon. The main post line was installed first, then local juniper and willow were woven between the posts, and the dam was packed up with local mud, turf and branches. An overflow ‘matress’ of material on the downstream side is built to dissipate the energy of water flowing over the top of the crest of the dam. The constructed crest-elevation was designed to just barely engage with the floodplain (i.e. at bankfull), but the posts were cut to a crest elevation roughly 12” higher so that if beaver built on-top of the structure this ‘suggested’ crest elevation could be realized and spread across the entire floodplain. .............................................................................................................................................. 10

Figure 5 – Photos from another workshop showing installation of post assisted BDAs and the mix of hand labor and hand tools (shovels, buckets, loppers) used to construct the structures. A major advantage of this approach is the minimal impact it has on adjacent riparian area because heavy-equipment is not needed or used. Plus, when only hand-labor is used, there is only so much material that tends to get moved, thereby limiting the potential for damage that might be made by poorly informed design decisions combined with the mechanical ease of using heavy equipment. .............................................................................................................................................. 11

Figure 6 – Examples of simple large woody debris structures, where the wood additions are temporarily pinned or anchored with posts, versus just seeded (and allowed to be recruited by high flows in lower right). These structures function very differently based on the their position (bank attached, mid-channel or channel spanning) and the context in which they are placed. They can be very effective at helping promote hydraulics and geomorphic processes that lead to creation and maintenance of better pool and bar habitat, as well as inset floodplain development. They are also effective for promoting recruitment of wood and sediment from local bank sources...................................................................................................................... 12

Figure 7 – The above is an example of a postless BDA (built to a crest elevation where the red line is shown), that was built in Idaho by a workshop, and beaver colonized the structure within a week and two months later (at time of photo) they had raised the crest elevation over a meter and expanded the dam to a valley-bottom wide dam (see also BDA-1 in Figure 8). .................................................................................................................................................................. 13

Figure 8 – The above illustrates how quickly and dramatically a BDA complex (in this example a postless one) can colonize BDAs, and dramatically alter the residence time of water, sediment and wood and create a rich and diverse riparian and instream habitat). .................................................................................................................................................................. 14

Figure 9 – Some of the most effective and efficient structures are those that can be built, quickly, simply and cheaply with entirely locally sourced materials (in the above example juniper, sage brush and mud), but can invoke the hydraulic and geomorphic responses intended by the designer to promote floodplain connectivity and creation of more complex and resilient habitats. In the example above, a postless BDA was built with juniper, sage brush and mud, and within one season accumulated over a meter of sediment behind it, effectively forced floodplain connectivity in flows that would not have gone overbank, raised water tables, and diversified in-channel hydraulics. .................................................................................................................................................................. 15

Figure 10 – In some instances, structures are specifically designed to promote bank erosion by either creating a convergent jet of flow towards an outside bank (e.g. bank blasters) or promoting dam or debris jam bank erosion by...
‘end-cutting’. We don’t consider this structural ‘failure’ when this is precisely the design intent of the geomorphic processes we are promoting. 

Figure 11 – In the case of incised channels, BDAs are now regularly used to promote channel aggradation and floodplain reconnection. Interestingly, we do this by accelerating the natural process of incised channel evolution recovery, which involves a critically important widening phase. The widening phase involves eroding the trench banks to both source local sediment and create accommodation space for that material to deposit new inset floodplains. See Pollock et al. (2014) for fuller description. In many cases, we’ve seen this accelerated recovery sped up by mimicking beaver activity take place in months to years instead of decades to centuries.

Figure 12 – Locations of proposed complexes to be built as part of workshop. The stream network shows (largely in yellow) reflects a preliminary output of the beaver dam capacity model withing in BRAT (http://brat.riverscapes.xyz) based on LANDFIRE data from 2014 (before the grazing management has changed). It shows a largely low capacity (i.e. yellow or occasional dams at 1-4 dams per kilometer) based on what at the time LANDSAT detected as very minimal riparian vegetation. Riparian vegetation has subsequently recovered and we see a much higher capacity to support dam building activity.

Figure 13 – Aerial oblique photo of Rock Creek looking downstream showing location of and extent of complex 1. 

Figure 14 – Aerial oblique photo of Smith Creek looking downstream and showing extent of complex 2. 

Figure 15 – Aerial oblique photo of East fork and West Fork Rock Creek confluence (looking upstream) and showing approximate locations and extents of proposed complexes 3, 4 and 5. 

Figure 16 – A preliminary run of RCAT (http://rcat.riverscapes.xyz) riparian vegetation departure, which estimates the degree of riparian vegetation loss in the valley bottom. In this example, it shows riparian departure as of 2014, as compared with LANDFIRE estimates of pre-European settlement vegetation conditions. This does not reflect the important gains in riparian vegetation that have taken place from 2014 to 2018.

Figure 17 – The above RCAT output attempts to contextualize the riparian vegetation losses in Figure 16 based on the type of conversion from riparian vegetation to what. The majority of the watershed shows up with conversion to grass/shrubland reflecting the grazing land use and loss of riparian vegetation replaced by grasses and shrubs. Some of the irrigated pasture valley bottoms along the mainstem show conversion to agriculture.

Figure 18 – Preliminary estimates from BRAT of historic capacity to support dam building activity by beaver were pervasive throughout most of the watershed (note that green line paralleling mainstem is an irrigation canal). 

Figure 19 – Example of the suggested evaluation of complexes in response to monitoring as part of adaptive management (from Bouwes et al. (2016a)). 

Figure 20 - Example of the specific evaluation of individual structures in response to monitoring as part of adaptive management (adapted from Bouwes et al. (2016a). Notice that if any harm is detected, we can remove the structures. (BDSS was an old acronym of beaver dam support structure and is synonymous with BDA).

Figure 21 – Flow chart illustrating a monitoring and evaluation protocol for potential risk posed by beaver activity. Chart highlights decisions and evaluations in diamonds, and recommends management actions in CAPITALS. 

Figure 22 – Schematic of a beaver deterrent used to control pond height. 

Figure 23 – Pond leveler installation. From left: securing flexible pipe in cage to protect inflow from being clogged; placing pipe into beaver pond; rebuilding beaver dam after setting pipe into notched dam at desired water height.
BACKGROUND & PURPOSE

A partnership between the Sage Grouse Initiative, the Natural Resource Conservation Service, Pheasants Forever, and the Working Lands for Wildlife programs, resulted in a four state workshop series planned for the summer of 2018, where five workshops will focus on how to use beaver and beaver dam analogues (BDAs) as low-cost tools to restore riparian areas to benefit wildlife and working lands (see: http://beaver.joewheaton.org/2018--nrcs-pf-sgi.html). The first of these workshops will be hosted by the Nature Conservancy and the Rock Creek Ranch will be used as the field site to demonstrate the application of these design principles to workshop participants. This will be carried out on June 20-21, 2018, and participants will learn design and construction principles associated with a mix of using and implementing beaver-assisted and beaver-mimicked restoration techniques as well as other low-cost restoration techniques (http://beaver.joewheaton.org/nrcs--idaho.html). Over the field portion of the two-day workshop, participants will construct a mix of different types of hand-built instream structures in four contrasting localities within the Rock Creek watershed. Specifically, the 30+ participants will break into groups of roughly 10 participants each, and rotate through stations where they design and build structures. A total of 20 to 30 structures will be built as part of five complexes of structures. Two of the complexes will be on the mainstem of Rock Creek (at two discrete locations). Two of the complexes will be on two separate perennial tributaries to Rock Creek. One of the complexes will be on a dry, ephemeral tributary. The individual structure designs will be completed in the field by workshop participants as part of the training (with supervision by experienced design professionals).

The purpose of this document is to outline the proposed restoration actions to take place as part of a two-day training workshop. The purpose of the proposed structures in this streambed alteration permit application is to illustrate the application of a variety of ‘cheap and cheerful’ (see: http://www.anabransolutions.com/cheap--cheerful-restoration.html) restoration techniques to workshop participants, in a variety of different settings in Rock Creek (e.g. mainstem of Rock Creek vs. perennial and ephemeral tributaries). In the context of the broader management of
Rock Creek Watershed, this pilot or demonstration project will compliment both past and planned future restoration efforts (see below), but these structures alone are expected to only have highly localized benefits in the reaches they are installed. A later permit application as part of a broader restoration and planning effort will use the lessons learnt from this pilot project to expand the effort to appropriate areas throughout the watershed.

ROCK CREEK RESTORATION

A variety of discrete restoration efforts have already taken place in the Rock Creek Ranch by the Nature Conservancy, the Wood River Land Trust and other partners. These efforts were intended to address specific localized problems along the creek associated with excessive bank erosion, and repair/improvement of irrigation diversions and some creek crossings. In addition, a progressive grazing management plan has been undertaken, which is already leading to dramatic improvements in riparian condition and health. Broadly speaking, the overall Rock Creek restoration efforts are intended to improve overall ecosystem health with specific improvements in range health, riparian health and instream habitat conditions. More fundamentally, the overall management is geared towards demonstrating how responsible grazing management and stewardship can promote the co-existence of productive, working ranch lands with thriving wildlife and ecosystems. Specific species of management concern include sage grouse, which need both health sage-brush uplands, as well as wet-meadow mesic habitats (e.g. riparian areas) to provide critical brood-rearing habitat. In addition, the intent is to develop a ranch-wide conservation, restoration and grazing management plan to effectively realize these goals.

PROPOSED PILOT / DEMONSTRATION COMPLEXES

We refer to a ‘complex’ as a collection of structures designed to work in concert with each other. The term is borrowed from natural beaver dam complexes, which typically have one primary dam (a larger dam to provide cover for the main lodge, and space for a food cache) and between 1 and up to 15 secondary dams (that act to extend their forage range, increase protection from predation and promote resilience to damage from floods). For this demonstration project, we are proposing five complexes (described below), which will have between three and ten structures each. All structures will be built by hand in the field with local materials. A hand-carried hydraulic post pounder will be used to construct ‘post-assisted’ structures for two of the complexes on the mainstem of Rock Creek. The other three complexes will consist of ‘postless’ structures built entirely by hand and with entirely locally sourced building materials (wood, turf, sediment) to make a robust ‘carbon-fiber’ matrix.
Figure 2 – Example conceptual cartoon of a ‘complex’ and how multiple structures designed to achieve different specific objectives are intended to work in concert with each other to function as a ‘unit’.
Figure 3 – Example of a BDA ‘complex’ consisting of three structures, with a larger primary dam at the top, and two secondary dams downstream, which both extend the forage range for beaver that might colonize and use the complex, but also reduce the head drop upstream and downstream of the primary dam, by backing water up from the secondary dams to the primary dam.

STRUCTURE TYPES

Part of the purpose of the workshop is to expose participants to a variety of structure types and construction techniques intended to achieve different objectives. While the overall function of a complex might be the same ‘plan’, the individual details of how the structures are built, what materials are used can vary significantly (just as they do with natural beaver dams). We propose different structure types to highlight the tradeoffs in cost, construction time, effectiveness and impacts. Below we briefly illustrate some of the structure types we may use.
**Post-Assisted**

The term beaver-dam analogue (BDA) was coined in combination with the Bridge Creek Intensively Monitored Watershed project in Central Oregon (Pollock *et al*., 2014; Bouwes *et al*., 2016b). It was meant as a catch-all term for a variety of channel-spanning structures that are built to mimic the functionality of natural beaver dams. Our first generation of BDAs were primarily built with untreated wooden fence posts to act as a temporary anchor, and then woody material woven through the posts to create the structure. Many different variations of this recipe have since been experimented with.

![Image](image_url)

**Figure 4** – A ‘text-book’ example of a post-assisted BDA from the Crooked River in Oregon. The main post line was installed first, then local juniper and willow were woven between the posts, and the dam was packed up with local mud, turf and branches. An overflow ‘matress’ of material on the downstream side is built to dissipate the energy of water flowing over the top of the crest of the dam. The constructed crest-elevation was designed to just barely engage with the floodplain (i.e. at bankfull), but the posts were cut to a crest elevation roughly 12” higher so that if beaver built on-top of the structure this ‘suggested’ crest elevation could be realized and spread across the entire floodplain.
BDA CONSTRUCTION

Figure 5 – Photos from another workshop showing installation of post assisted BDAs and the mix of hand labor and hand tools (shovels, buckets, loppers) used to construct the structures. A major advantage of this approach is the minimal impact it has on adjacent riparian area because heavy-equipment is not needed or used. Plus, when only hand-labor is used, there is only so much material that tends to get moved, thereby limiting the potential for damage that might be made by poorly informed design decisions combined with the mechanical ease of using heavy equipment.

Woody Debris Structures

We may install a few simple woody debris structures as part of some of the complexes. These structures can be built with or without posts (in case of those with posts, we call them PALS – post assisted log structures). A few examples are shown from structures we built in Asotin Creek, Washington in Figure 6 (Bennett et al., 2012; Camp, 2015).
Figure 6 – Examples of simple large woody debris structures, where the wood additions are temporarily pinned or anchored with posts, versus just seeded (and allowed to be recruited by high flows in lower right). These structures function very differently based on the their position (bank attached, mid-channel or channel spanning) and the context in which they are placed. They can be very effective at helping promote hydraulics and geomorphic processes that lead to creation and maintenance of better pool and bar habitat, as well as inset floodplain development. They are also effective for promoting recruitment of wood and sediment from local bank sources.

Postless Structures

Not all structures need to be built with posts. In fact, natural beaver dams are made in a huge diversity of settings with a huge diversity of onsite materials. We started experimenting with BDAs that don’t require posts as this greatly expands the areas in which BDAs can be built (not needing to carry post pounder around), and decreases the need for off-site materials (e.g. untreated wooden fence posts at $2.50 to $8.00 a post). We have seen postless BDAs can be every-bit as stable and even more effective than post-assisted structures. Using posts to assist in building a BDA still may be desirable in areas with higher stream power and where the ability of the dams to withstand blowouts during typical floods is a concern.
Figure 7 – The above is an example of a postless BDA (built to a crest elevation where the red line is shown), that was built in Idaho by a workshop, and beaver colonized the structure within a week and two months later (at time of photo) they had raised the crest elevation over a meter and expanded the dam to a valley-bottom wide dam (see also BDA-1 in Figure 8).
A POSTLESS EXAMPLE...

- September 2016 – NRCS Class builds 4 postless BDAs
- October 2016 – 6 more beaver introduced
- By November, they remodeled...

Figure 8 – The above illustrates how quickly and dramatically a BDA complex (in this example a postless one) can colonize BDAs, and dramatically alter the residence time of water, sediment and wood and create a rich and diverse riparian and instream habitat.)
Figure 9 – Some of the most effective and efficient structures are those that can be built, quickly, simply and cheaply with entirely locally sourced materials (in the above example juniper, sage brush and mud), but can invoke the hydraulic and geomorphic responses intended by the designer to promote floodplain connectivity and creation of more complex and resilient habitats. In the example above, a postless BDA was built with juniper, sage brush and mud, and within one season accumulated over a meter of sediment behind it, effectively forced floodplain connectivity in flows that would not have gone overbank, raised water tables, and diversified in-channel hydraulics.
Figure 10 – In some instances, structures are specifically designed to promote bank erosion by either creating a convergent jet of flow towards an outside bank (e.g. bank blasters) or promoting dam or debris jam bank erosion by ‘end-cutting’. We don’t consider this structural ‘failure’ when this is precisely the design intent of the geomorphic processes we are promoting.
Figure 11 – In the case of incised channels, BDAs are now regularly used to promote channel aggradation and floodplain reconnection. Interestingly, we do this by accelerating the natural process of incised channel evolution recovery, which involves a critically important widening phase. The widening phase involves eroding the trench banks to both source local sediment and create accommodation space for that material to deposit new inset floodplains. See Pollock et al. (2014) for fuller description. In many cases, we’ve seen this accelerated recovery sped up by mimicking beaver activity take place in months to years instead of decades to centuries.

**COMPLEX LOCATIONS**

The five complexes proposed to be built as part of the workshop are shown in Figure 12. See sub-sections for rough descriptions.
Figure 12 – Locations of proposed complexes to be built as part of workshop. The stream network shows (largely in yellow) reflects a preliminary output of the beaver dam capacity model within BRAT (http://brat.riverscapes.xyz) based on LANDFIRE data from 2014 (before the grazing management has changed). It shows a largely low capacity (i.e. yellow or occasional dams at 1-4 dams per kilometer) based on what at the time LANDSAT detected as very minimal riparian vegetation. Riparian vegetation has subsequently recovered and we see a much higher capacity to support dam building activity.
COMPLEX 1 - ROCK CREEK – NEAR HATTY GULCH & IRRIGATION DIVERSION (MAINSTEM)

On day one of the workshop, our first activity will be to have participants build post-assisted BDAs according to the traditional recipe (i.e. post line, with wicker weaver). We will do this in an area with successful beaver activity already and in attempt to attract the beaver upstream from an existing beaver dam that is interfering with the design of recent restoration efforts to build a new irrigation diversion structure into the canal. We will notch their existing dam and install a beaver deterrent (Figure 22). The BDAs as part of this complex will promote the expansion of riparian area and hopefully encourage opportunistic beaver to focus their activities further upstream (Figure 13).

Figure 13 – Aerial oblique photo of Rock Creek looking downstream showing location of and extent of complex 1.

COMPLEX 2 - SMITH CREEK (PERENNIAL TRIBUTARY)

Participants will design and build their first postless BDAs as part of a complex on the heavily wooded (aspen and willow) Smith Creek (Figure 14). There are ample woody building materials available to assist and we will build a complex that repairs an abandon and disrepaired relic beaver dam complex and expands its footprint downstream.
COMPLEX 3 - ROCK CREEK @ EAST FORK & WEST FORK CONFLUENCE

Complex 3 will be a repair of an existing beaver dam complex that blew out in the 2018 spring runoff. Participants will use posts to reinforce the remnants of the existing dam and to reinforce their BDA (Figure 15). This will restore/expand the footprint and extent of the existing upstream complex. This site was chosen for ease of access to illustrate how maintenance and/or repair of existing blown-out or breached dams can be accomplished by human activity. A more self-sustaining solution is leaving that decision making to beaver to do the maintenance, but in this case this provides a useful learning opportunity.
COMPLEX 4 - WEST FORK ROCK CREEK

Complex 4 will consist of postless BDAs and some large woody debris additions to a smaller perennial tributary – West Fork Rock Creek (Figure 14). A beaver dam complex exists upstream around the corner, and this complex will mimic that one and promote the expansion of the riparian valley bottom sponge and hopefully be taken over by beaver in the area. This complex will provide

COMPLEX 5 - EPHEMERAL TRIBUTARY TO WEST FORK ROCK CREEK

Complex 5 is on an entirely dry, ephemeral tributary to West Fork Rock Creek and will be a place to illustrate the use of simple brush mattresses, rock-check dams and Zuni bowls to slow down ephemeral flows, promote deposition of sediment, and create sponges in headwater draws, that help slow-the-flow and promote mesic vegetation growth (Figure 14). These structures are based on Zeedyk and Clothier (2006), ‘Let the Water do the Work’, and are very low-tech, low-risk, but high potential rewards when installed in high density.
EXISTING CONDITIONS

Rock Creek had been severely degraded after decades of traditional grazing/ranching land uses and over-grazing. Since the property came under new ownership and management in 2014, the recovery of the riparian vegetation communities in particular is notable. An on the ground assessment of current conditions and survey of beaver activity revealed that conditions as of 2018 are improving and plenty to support beaver dam building activity (which has been expanding).

RIPARIAN CONDITIONS

Riparian conditions have improved considerably since grazing management changed in 2014. From freely-available national datasets, a preliminary assessment of riparian conditions was done using the RCAT (Riparian Condition Assessment Tool: http://rcat.riverscapes.xyz) developed by Macfarlane et al. (2018) and Macfarlane et al. (2017). Unfortunately, the latest LANDFIRE vegetation assessment that was available is from 2014. Figure 16 and Figure 17 show preliminary outputs of the Riparian Departure portion of RCAT, that highlights the large loss of riparian vegetation from pre-European settlement conditions up to 2014.
Figure 16 – A preliminary run of RCAT (http://rcat.riverscapes.xyz) riparian vegetation departure, which estimates the degree of riparian vegetation loss in the valley bottom. In this example, it shows riparian departure as of 2014, as compared with LANDFIRE estimates of pre-European settlement vegetation conditions. This does not reflect the important gains in riparian vegetation that have taken place from 2014 to 2018.
Figure 17 – The above RCAT output attempts to contextualize the riparian vegetation losses in Figure 16 based on the type of conversion from riparian vegetation to what. The majority of the watershed shows up with conversion to grass/shrubland reflecting the grazing land use and loss
of riparian vegetation replaced by grasses and shrubs. Some of the irrigated pasture valley bottoms along the mainstem show conversion to agriculture.

ABILITY TO SUPPORT DAM BUILDING ACTIVITY BY BEAVER

As of 2017 there were roughly 100 dams in 15-20 complexes with roughly 15 identifiable lodges. These are spread throughout the watershed in a diverse range of conditions. Thus, it is clear beaver can build dams. To corroborate this evidence, inform the restoration design/planning and expand it to the rest of the watershed, we also ran the Beaver Restoration Assessment Tool (BRAT: http://brat.riverscapes.xyz) developed by Macfarlane et al. (2015). Although the conditions as of 2014 only suggest that occasional dam densities (i.e. 1-4 dams / kilometer) can be supported (Figure 12), it is clear from a site visit that in many localities higher densities can be supported. A preliminary run of BRAT predicted capacities with historic vegetation estimates in Figure 18 suggest that dam building activity could be pervasive throughout much of the watershed (i.e. upwards of 15-40 dams/kilometer).
Figure 18 – Preliminary estimates from BRAT of historic capacity to support dam building activity by beaver were pervasive throughout most of the watershed (note that green line paralleling mainstem is an irrigation canal).
ADAPTIVE MANAGEMENT

While the threats to infrastructure within the restoration areas are limited, it is plausible that existing beaver populations working in the treated areas or elsewhere on Rock Creek may cause undesirable impacts. Fortunately, the ownership in Rock Creek Ranch is relatively simple with t includes many landowners includes many kilometers of stream. As such, it is impractical to assess each and every discrete potential risk. Instead, here we present a more generalized framework for addressing potential threats posed by beaver dam-building activity and present a suite of approaches that may be used in addressing threats before and once they have been detected.

MONITORING

Monitoring is an essential component of the adaptive management plan for Rock Creek because it requires the evaluation of management actions (i.e. building structures) and the impacts of those actions. Monitoring may be a simple visual inspection of current beaver activity and condition of structures installed during the workshop. In areas that have been identified as potentially at risk, for example, diversions, stream crossings, and culverts. In many cases, such monitoring may be as simple as walking 50 m of stream to look for evidence of beaver activity (e.g., dams or felled trees). While monitoring can take place any time of year, we specifically recommend monitoring in the spring, after runoff, and in the fall when beaver activity is high.

If beaver activity has been identified as a potential problem, we recommend following the evaluation process outlined in Figure 16. In many cases beaver activity may not pose a threat, or it may be able to be mitigating using ‘living with beaver’ strategies such as pond levelers, beaver deceivers or tree-fencing. If beaver activity is threatening or damaging infrastructure, dam-breaching, live trapping and relocation, or lethal trapping may be required. Choosing a specific course of action will depend on the specific threat posed by beaver activity and/or the effectiveness of previous management actions.

MANAGEMENT OPTIONS TO MITIGATE UNDESIREABLE IMPACTS OF CONSTRUCTUED STRUCTURES

It is tempting for designers to want their structures to stay put, exactly as they built them in perpetuity. This can also lead to a temptation to undertake maintenance to keep things looking like they were originally built. This IS NOT our intent here. We build the structures themselves to have a design-life of less than a year. Many structures will persist in some form for many more years (even decades), but it is important for expectation management that this is not the stated goal. In the design process, we encourage designers to articulate clear design hypotheses and objectives that then can help differentiate what maintenance actions may be needed (if any).
Figure 19 – Example of the suggested evaluation of complexes in response to monitoring as part of adaptive management (from Bouwes et al. (2016a).
MANAGEMENT OPTIONS TO MITIGATE NUISANCE BEAVER PROBLEMS

If beaver activity has been determined to be sufficiently damaging or threatening as to require management intervention there are a number of tools that can be used. All management decisions require resources, whether financial or temporal. We therefore recommend attempting to use the most cost-efficient strategies before moving on to more-costly solutions. Anabranch Solutions is available on a contractual basis to assist in decision making implementation of ‘Living with Beaver’ strategies.
Living with Beaver Strategies

Traditionally, beaver management has relied on lethal trapping to prevent threats to infrastructure posed by beaver dam building activity. The increased awareness of the ecosystem benefits provided by beaver activity and their ability to help achieve a number of restoration goals has spurred the development of approaches capable of mitigating the negative results of beaver activity in order to retain the benefits such activity produces. Here we summarize a number of 'living with beaver' strategies.

Breach Dam

Breaching or partial breaching (i.e., notching) a dam is an effective way to mitigate the risk of flooding due to a specific dam, if that dam is no longer being actively maintained by beaver. Breaching, rather than full removal, allows managers to effectively control the water height of the dam while also still retaining the ecosystem services provided by such a dam. Breaching a dam is not an effective strategy if the dam is being actively maintained, given beavers’ ability to repair breaches within short periods of time (i.e., hours to days).
Notch Dam and Install Beaver Deterrent

In areas where an actively maintained dam is posing a threat of flooding but has not reached a critical level, notching the dam to reduce the pond height and installing a beaver deterrent may reduce the threat of flooding. A beaver deterrent is simply a white sheet that is strung between two fence posts and placed just upstream of the notched dam,
such that it can move freely in the wind. The sheet is cut vertically to create strips that can blow in the wind. The movement of the sheet deters beaver from repairing the notched dam. This approach is very inexpensive (< $10 and < 10 minutes) and an excellent first approach to dealing with potentially threatening pond heights.

**Construction Details: Beaver Deterrent**

(View looking upstream from below dam)

**Construction Notes**

1. Notch dam to desired pond level height.
2. Pound 6-8 ft. metal fenceposts just upstream of dam notch. Fencepost length depends on depth of pond/height of dam.
3. Attach 11-gauge or baling wire between the tops of fenceposts.
4. Affix white sheet or Tyvek house wrap to wire between fenceposts ~1-2 inches above pond water level. Clamps, clothespins, or sewing a sleeve can all be used to attach the sheet to wire.
5. Cut slits into the sheet spaced ~ 2ft.

*Figure 22 – Schematic of a beaver deterrent used to control pond height.*

**Install Pond Leveler to Control Pond Height**

Pond levelers are another way managers and land owners can mitigate the risk of flooding due to beaver activity while allowing beaver to remain in a given area. Pond levelers installation typically requires a half-day of labor for 2-3 people and materials cost approximately $600 – 1000 depending on site specific conditions. A pond leveler consists of a flexible, perforated plastic pipe that has an inflow protected by a large metal cage and is anchored to the bottom of the pond, and runs through the dam, and is set at the desired water level height. It may be necessary to notch the dam in order to set the pipe at the desired pond height. Following installation, we recommend placing additional material over the end of the pipe in order to prevent beaver from clogging the outflow. Examples of a pond leveler installation performed by Anabot Solutions personnel are shown in Figure 9.
Beaver Deterrent to Prevent Culvert/Irrigation Diversion Clogging
As shown above beaver deterrents (Figure 8) can be used preemptively in order to prevent beaver from becoming active in areas that are determined to be high risk. In Rock Creek, we recommend using beaver deterrents at culverts and/or points of diversion if beaver activity poses a threat to their proper function.

Removal, Live Trapping and Relocation
If beaver activity is having a negative impact and/or posing unacceptable risks, and ‘living with beaver’ strategies have proved ineffective, then removal, whether by live trapping and relocation or lethal trapping may be required. We strongly recommend live-trapping and relocation in order to maintain the benefits of beaver activity elsewhere in the watershed, and further recommend that lethal trapping should be treated as a last resort. Any live trapping and relocation efforts work will need to be undertaken in collaboration with and under the authority of Idaho Department of Fish and Game. While we recognize that beaver activity may pose a threat at any time of year, we recommend, when possible that trapping and relocation do not take place during winter months, when their chances of survival are limited. Choosing an appropriate relocation site, with suitable habitat, and limited threats to infrastructure is also critical.

RECOMMENDED FUTURE WORK
Stream restoration that ‘partners with beaver’ has been increasingly recognized as a viable strategy to restore stream ecosystems. In areas dominated by private land ownership, such as the Rock Creek watershed, there may be multiple perspectives on the benefits and risks posed by beaver activity. Because beaver are highly mobile, there is no guarantee that they will remain within the restoration reaches where they are released. It is therefore critical to the long-term success of restoration to build community support and understanding about the benefits and risks of restoring beaver to the watershed. Such a community-based process takes into consideration the concerns of all stakeholders whose property and/or water may be affected by beaver activity and should be formalized within the Adaptive Management Plan. This is easier within the Rock Creek Watershed, as the ownership is simple (one primary landowner who is also the permittee to grazing allotments on pockets of public lands within the watershed).
REFERENCES


Bouwes N, Weber N, Jordan CE, Saunders WC, Tattam IA, Volk C, Wheaton JM and Pollock MM. 2016b. Ecosystem experiment reveals benefits of natural and simulated beaver dams to a threatened population of steelhead (Oncorhynchus mykiss). Scientific Reports. 6: 28581. DOI: 10.1038/srep28581.


In Chapters 7, 11 and 12 of the Riverscapes Restoration Design Manual, we provide a detailed overview of these design forms and how to use them. As part of the design process, we focus on tying individual structure design, to the design of a complex of structures (designed to work together). We also advocate identifying specific design hypotheses about the hydraulic, geomorphic, habitat and ecological responses in the:

- Immediate, short-term (i.e. baseflow)
- In response to typical floods (i.e. 1-2 year RI flows)
- In response to larger, rarer floods

The design is meant to not only capture where to build, and what materials are necessary, but also the design intent through articulation of these design hypotheses. This maximizes the opportunity for learning, and allows for multiple alternative responses.

Figure 17 – Examples of predicted hydraulic and geomorphic responses associated with PALS (post assisted log structures) from (Camp, 2015).
**BDA OR PAL STRUCTURE DESIGN FORM**

### DESIGN INFO

**Designer Name(s):** ____________________________

**Structure ID:** ____________________________

**Observation Date:** ____________________________

**DESIGN TYPE:**
- ○ Beaver Dam Analogue
- ○ Post Assisted Log Structure
- ○ Unanchored/Pinned Wood Addition

**DESIGN VIDEO:** ____________________________

**DESIGN FLOW CONDITIONS**
- ○ Baseflow
- ○ Spring runoff
- ○ Flood
- ○ Post Flood

### POSITIONAL ATTRIBUTES

**GPS UTM Easting:** ____________________________

**GPS UTM Northing:** ____________________________

**STRUCTURE LOCATION RELATIVE TO CHANNEL(S)**
- ○ On Main Channel
- ○ On Right Side Channel(s)
- ○ On Left Side Channel(s)
- ○ On Left Floodplain
- ○ On Right Floodplain

**PART OF COMPLEX?**
- ○ Complex ID ____________________________
- ○ Part of new dam complex
- ○ Expansion of existing dam complex
- ○ NA - Isolated Dam
- ○ NA - Non-Dam

### STRUCTURE DESIGN

**STRUCTURE POSITION**
- ○ River Right Margin Attached
- ○ River Left Margin Attached
- ○ Channel Spanning (i.e. BDA or Debris Jam)
- ○ Mid-Channel

**STRUCTURE ORIENTATION**
- ○ Perpendicular to Flow
- ○ Angled Flow Downstream
- ○ Angled Flow Upstream
- ○ Diamond
- ○ Triangle pointing Upstream
- ○ Triangle pointing Downstream

**CHANNEL CONSTRICION (% OF BANKFULL WIDTH)**
- ○ 100% BFW
- ○ 95-99%
- ○ 85-95%
- ○ 75-85%
- ○ 50-75%
- ○ 25-50%
- ○ < 25%

**STRUCTURE MATERIALS**
- □ Posts: Approx. Count: ______
- □ Willow Weave
- □ Key piece (completely limbed)
- □ Key piece (limbed on bottom side only)
- □ Root wad
- □ Small Woody Debris
- □ Woody branches (single limbed) > 15 cm diameter
- □ Woody branches (single limbed) < 15 cm diameter
- □ Mud
- □ Grass / Reeds
- □ Other organic
- □ Cobble or Boulders
- □ 2-3 Guy Woody Debris
- □ Turf
- □ Dowelled or Twine tied Simple Logs
- □ ____________________________

**STRUCTURE DIMENSIONS**
- Max dam/structure height (m) +/- 0.1 m ______
- Max pond depth (m if applicable) +/- 0.1 m ______
- Water Surface Difference (m if applicable) +/- 0.1 m ______
- Structure Length (m) +/- 1 m ______
EXISTING FEATURES

GEOMORPHIC UNITS AT STRUCTURE LOCATION
- □ Planar
- □ Convexity (bar) type: ________
- □ Saddle (riffle)
- □ Concavity (true pool)
- □ Trough (shallow thalweg or chute)
- □ Wall: Bank
- □ Wall: Bar edge

How are above used? (grow (deposit), shrink (erode), maintain, build, destroy, protect)

STRUCTURAL ELEMENTS AT STRUCTURE LOCATION
- □ Roots
- □ Live Trees/Shrubs
- □ Aquatic Vegetation
- □ Boulder(s)
- □ Woody Debris
- □ Wall: Bank
- □ Wall: Bar edge

How are above used? (exploit, anchor, deflect, attack, protect)

ANTICIPATED HYDRAULIC RESPONSES

LOW FLOW BEHAVIOR
For Channel Spanners:
(Specify Value 0-100%; Sum should be 100%)
Flow Over Top    _____
Basal Flow      _____
Throughflow      _____
Flow Around Left     _____
Flow Around Right  _____
Total Check      =        100%?

For Non-Channel Spanners:
(Specify Value 0-100%; Sum should be 100%)
Shunted Flow Left  _____
Shunted Flow Right     _____
Flow Through (sieve)  _____
Flow Over Top      _____
Flow Under        _____
Total Check      =        100%?

TYPICAL FLOOD BEHAVIOR
- ○ In-tact
- ○ Minor breach (< 25 cm height ) on left
- ○ Minor breach (< 25 cm height ) on right
- ○ Minor breach (< 25 cm height ) on center
- ○ Minor basal breach
- ○ Major breach (> 25 cm height ) on left
- ○ Major breach (> 25 cm height ) on right
- ○ Major breach (> 25 cm height ) on center
- ○ Major basal breach
- ○ Blowout (whole height of dam breached)

BIG FLOOD BEHAVIOR
- ○ In-tact
- ○ Minor breach (< 25 cm height ) on left
- ○ Minor breach (< 25 cm height ) on right
- ○ Minor breach (< 25 cm height ) on center
- ○ Minor basal breach
- ○ Major breach (> 25 cm height ) on left
- ○ Major breach (> 25 cm height ) on right
- ○ Major breach (> 25 cm height ) on center
- ○ Major basal breach
- ○ Blowout (whole height of dam breached)

ESTIMATED UPSTREAM ZONE OF HYDRAULIC INFLUENCE
- ○ < 1 BFW
- ○ 1-2 BFW
- ○ 2 – 5 BFW
- ○ 5 -10 BFW
- ○ > 10 BFW

ESTIMATED DOWNSTREAM ZONE OF HYDRAULIC INFLUENCE
- ○ < 1 BFW
- ○ 1-2 BFW
- ○ 2 – 5 BFW
- ○ 5 -10 BFW
- ○ > 10 BFW

SIDE CHANNELS FORCED?
- □ None
- □ Single Left
- □ Multiple Left
- □ Single Right
- □ Multiple Right

POND EXTENT
- ○ Contained within bankfull channel
- ○ Expanding out onto floodplain
- ○ Drained

FLOODPLAIN INUNDATION
- □ During Extreme Floods - River Right
- □ During Extreme Floods - River Left
- □ During Seasonal Floods - River Right
- □ During Seasonal Floods - River Left
- □ Year Round Inundation - River Right
- □ Year Round Inundation - River Left
**ANTICIPATED GEOMORPHIC RESPONSES**

**POND CAPACITY (FIRST YEAR FLOODS)**
- Clean
- Partial Filling (upto 50% of original pond capacity)
- Major Filling (50% to 95% of original pond capacity)
- Full of sediment (no longer a pond)

**POND CAPACITY (IF BIG FLOODS)**
- Clean
- Partial Filling (upto 50% of original pond capacity)
- Major Filling (50% to 95% of original pond capacity)
- Full of sediment (no longer a pond)

**Dominant Substrate in Deepest**

**EXPECTED DOMINANT SUBSTRATE UPSTREAM OF STRUCTURE**
- Fines (clays and silts)
- Gravels
- Food Cache & Fines
- Sands
- Cobble

**EXPECTED DOMINANT SUBSTRATE DOWNSTREAM OF STRUCTURE**
- Fines (clays and silts)
- Gravels
- Food Cache & Fines
- Sands
- Cobble

**EXPECTED GEOMORPHIC UNITS AT STRUCTURE LOCATION**
- Planar
- Convexity (bar) type: ________
- Saddle (rifflle)
- Concavity (true pool)
- Trough (shallow thalweg or chute)
- Wall: Bank
- Wall: Bar edge

How are above used? (grow (deposit), shrink (erode), maintain, build, destroy, protect)

**EXPECTED STRUCTURAL ELEMENTS AT STRUCTURE LOCATION**
- Roots
- Live Trees/Shrubs
- Aquatic Vegetation
- Boulder(s)
- Woody Debris
- Wall: Bank
- Wall: Bar edge

How are above used? (accumulate remain, recruit)

**NOTES & SKETCH**
# BDA OR PAL STRUCTURE DESIGN FORM

## DESIGN INFO

<table>
<thead>
<tr>
<th>Designer Name(s):</th>
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<tr>
<td>Observation Date:</td>
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### DESIGN TYPE:
- ☐ Beaver Dam Analogue
- ☐ Post Assisted Log Structure
- ☐ Unanchored/Pinned Wood Addition

### DESIGN VIDEO:
[_______________________]

### DESIGN FLOW CONDITIONS:
- ☐ Baseflow
- ☐ Spring runoff
- ☐ Flood
- ☐ Post Flood

## POSITIONAL ATTRIBUTES

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### STRUCTURE LOCATION RELATIVE TO CHANNEL(S):
- ☐ On Main Channel
- ☐ On Right Side Channel(s)
- ☐ On Left Side Channel(s)
- ☐ On Left Floodplain
- ☐ On Right Floodplain

### PART OF COMPLEX?

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- ☐ Expansion of existing dam complex
- ☐ NA - Isolated Dam
- ☐ NA - Non-Dam

## STRUCTURE DESIGN

### STRUCTURE POSITION
- ☐ River Right Margin Attached
- ☐ River Left Margin Attached
- ☐ Channel Spanning (i.e. BDA or Debris Jam)
- ☐ Mid-Channel

### STRUCTURE ORIENTATION
- ☐ Perpendicular to Flow
- ☐ Angled Flow Downstream
- ☐ Angled Flow Upstream
- ☐ Diamond
- ☐ Triangle pointing Upstream
- ☐ Triangle pointing Downstream

### CHANNEL CONSTRICTION (% OF BANKFULL WIDTH)
- ☐ 100% BFW
- ☐ 95-99%
- ☐ 85-95%
- ☐ 75-85%
- ☐ 50-75%
- ☐ 25-50%
- ☐ < 25%

### STRUCTURE MATERIALS

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<td></td>
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<tr>
<td>□ Mud</td>
<td></td>
</tr>
<tr>
<td>□ Grass / Reeds</td>
<td></td>
</tr>
<tr>
<td>□ Other organic</td>
<td></td>
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<tr>
<td>□ Cobble or Boulders</td>
<td></td>
</tr>
<tr>
<td>□ 2-3 Guy Woody Debris</td>
<td></td>
</tr>
<tr>
<td>□ Turf</td>
<td></td>
</tr>
<tr>
<td>□ Dowelled or Twine tied Simple Logs</td>
<td></td>
</tr>
</tbody>
</table>

### MATERIALS Sourced on-site?
- ☐ Yes
- ☐ No

### STRUCTURE DIMENSIONS

<table>
<thead>
<tr>
<th>Max dam/structure height (m) +/- 0.1 m</th>
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</tr>
<tr>
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</tr>
</tbody>
</table>

---
### Existing Features

#### Geomorphic Units at Structure Location
- Planar
- Convexity (bar) type: ________
- Saddle (riffle)
- Concavity (true pool)
- Trough (shallow thalweg or chute)
- Wall: Bank
- Wall: Bar edge

How are above used? (grow (deposit), shrink (erode), maintain, build, destroy, protect)

#### Structural Elements at Structure Location
- Roots
- Live Trees/Shrubs
- Aquatic Vegetation
- Boulder(s)
- Woody Debris
- Wall: Bank
- Wall: Bar edge

How are above used? (exploit, anchor, deflect, attack, protect)

### Anticipated Hydraulic Responses

#### Low Flow Behavior
For Channel Spanners:
(Specify Value 0-100%; Sum should be 100%)
- Flow Over Top  
- Basal Flow  
- Throughflow  
- Flow Around Left  
- Flow Around Right  
- Total Check = 100%?

For Non-Channel Spanners:
(Specify Value 0-100%; Sum should be 100%)
- Shunted Flow Left  
- Shunted Flow Right  
- Flow Through (sieve)  
- Flow Over Top  
- Flow Under  
- Total Check = 100%?

#### Typical Flood Behavior
- In-tact
- Minor breach (< 25 cm height) on left
- Minor breach (< 25 cm height) on right
- Minor breach (< 25 cm height) on center
- Minor basal breach
- Major breach (> 25 cm height) on left
- Major breach (> 25 cm height) on right
- Major breach (> 25 cm height) on center
- Major basal breach
- Blowout (whole height of dam breached)

#### Big Flood Behavior
- In-tact
- Minor breach (< 25 cm height) on left
- Minor breach (< 25 cm height) on right
- Minor breach (< 25 cm height) on center
- Minor basal breach
- Major breach (> 25 cm height) on left
- Major breach (> 25 cm height) on right
- Major basal breach
- Blowout (whole height of dam breached)

### Estimated Upstream Zone of Hydraulic Influence
- < 1 BFW
- 1-2 BFW
- 2 – 5 BFW
- 5-10 BFW
- > 10 BFW

### Estimated Downstream Zone of Hydraulic Influence
- < 1 BFW
- 1-2 BFW
- 2 – 5 BFW
- 5-10 BFW
- > 10 BFW

### Side Channels Forced?
- None
- Single Left
- Multiple Left
- Single Right
- Multiple Right

### Pond Extent
- Contained within bankfull channel
- Expanding out onto floodplain
- Drained

### Floodplain Inundation
- During Extreme Floods - River Right
- During Extreme Floods - River Left
- During Seasonal Floods - River Right
- During Seasonal Floods - River Left
- Year Round Inundation - River Right
- Year Round Inundation - River Left
ANTICIPATED GEOMORPHIC RESPONSES

POND CAPACITY (FIRST YEAR FLOODS)
- Clean
- Partial Filling (upto 50% of original pond capacity)
- Major Filling (50% to 95% of original pond capacity)
- Full of sediment (no longer a pond)

POND CAPACITY (IF BIG FLOODS)
- Clean
- Partial Filling (upto 50% of original pond capacity)
- Major Filling (50% to 95% of original pond capacity)
- Full of sediment (no longer a pond)

Dominant Substrate in Deepest

EXPECTED DOMINANT SUBSTRATE UPSTREAM OF STRUCTURE
- Fines (clays and silts)
- Gravels
- Food Cache & Fines

EXPECTED DOMINANT SUBSTRATE DOWNSTREAM OF STRUCTURE
- Fines (clays and silts)
- Gravels
- Food Cache & Fines

EXPECTED GEOMORPHIC UNITS AT STRUCTURE LOCATION
- Planar
- Convexity (bar) type: ________
- Saddle (riffle)
- Concavity (true pool)
- Trough (shallow thalweg or chute)
- Wall: Bank
- Wall: Bar edge

How are above used? (grow (deposit), shrink (erode), maintain, build, destroy, protect)

EXPECTED STRUCTURAL ELEMENTS AT STRUCTURE LOCATION
- Roots
- Live Trees/Shrubs
- Aquatic Vegetation
- Boulder(s)
- Woody Debris
- Wall: Bank
- Wall: Bar edge

How are above used? (accumulate remain, recruit)

NOTES & SKETCH
### DESIGN INFO

<table>
<thead>
<tr>
<th>Designer Name(s):</th>
<th>____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure ID:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Observation Date:</td>
<td>____________________________</td>
</tr>
</tbody>
</table>

### DESIGN TYPE:
- Beaver Dam Analogue
- Post Assisted Log Structure
- Unanchored/Pinned Wood Addition

### DESIGN VIDEO:

_______________________

### DESIGN FLOW CONDITIONS
- Baseflow
- Spring runoff
- Flood
- Post Flood

### POSITIONAL ATTRIBUTES

<table>
<thead>
<tr>
<th>GPS UTM Easting:</th>
<th>____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS UTM Northing:</td>
<td>____________________________</td>
</tr>
</tbody>
</table>

### STRUCTURE LOCATION RELATIVE TO CHANNEL(s)
- On Main Channel
- On Right Side Channel(s)
- On Left Side Channel(s)
- On Left Floodplain
- On Right Floodplain

### PART OF COMPLEX?

<table>
<thead>
<tr>
<th>Complex ID</th>
<th>____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Part of new dam complex</td>
</tr>
<tr>
<td></td>
<td>Expansion of existing dam complex</td>
</tr>
<tr>
<td></td>
<td>NA - Isolated Dam</td>
</tr>
<tr>
<td></td>
<td>NA - Non-Dam</td>
</tr>
</tbody>
</table>

### STRUCTURE DESIGN

#### STRUCTURE POSITION
- River Right Margin Attached
- River Left Margin Attached
- Channel Spanning (i.e. BDA or Debris Jam)
- Mid-Channel

#### STRUCTURE ORIENTATION
- Perpendicular to Flow
- Angled Flow Downstream
- Angled Flow Upstream
- Diamond
- Triangle pointing Upstream
- Triangle pointing Downstream

#### CHANNEL CONSTRUCTION (% OF BANKFULL WIDTH)
- 100% BFW
- 95-99%
- 85-95%
- 75-85%
- 50-75%
- 25-50%
- < 25%

#### STRUCTURE MATERIALS
- Posts: Approx. Count: ______
- Willow Weave
- Key piece (completely limbed)
- Key piece (limbed on bottom side only)
- Root wad
- Small Woody Debris
- Woody branches (single limbed) > 15 cm diameter
- Woody branches (single limbed) < 15 cm diameter
- Mud
- Grass / Reeds
- Other organic
- Cobble or Boulders
- 2-3 Guy Woody Debris
- Turf
- Dowelled or Twine tied Simple Logs
- ____________________________

### STRUCTURE DIMENSIONS

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<td>Water Surface Difference (m if applicable) +/- 0.1 m</td>
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<table>
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</table>
EXISTING FEATURES

**Geomorphic units at structure location**

- Planar
- Convexity (bar) type: __________
- Saddle (riffle)
- Concavity (true pool)
- Trough (shallow thalweg or chute)
- Wall: Bank
- Wall: Bar edge

How are above used? (grow (deposit), shrink (erode), maintain, build, destroy, protect)

**Structural elements at structure location**

- Roots
- Live Trees/Shrubs
- Aquatic Vegetation
- Boulder(s)
- Woody Debris
- Wall: Bank
- Wall: Bar edge

How are above used? (exploit, anchor, deflect, attack, protect)

ANTICIPATED HYDRAULIC RESPONSES

**Low flow behavior**

For Channel Spanners:

(Specify Value 0-100%; Sum should be 100%)

- Flow Over Top ______
- Basal Flow ______
- Throughflow ______
- Flow Around Left ______
- Flow Around Right ______
- Total Check = 100%?

For Non-Channel Spanners:

(Specify Value 0-100%; Sum should be 100%)

- Shunted Flow Left ______
- Shunted Flow Right ______
- Flow Through (sieve) ______
- Flow Over Top ______
- Flow Under ______
- Total Check = 100%?

**Typical flood behavior**

- In-tact
- Minor breach (< 25 cm height) on left
- Minor breach (< 25 cm height) on right
- Minor breach (< 25 cm height) on center
- Minor basal breach
- Major breach (> 25 cm height) on left
- Major breach (> 25 cm height) on right
- Major breach (> 25 cm height) on center
- Major basal breach
- Blowout (whole height of dam breached)

**Big flood behavior**

- In-tact
- Minor breach (< 25 cm height) on left
- Minor breach (< 25 cm height) on right
- Minor breach (< 25 cm height) on center
- Minor basal breach
- Major breach (> 25 cm height) on left
- Major breach (> 25 cm height) on right

**Estimated upstream zone of hydraulic influence**

- < 1 BFW
- 1-2 BFW
- 2-5 BFW
- 5-10 BFW
- > 10 BFW

**Estimated downstream zone of hydraulic influence**

- < 1 BFW
- 1-2 BFW
- 2-5 BFW
- 5-10 BFW
- > 10 BFW

**Side channels forced?**

- None
- Single Left
- Multiple Left
- Single Right
- Multiple Right

**Pond extent**

- Contained within bankfull channel
- Expanding out onto floodplain
- Drained

**Floodplain inundation**

- During Extreme Floods - River Right
- During Extreme Floods - River Left
- During Seasonal Floods - River Right
- During Seasonal Floods - River Left
- Year Round Inundation - River Right
- Year Round Inundation - River Left
**ANTICIPATED GEOMORPHIC RESPONSES**

**Pond Capacity (First Year Floods)**
- Clean
- Partial Filling (upto 50% of original pond capacity)
- Major Filling (50% to 95% of original pond capacity)
- Full of sediment (no longer a pond)

**Pond Capacity (If Big Floods)**
- Clean
- Partial Filling (upto 50% of original pond capacity)
- Major Filling (50% to 95% of original pond capacity)
- Full of sediment (no longer a pond)

**Expected Dominant Substrate Upstream of Structure**
- Fines (clays and silts)
- Gravels
- Food Cache & Fines

**Expected Dominant Substrate Downstream of Structure**
- Fines (clays and silts)
- Gravels
- Food Cache & Fines

**Expected Geomorphic Units At Structure Location**
- Planar
- Convexity (bar) type: ________
- Saddle (riffle)
- Concavity (true pool)
- Trough (shallow thalweg or chute)
- Wall: Bank
- Wall: Bar edge

How are above used? (grow (deposit), shrink (erode), maintain, build, destroy, protect)

**Expected Structural Elements At Structure Location**
- Roots
- Live Trees/Shrubs
- Aquatic Vegetation
- Boulder(s)
- Woody Debris
- Wall: Bank
- Wall: Bar edge

How are above used? (accumulate remain, recruit)

**NOTES & SKETCH**
Complex Setting

Active channel sits between low elevation and largely unvegetated active floodplain (~0.3 m) consisting of multithreaded high flow channels. Channel substrate is largely unconsolidated cobbles likely leading to infiltration and loss of surface flow. High (> 0.5 m) unvegetated old terraces sit above active floodplain.

Complex Restoration Objective

Increase surface water storage with intent to increase water table elevation. Active trapping of sediment to aid in establishment of riparian vegetation.

Number of Structures 7

<table>
<thead>
<tr>
<th>ID</th>
<th>Type</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>08</td>
<td>Primary Ponding</td>
<td>2017</td>
</tr>
<tr>
<td>09</td>
<td>Primary Ponding</td>
<td>2017</td>
</tr>
<tr>
<td>10</td>
<td>Secondary Support</td>
<td>2017</td>
</tr>
<tr>
<td>11</td>
<td>Floodplain Expansion</td>
<td>2017</td>
</tr>
<tr>
<td>12</td>
<td>Secondary Support</td>
<td>2017</td>
</tr>
<tr>
<td>13</td>
<td>Primary Ponding</td>
<td>2017</td>
</tr>
<tr>
<td>14</td>
<td>Primary Ponding</td>
<td>2017</td>
</tr>
<tr>
<td>15</td>
<td>Secondary Support</td>
<td>2017</td>
</tr>
</tbody>
</table>
Complex 02 - Structure 08

Structure Type: Primary Ponding

Date Designed: 7/28/17
Total Posts: 30
Crest Elevation: 0.40
Latitude: 44.629701
Longitude: -120.333379

Repeat Photo Location:
- Photo Facing: Upstream
- Standing: River Right
- Distance (m): 10

Channel Setting:
Plain bed channel, lack of vegetation on banks may lead to endcut. Location little more than wet rocks at install. Long low gradient stretch above should offer extensive pond creation.

Construction and Design Elements:
Standard built with three lines of posts at height of low river right terrace. Posts cut to river right terrace elevation.

Structure Functional Objective:
Extensive pond creation for beaver habitat. Increase water table elevation for increase riparian vegetation on river right low terrace. Increase high flow dispersion on river right terrace.
Complex 02 - Structure 09

Structure Type: Primary Ponding  
Date Designed: 7/28/17  
Total Posts: 30  
Crest Elevation: 0.33  
Latitude: 44.629727  
Longitude: -120.333195

Channel Setting
Wide plain bed channel with moderate gradient. Lack of vegetation on banks may lead to end cuts.

Construction and Design Elements
Standard construction specifications. Bit lower than upstream 08. Low terrace elevation river left may allow high flows to escape and avoid scour.

Structure Functional Objective
Ponding, aggradation, beaver attraction. Increase water surface height. But, also to provide redundancy for next upstream structure.
Complex 02 - Structure 10

Date Designed 8/4/17
Total Posts 32
Crest Elevation 0.30
Latitude 44.629811
Longitude -120.333259

Repeat Photo Location
- Photo Facing Downstream
- Standing River Right
- Distance (m) 13

Channel Setting
Bottom of complex 02. More vegetated banks than 08 & 09 should increase stability. Willows throughout channel also provide support. Gradient just downstream hopefully won't cause headcut.

Construction and Design Elements
Built through existing willow line for and bank support.

Structure Functional Objective
Ponding in low gradient section to increase water storage, raise groundwater elevation. Dissipate gradient from upstream structures.
Complex 02 - Structure 11

Structure Type  Floodplain Expansion  Date Designed  8/4/17

Total Posts  20
Crest Elevation  0.30
Latitude  44.630009
Longitude  -120.333147

Repeat Photo Location
Photo Facing  Upstream
Standing  River Left
Distance (m)  10

Channel Setting
Structure just below steep constriction, and just downstream of high flow side channel river right. Some willow on banks should provide bank stability.

Construction and Design Elements
Standard design that incorporates willow on banks.

Structure Functional Objective
Cause ponding in upstream low gradient run. But, mostly increase duration of flow in river right high-flow side channel to increase riparian expansion and groundwater recharge.
Complex 02 - Structure 12

Structure Type  Secondary Support

Date Designed  8/4/17
Total Posts  20
Crest Elevation  0.25

Latitude  44.630055
Longitude  -120.333082

Repeat Photo Location
    Photo Facing Upstream
    Standing Mid-Channel
    Distance (m)  10

Channel Setting
Adjacent to low unvegetated alluvial gravel bars and high flow channels river right. Low gradient active floodplain zone.

Construction and Design Elements
River left willow should protect bank. Low elevation of river right bars and channels may allow diversion of high flow without structural integrity loss.

Structure Functional Objective
Low flow pond creation upstream, support for structure 11 upstream, increase flow duration across river right unvegetated alluvial bars and channels.
Complex 02 - Structure 13

Structure Type: Primary Ponding

Date Designed: 8/9/17
Total Posts: 29
Crest Elevation: 0.45
Latitude: 44.630265
Longitude: -120.332659

Repeat Photo Location
Photo Facing: Upstream
Standing: River Right
Distance (m): 10

Channel Setting
High terrace on river right with unstable bank. Toward bottom of braided active floodplain.

Construction and Design Elements
Roughly 23 m wide structure spanning multiple braided high flow channels. Uses some existing willow for support.

Structure Functional Objective
Creation of big pond and intended to trap sediment in braided mobile channel for establishment of riparian vegetation leading to increased channel roughness.
Complex 02 - Structure 14

**Structure Type** Primary Ponding

**Date Designed** 8/9/17

**Total Posts** 28

**Crest Elevation** 0.40

**Latitude** 44.630262

**Longitude** -120.332606

**Repeat Photo Location**
- Photo Facing River Right
- Standing River Left
- Distance (m) 5

**Channel Setting**
Structure sits between lower terrace on river left and high river right terrace. Spans entire broad - braided - unvegetated - active floodplain.

**Construction and Design Elements**
Standard construction, but wide structure spanning pinch point of active braided floodplain.

**Structure Functional Objective**
Creation of large pond, and acts as "cap" at lower end of floodplain. Structure should trap mobile sediment during high flows for vegetation establishment.
Complex 02 - Structure 15

Structure Type  Secondary Support

Date Designed  8/9/17
Total Posts  5
Crest Elevation  0.30
Latitude  44.630362
Longitude  -120.332324

Repeat Photo Location
Photo Facing  Upstream
Standing  River Right
Distance (m)  5

Channel Setting
Confined by high terraces both banks. Channel has extensive willow and extremely stable (i.e. cement) bed composition.

Construction and Design Elements
Uses only 5 posts and relies on weave and fill being added to existing vegetation.

Structure Functional Objective
Step down grade control designed to support upstream primary structures.
Logistics
Partnering with Beaver in Restoration Design

Summary
Restoration that partners with and/or mimics beaver activity can be scaled up to address large (~10^2 km) spatial extents. Restoration over large spatial extents is likely to encounter a range of geomorphic and riparian conditions that affect restoration design and implementation. Furthermore, site accessibility and access, which exerts an important control on project design and implementation is often variable. Because restoration projects that ‘partner with beaver’ rely on a high density and total number of structures over large extents, logistics present a special challenge. Planning, design and efficient implementation enables the construction of a greater number and density of structures, which is essential to achieving restoration goals. This section addresses the logistic concerns that need to be considered during the planning and implementation phases of any restoration project.

Planning

Materials
- To post or not to post?
- What woody material is available onsite?

Equipment
- Post pounder
- Hand tools e.g. shovels, loppers, buckets
- Chainsaw
- Grip hoist

Site Accessibility
- Vehicle
- Post-pounder

Permits and Regulations
- 401 & 404 permits (Clean Water Act)
- State permits (e.g. Nevada Working in Waterways permit)
- County permits (e.g. Blaine County)
- Industrial Fire Precaution Level (i.e., Hoot owl)
- Spawning season regulations

Project Management

Group Management
- How many people are onsite?
- What level of training do they have?

Implementation
- Working upstream vs. working downstream
- High flow and low flow construction considerations
The Pollock et al. (2018) version 2 of the beaver restoration guidebook is a good source of basic information on beaver-based restoration techniques.


HAND-BUILT STRUCTURES FOR RESTORING DEGRADED MEADOWS IN SAGEBRUSH RANGELANDS

For those interested in the Zeedyk techniques, particularly for ephemeral and intermittent washes, the NRCS just prepared Range Technical Note No. 40.


Available at: https://www.sagegrouseinitiative.com/starter-guide-for-healing-incised-meadows-with-hand-built-structures-in-sagebrush-country/
RIVERSCAPE RESTORATION DESIGN MANUAL: A GUIDE TO ‘CHEAP & CHEERFUL’ RESTORATION

As part of this workshop series, we are preparing a design manual for more detail and specifics on these ‘cheap and cheerful’, low-cost techniques. This is made possible thanks to the generous support of the Natural Resource Conservation Service’s Sage Grouse Initiative and Working Lands for Wildlife Initiative, a grant through Pheasants Forever to Joe Wheaton’s ET-AL lab at Utah State University. The Riverscape Restoration Design Manual for streams and riparian areas (i.e. riverscapes) shows how to embrace process-based restoration, low-cost restoration techniques and a ‘cheap and cheerful ethos’. This effort started as a design manual by the Wheaton ETAL group for the Utah Division of Wildlife Resources and the Utah Watershed Restoration Initiative.


The chapters include:

- Chapter 1 – Background and Purpose
- Chapter 2 – The Role of Meals and Exercise in Restoring Healthy Lifestyles for Riverscapes
- Chapter 3 – Impairments: what are they, how did we get here, and how can cheap and cheerful help?
- Chapter 4 - Condition Assessment
- Chapter 5 – Overview of Cheap & Cheerful Recipes – a growing list
- Chapter 6 – Planning & Prioritization For Working in the Right Places Effectively
- Chapter 7 – Design Principles for Cheap & Cheerful Restoration
- Chapter 8 – Permitting Cheap & Cheerful Restoration
- Chapter 9 – Construction & Implementation
- Chapter 10 - Adaptive Management
- Chapter 11 – Beaver Dam Analogues
- Chapter 12 – High Density Large Woody Debris
- Appendices – Case Studies

The manual is nearing completion and will be available later this Summer (2018) at:
GOOD BOOKS ON BEAVER

There are a variety of good books on beaver if you’re interested. We maintain a list at: http://beaver.joewheaton.org/beaver-literature.html

The most recent addition to the list is Ben Goldfarb’s new *Eager* (announcement on following pages).
Eager
The Surprising, Secret Life of Beavers and Why They Matter

Ben Goldfarb
foreword by Dan Flores

$24.95 • Hardcover
6 × 9 • 304 pages
Black-and-white illustrations throughout,
8-page color insert
ISBN 978-1-60358-739-6
Pub Date: July 20, 2018

“This book is going to make you look out on the world and see our wildlife story with new eyes.”

—DAN FLORES, New York Times bestselling author of Coyote America (from the foreword)

Award-winning journalist Ben Goldfarb has traveled the world writing about wildlife conservation and the environment. He has chased endangered woodpeckers through war games on a North Carolina military base and withstood a bluff charge from a Yellowstone grizzly bear. He has tagged sea turtles, radio-tracked bats, and hand-lined sharks. Now, he turns his attention to nature’s most ingenious architects—the beaver.

Did you know beavers create habitat for countless species from salmon to trumpeter swans to river otters and bats? This super power makes beavers a keystone species, meaning their protection will help all other members of their biological communities thrive. Goldfarb describes beavers as ecological and hydrological swiss army knives, capable, in the right circumstances, of tackling many landscape-scale problems.

Trying to mitigate floods or improve water quality? There’s a beaver for that. Hoping to capture more water for agriculture in the face of climate change? Add a beaver. Concerned about sedimentation, salmon runs, or wildfire? Take two families of beaver and check back in a year.

In his new book Eager, Goldfarb tells the powerful story of how these ecosystem engineers have shaped our world, and how they can help save it—if we let them.

Check out the reverse side of this page for 8 Beaver Facts you need to know right now. For more information about Ben Goldfarb and his writing go to www.bengoldfarb.com or follow him on Twitter @ben_a_goldfarb.

Beaver fur is so thick that a stamp-sized patch of skin is carpeted with 125,000 individual hairs—more than the average human has on their entire head!

A beaver tail is lined with a web of blood vessels, called a rete mirabile, that exchange heat and regulate body temperature.

Beavers secrete castoreum, a musky oil the rodents spray to delineate their territories. Castoreum contains salicylic acid, which beavers derive from willow—and which happens to be the active ingredient in aspirin.

By creating ponds, wetlands, and damp meadows, beavers create habitat for countless other species, from river otters to pileated woodpeckers to silver-haired bats.

When Europeans arrived in North America, as many as 400 million beavers swam the continent's rivers and ponds; by 1900, fur trapping had reduced the continent's population to just 100,000.

Trying to tell a male beaver from a female? Good luck. Almost unique among mammals, beavers hide their genitalia within modified cloacas—fleshy vents that do triple duty in the departments of urine disposal, scent secretion, and reproduction.

Remarkably, beavers are capable of fighting both floods and droughts. By slowing down stream flows, forcing water onto flood plains and soaking it into the ground, beaver dams and ponds can reduce both the volume and speed of water, protecting downstream farms and towns.

For more: @ben_a_goldfarb
REFERENCES


