LOW TECH – LOW COST TOOLS IN MESIC RESTORATION

ELKO, NEVADA 2018

WORKSHOP FIELD NOTEBOOK

Prepared by:

UtahStateUniversity 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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CONTENTS

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---utah.html

Design Manual

Available later this summer!

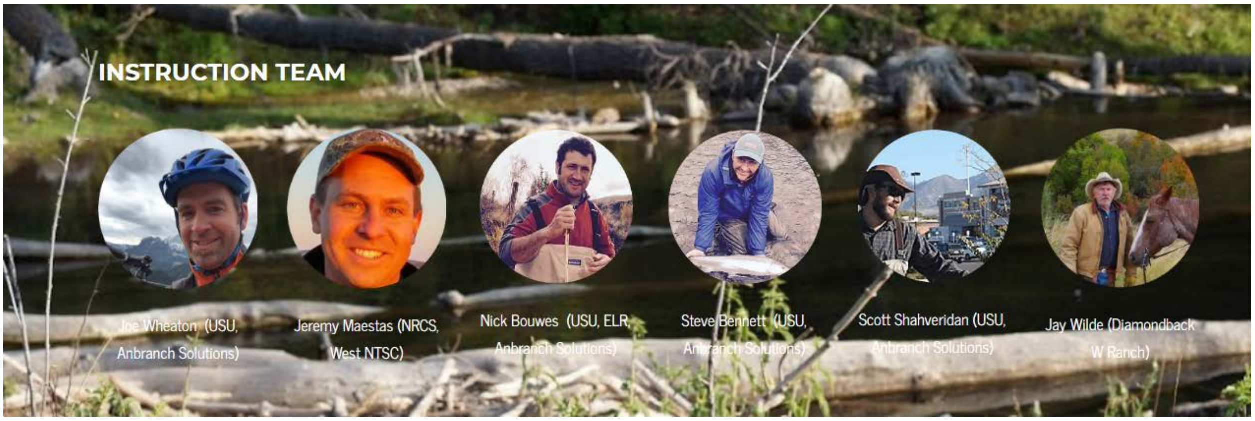
http://beaver.joewheaton.org/restoration-manual.html

Where to Get More Help:

http://beaver.joewheaton.org/need-help-planning-designing--building.html

YOUR INSTRUCTION TEAM

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



The above is your cheat sheet for pretending you remembered all our names.

OUR PHILOSOPHY & THE ALPHABET SOUP – PBR… BDA… PALS…

There are many ways to tackle the challenges of restoration. Like many others, we advocate 'working with' systems (e.g. Zeedyk's 'Let the Water do the Work', our 'Let the Rodent do the Work'. This concept is embodied in calls for 'process based restoration'. There are plenty of examples of engineered approaches to restoration that 'ignore' process and obsessively focus on stability (confused with static) instead of working with systems. Although rare, there are some noteworthy examples of expensive, engineered solutions to process-based restoration (PBR). In this workshop, we focus exclusively on 'non-engineered' or 'low-tech' (PBR-lt or light) solutions to process based restoration. We do this because the scope of degradation is massive (millions of miles), and we need cheaper ways of addressing this problem that scale-up to the scope of degradation. Specific structures like BDAs (beaver dam analogues), one-rock dams, Zuni-bowls and PALS (post assisted log structures) will all have recipes to help you get started, but they themselves only become process based restoration when implemented at scale and in a manner designed to get the system to use its own processes to find a self-sustaining, long-term solution.

- See our ideas on Cheap & Cheerful Restoration: http://www.anabranchsolutions.com/cheap--cheerful-restoration.html
- our Philosophy: http://www.anabranchsolutions.com/our-philosophy.html
- our ambitions & goals: http://www.anabranchsolutions.com/about.html

ANABRANCH SOLUTIONS

GEOMORPHOLOGY EXCERCISE

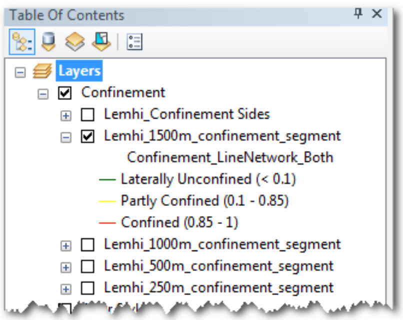
The valley bottom consists of the areas that could plausibly flood (i.e. floodplain). The building blocks of the valley bottom include the floodplain, and where present the channel(s) flowing through them, standing water bodies (ponds, lakes, etc.) and wetlands (Fryirs *et al.*, 2015). By contrast, valleys 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).

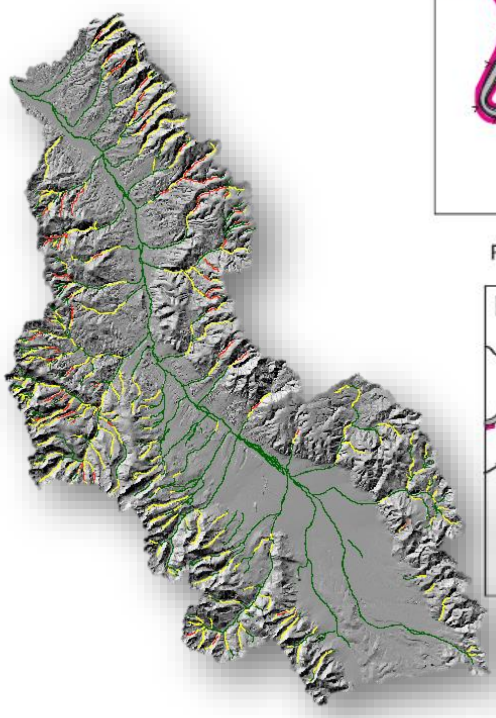
We will do an exercise in class to help you identify these features on a map, and then attempt to apply that same lens out in the field.

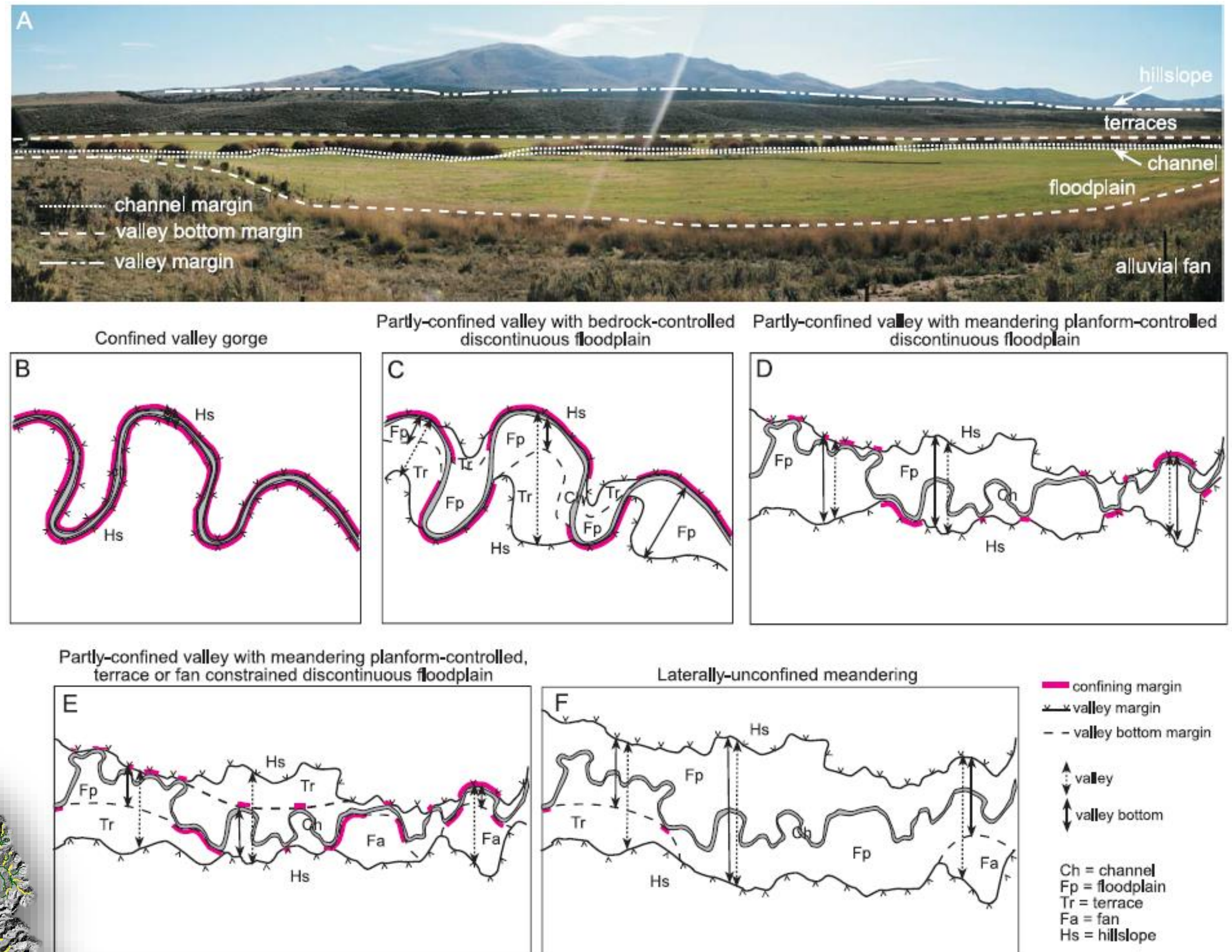
For more information see:

- Fryirs K, Wheaton J and Brierley GJ. 2015. An approach for measuring confinement and assessing the influence of valley setting on river forms and processes. Earth Surface Processes and Landfroms. DOI: 10.1002/esp.3893.
- Fryirs KA and Brierley GJ. 2013. Geomorphic Analysis of River Systems: An Approach to Reading the Landscape, First Edition. Blackwell Publishing Ltd.: Chichester, U.K., 345 pp.
- Wheaton J, Fryirs K, Brierley GJ, Bangen SG, Bouwes N and O'Brien G. 2015. Geomorphic Mapping and Taxonomy of Fluvial Landforms. Geomorphology. 248: 273-295. DOI: 10.1016/j.geomorph.2015.07.010.
- Design Manual: Chapter

CONTINUUM OF CONFINEMENT

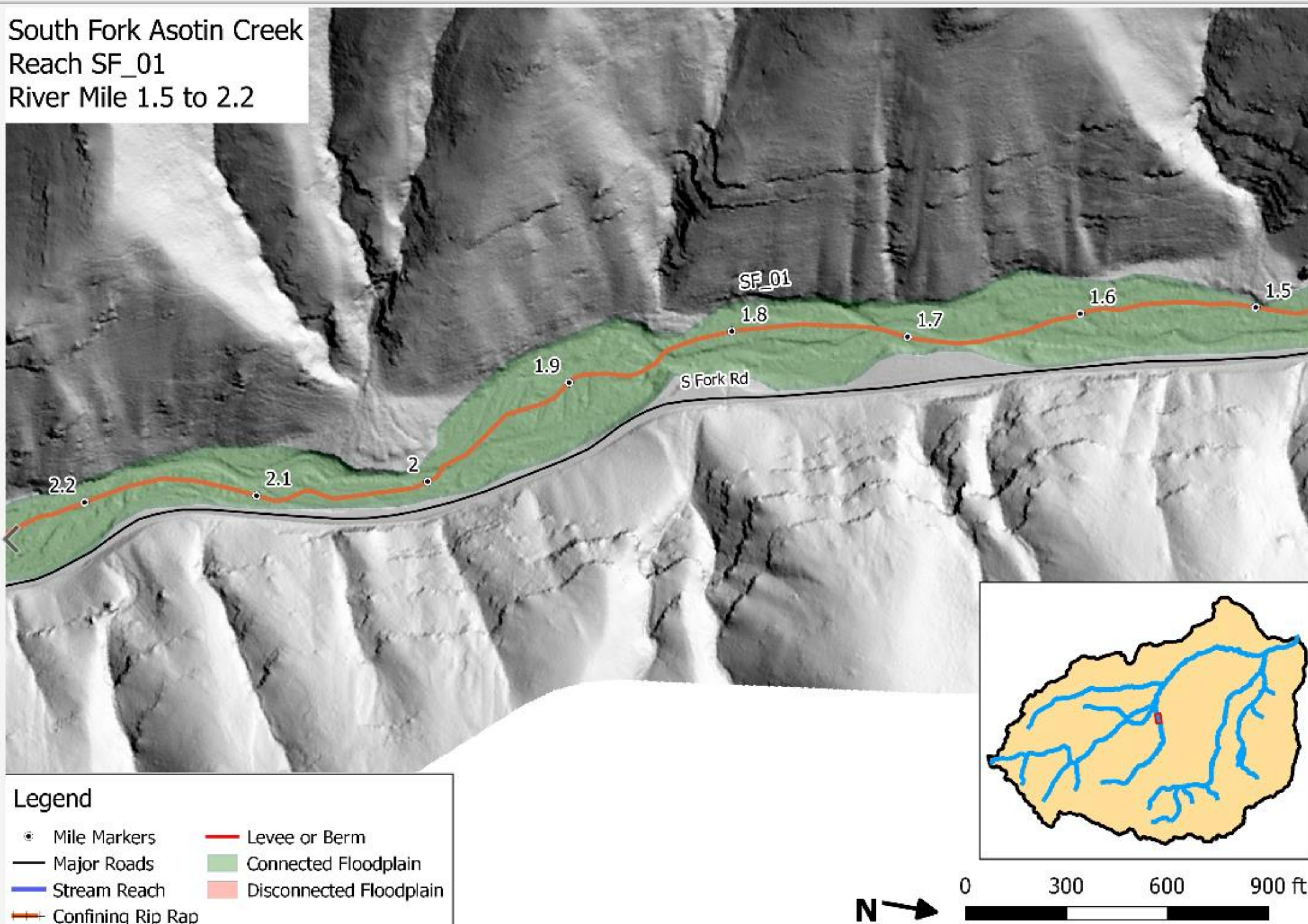






From: Fryirs et al. (2015) – ESPL;
DOI: 10.1002/esp.3893

EXERCISE 2 - VALLEY SETTING



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 restoraton.

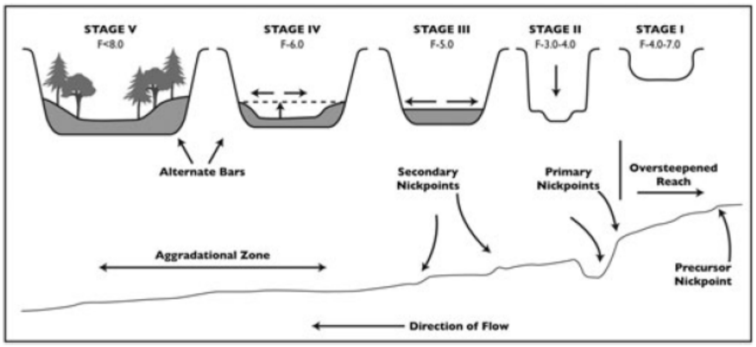


Figure 1. Schumm *et al.* (1984) Channel Evolution Model with typical width–depth ratios (F). The size of each arrow indicates the relative importance and direction of the dominant processes of degradation, aggradation and lateral bank erosion. (Redrawn with permission from Water Resources Publications)

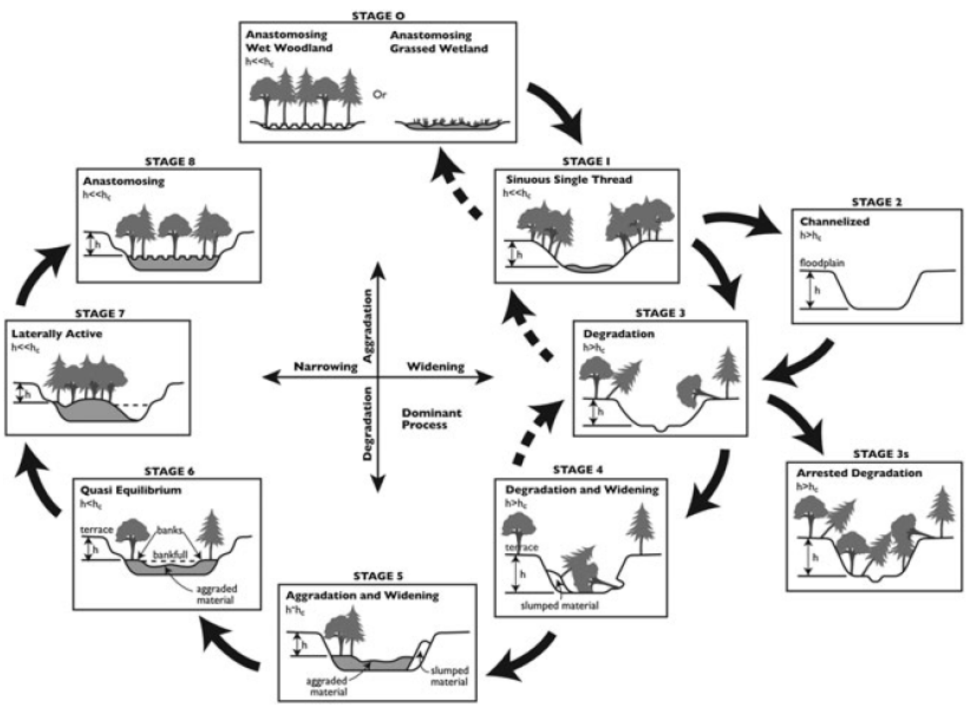


Figure 4. Stream Evolution Model based on combining the Channel Evolution Models in Figures 1–3, inserting a precursor stage to better represent pre-disturbance conditions, adding two successor stages to cover late-stage evolution and representing incised channel evolution as a cyclical rather than a 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 (3s) 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.

BioScience Advance Access published March 26, 2014

Overview Articles

Using Beaver Dams to Restore Incised Stream Ecosystems

MICHAEL M. POLLOCK, TIMOTHY J. BEECHIE, JOSEPH M. WHEATON, CHRIS E. JORDAN, NICK BOUWES, NICHOLAS WEBER, AND CAROL VOLK

Biogenic features such as beaver dams, large wood, and live vegetation are essential to the maintenance of complex stream ecosystems, but these features are largely absent from models of how streams change over time. Many streams have incised because of changing climate or land-use practices. Because incised streams provide limited benefits to biota, they are a common focus of restoration efforts. Contemporary models of long-term change in streams are focused primarily on physical characteristics, and most restoration efforts are also focused on manipulating physical rather than ecological processes. We present an alternative view, that stream restoration is an ecosystem process, and suggest that the recovery of incised streams is largely dependent on the interaction of biogenic structures with physical fluvial processes. In particular, we propose that live vegetation and beaver dams or beaver dam analogues can substantially accelerate the recovery of incised streams and can help create and maintain complex fluvial ecosystems.

Keywords: ecosystem restoration, stream restoration, conservation, beaver, Castor canadensis

Throughout many regions of the world, channel incision is a widespread environmental problem that has caused extensive ecosystem degradation (Wang et al. 1997, Montgomery 2007). The defining characteristics of an incised alluvial stream are a lowered streambed and disconnection from the floodplain (Darby and Simon 1999). The resulting changes in physical habitat degrade stream ecosystems (Shields et al. 1994, 2010). Ample evidence in the geological record indicates that channel incision occurs naturally and may be related to changes in climate (Bryan 1925, Elliot et al. 1999). However, a great many instances of channel incision have been shown to be caused by or to be correlated with changes in land use (Cooke and Reeves 1976, Montgomery 2007). Many of these changes are also contemporary with the widespread extirpation of beaver (*Castor canadensis*) in the nineteenth century (Naiman et al. 1988).

In addition to lowered streambed elevation and disconnection from the floodplain, common physical effects of alluvial incision include lowered groundwater tables, the loss of wetlands, lower summer base flows, warmer water temperatures, and the loss of habitat diversity. Biological effects include a substantial loss of riparian plant biomass and diversity and population declines in fish and other aquatic organisms (for a review, see Cluer and Thorne 2014).

Understanding how the ecology of an incised stream changes over time is essential for assessing recovery potential. However most incision–aggradation models describe only those geomorphological changes on the basis of relationships between sediment transport and hydrology. The role of living organisms is generally minimized, especially for beaver, live vegetation, and dead wood (Schumm et al. 1984, Simon and Hupp 1986, Elliot et al. 1999). The absence of beaver in such models is particularly notable, given their widely recognized role in shaping stream ecosystems (Naiman et al. 1988, Gurnell 1998, Pollock et al. 2003, Burchsted et al. 2010). More recently, incision–aggradation models have included floodplain complexes as an additional and ecologically desirable hydrogeomorphic stage that occurs in some fluvial ecosystems (see Cluer and Thorne 2014). Restoration of complex floodplains is important because such habitat is essential for the maintenance of biological diversity, including commercially important species, and for providing other important ecosystem services, such as flood control, groundwater recharge, and carbon storage (Grosholz and Gallo 2006, Westbrook et al. 2006, Jeffres et al. 2008, Wohl 2011, Bellmore et al. 2012, Cluer and Thorne 2014, Polvi and Wohl 2013).

In this article, we propose an alternative and more comprehensive view of stream evolution as an ecological—or more precisely, *ecogeomorphic*—process (*sensu* Wheaton et al. 2011). We provide a conceptual model for incised stream evolution that describes stream succession as a process dependent on the interaction of living organisms with hydrologic and sediment dynamics. We believe that such a model is consistent with recent findings concerning the role of biogenic features, such as wood and beaver dams, in

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doi:10.1093/biosci/biu036 Advance Access publication XXXX XX, XXXX

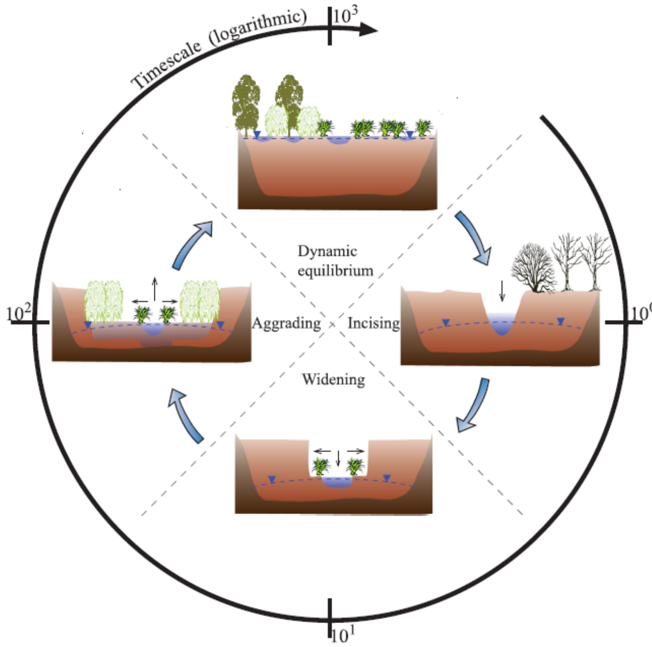


Figure 2. A simplified stream succession model showing the cyclical nature of incision-prone stream ecosystems on alluvial floodplains. Succession is divided into four phases: rapid incision, trench widening, slow aggradation, and dynamic equilibrium. This model highlights the dominant physical processes driving each phase and the common timescales for each phase. The small arrows highlight the direction of dominant and subdominant erosion or deposition; the dashed lines indicate water table elevation. Source: Adapted from Cluer and Thorne (2014).

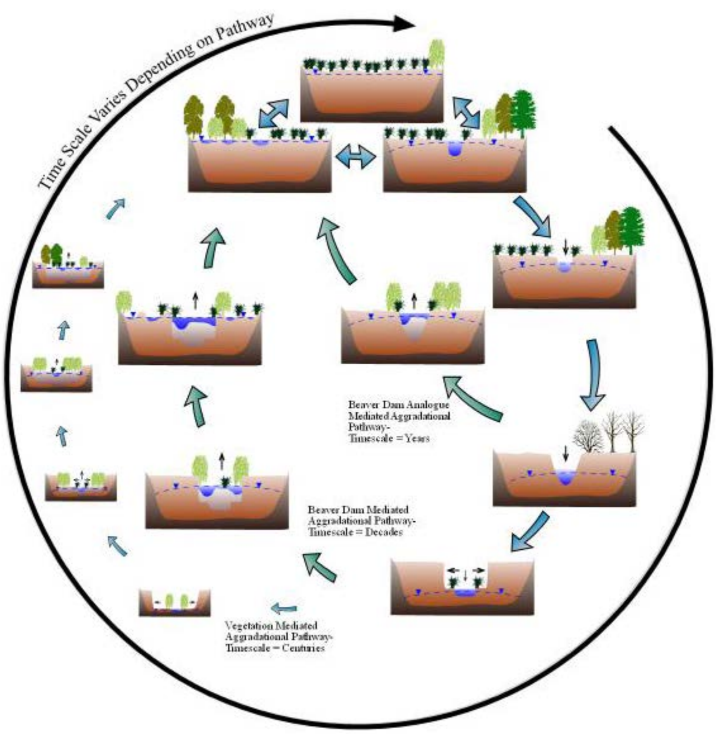


Figure 2 – Channel Evolution Models modified for beaver and BDAs.

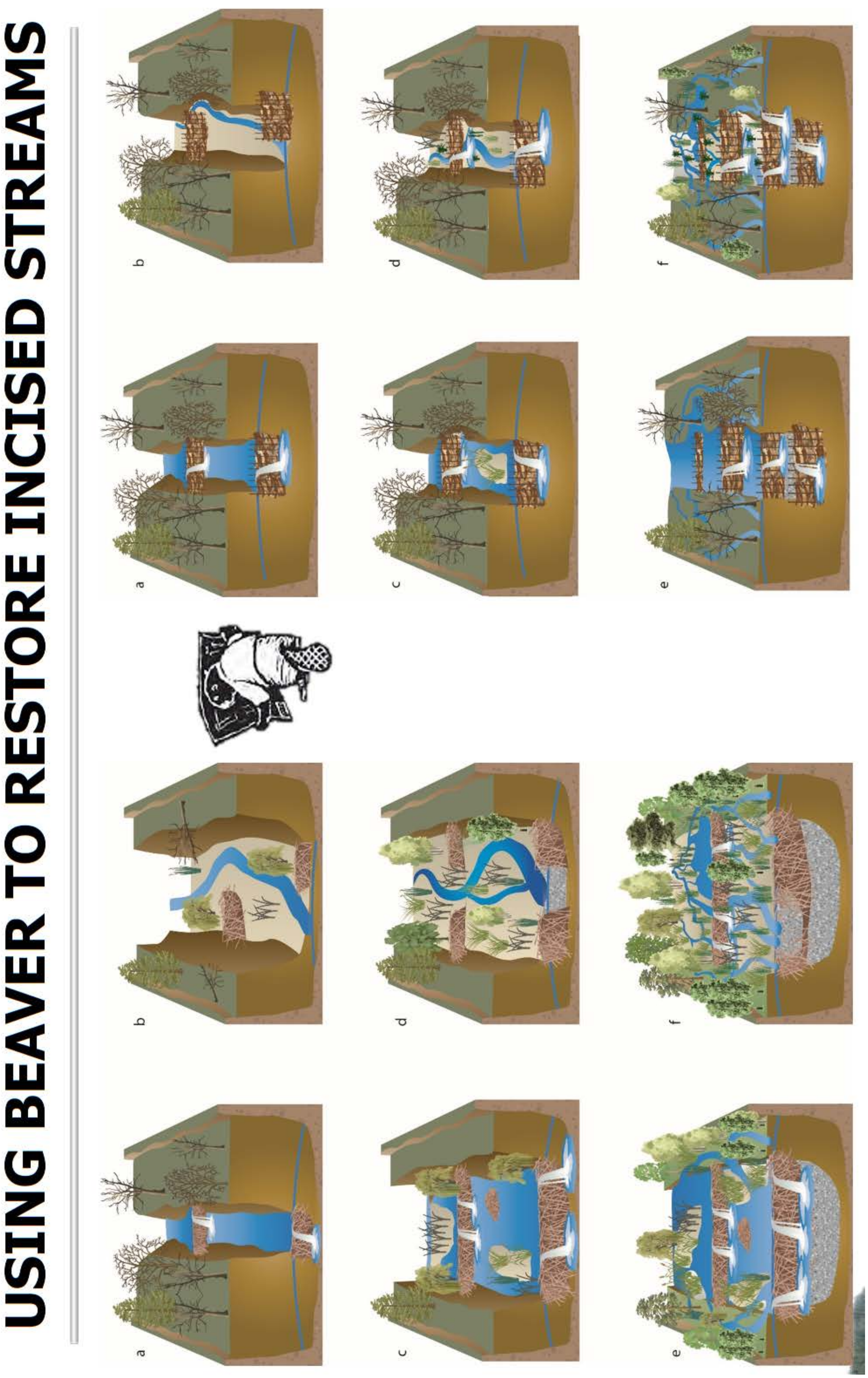
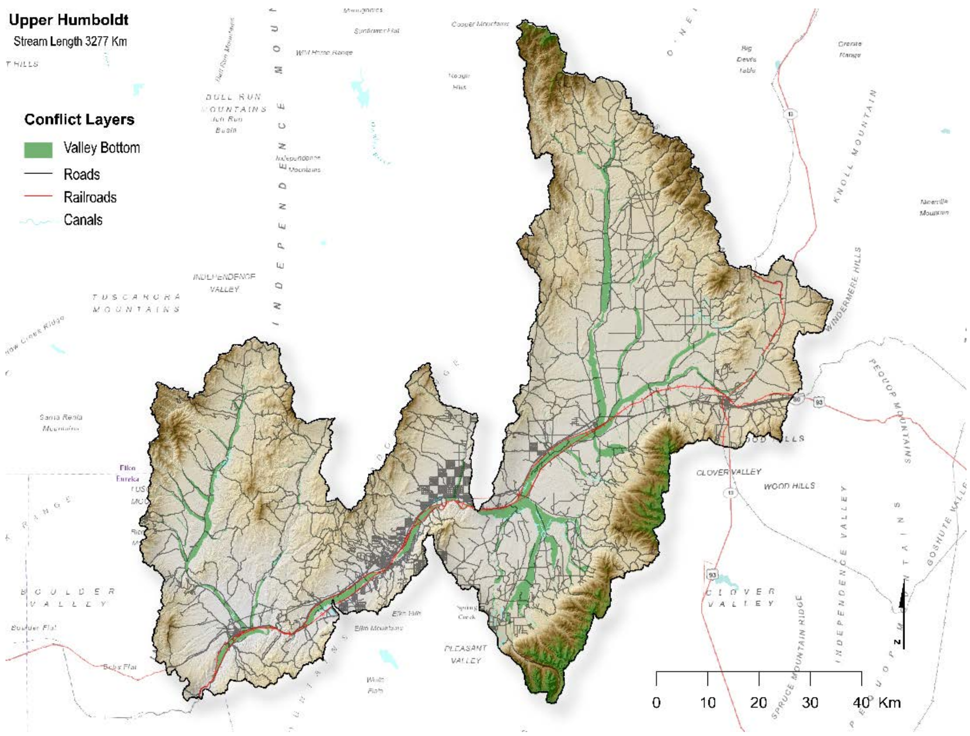


Figure 3 - Examples on left of acceleration of aggradation and recovery of incised channel with beaver dams and on right with BDAs. The big difference is who does the maintenance and when its done.



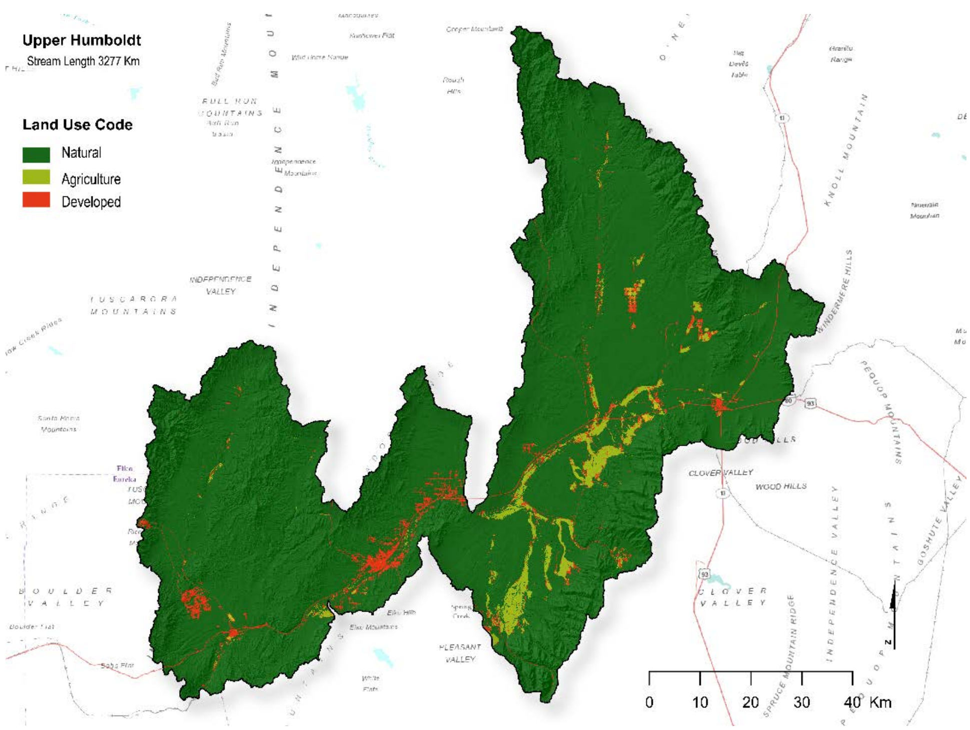


Figure 4 – Context maps for the Upper Humboldt watershed (maps from ET-AL). Top map shows overlay of valley bottoms, roads, railroads and canals on topography. The bottom map shows land use.

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 Sruvey 123.

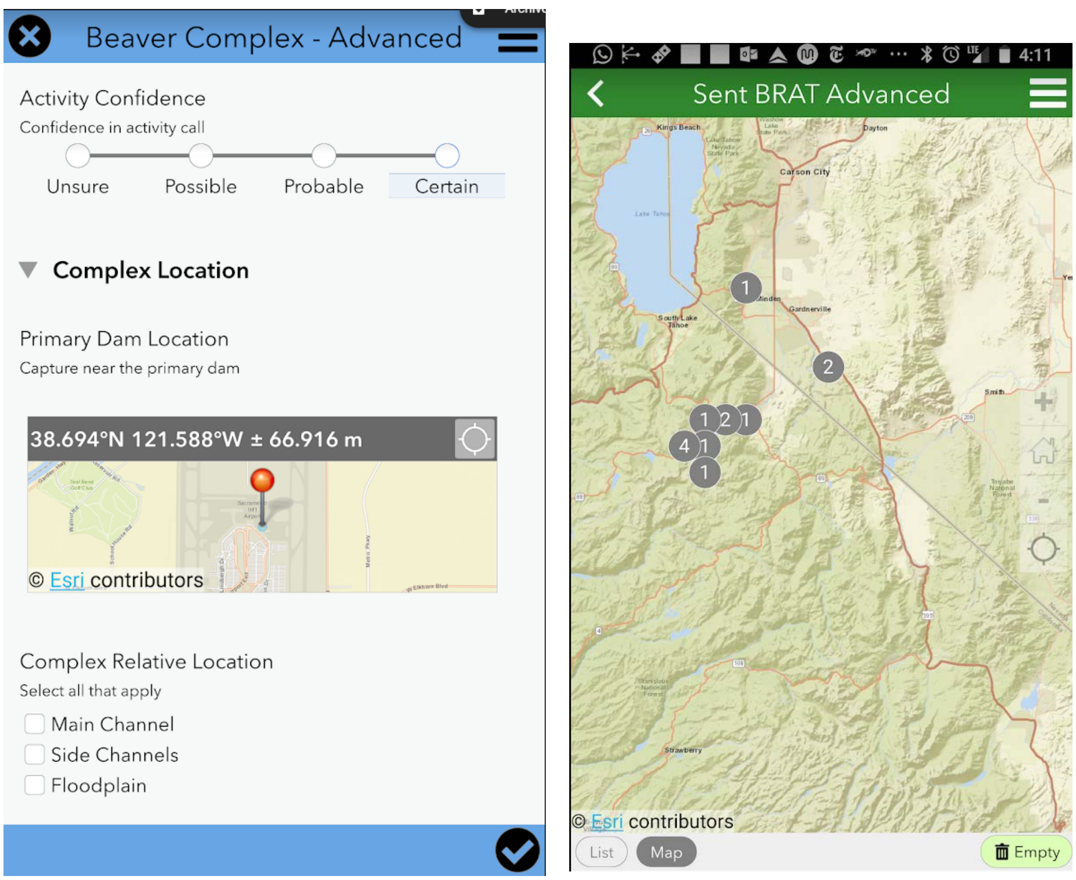


Figure 5 – Screen shots from Survey 123 Apps.

BEAVER ACTIVITY MONITORING FORM

Utah State University Restoration Consortium

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: ___________________________________

NOTES:

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

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

SCENT 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

DRAINING/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
○ 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.

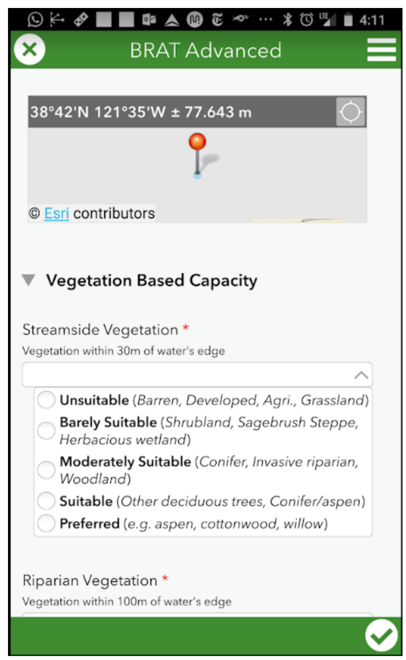
This model is part of the BRAT – Beaver Restoration Assessment Tool. It is part of a family of open-source tools our lab built and are available through the Riverscapes Consortium. See: http://brat.riverscapes.xyz

BRAT and RCAT are available for the state of Utah on the Utah GIS Portal, http://brat.riverscapes.xyz and Databasin.org.

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.



BRAT-cIS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC

UtahStateUniversity RESTORATION CONSORTIUM

OBSERVATION INFO

Observer Name: ____________________________

Reach ID: ____________________________

Observation Date: ____________________________

Stream Name: ____________________________

Location of Assessment Reach

GPS UTM Easting: ____________________________

GPS UTM Northing: ____________________________

Length of Reach

Length ____________ meters OR _______ x bankfull widths

VEGETATION CAPACITY 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)

If beavers build a dam, consider what happens to the dam(s) in a typical flood (e.g. mean annual flood)?

○ Blowout
○ Occasional Blowout
○ Occasional Breach
○ Dam Persists

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)

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)

0 - None | 0 - 1 Rare | 1 - 4 Occasional | 5 - 15 Frequent | 16 - 40 Pervasive

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 streamside vegetation and suitability of riparian/upland vegetation as inputs.

		Inputs				Output
Rules		**Suitability of streamside vegetation**	&	**Suitability of riparian/upland vegetation**		**Dam density capacity**
1	*If*	Unsuitable	&	Unsuitable	*, then*	None
2	*If*	Unsuitable	&	Barely suitable	*, then*	Rare
3	*If*	Unsuitable	&	Moderately suitable	*, then*	Rare
4	*If*	Unsuitable	&	Suitable	*, then*	Occasional
5	*If*	Unsuitable	&	Preferred	*, then*	Occasional
6	*If*	Barely suitable	&	Unsuitable	*, then*	Rare
7	*If*	Barely suitable	&	Barely suitable	*, then*	Rare
8	*If*	Barely suitable	&	Moderately suitable	*, then*	Occasional
9	*If*	Barely suitable	&	Suitable	*, then*	Occasional
10	*If*	Barely suitable	&	Preferred	*, then*	Occasional
11	*If*	Moderately suitable	&	Unsuitable	*, then*	Rare
12	*If*	Moderately suitable	&	Barely suitable	*, then*	Occasional
13	*If*	Moderately suitable	&	Moderately suitable	*, then*	Occasional
14	*If*	Moderately suitable	&	Suitable	*, then*	Frequent
15	*If*	Moderately suitable	&	Preferred	*, then*	Frequent
16	*If*	Suitable	&	Unsuitable	*, then*	Occasional
17	*If*	Suitable	&	Barely suitable	*, then*	Occasional
18	*If*	Suitable	&	Moderately suitable	*, then*	Frequent
19	*If*	Suitable	&	Suitable	*, then*	Frequent
20	*If*	Suitable	&	Preferred	*, then*	Pervasive
21	*If*	Preferred	&	Unsuitable	*, then*	Occasional
22	*If*	Preferred	&	Barely suitable	*, then*	Frequent
23	*If*	Preferred	&	Moderately suitable	*, then*	Pervasive
24	*If*	Preferred	&	Suitable	*, then*	Pervasive
25	*If*	Preferred	&	Preferred	*, then*	Pervasive

COMBINED INFERENCE SYSTEM:

Table 2. Rule table for four input inference system that models the capaicty of the reach to support dam building activity (in dam density) uisng the vegetation dam density capacity (output of Table 1 model), the two-year flood stream power, baseflow stream power and reach slope.

		Inputs								Output
Rules		**Vegetation dam density capacity**	&	**2-year flood stream power**	&	**Baseflow stream power**	&	**Reach slope**		**Dam density capacity**
1	*If*	None	&	-	&	-	&	-	, *then*	None
2	*If*	-	&	-	&	Cannot build dam	&	-	, *then*	None
3	*If*	-	&	-	&	-	&	Cannot build dam	, *then*	None
4	*If*	Rare	&	Dam persists	&	Can build dam	&	NOT Cannot build dam	, *then*	Rare
5	*If*	Rare	&	Dam persists	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Rare
6	*If*	Rare	&	Occasional breach	&	Can build dam	&	NOT Cannot build dam	, *then*	Rare
7	*If*	Rare	&	Occasional breach	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Rare
8	*If*	Rare	&	Occasional blowout	&	Can build dam	&	NOT Cannot build dam	, *then*	Rare
9	*If*	Rare	&	Occasional blowout	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Rare
10	*If*	Rare	&	Blowout	&	Can build dam	&	NOT Cannot build dam	, *then*	None
11	*If*	Rare	&	Blowout	&	Probably can build dam	&	NOT Cannot build dam	, *then*	None
12	*If*	Occasional	&	Dam persists	&	Can build dam	&	NOT Cannot build dam	, *then*	Occasional
13	*If*	Occasional	&	Dam persists	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Occasional
14	*If*	Occasional	&	Occasional breach	&	Can build dam	&	NOT Cannot build dam	, *then*	Occasional
15	*If*	Occasional	&	Occasional breach	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Occasional
16	*If*	Occasional	&	Occasional blowout	&	Can build dam	&	NOT Cannot build dam	, *then*	Occasional
17	*If*	Occasional	&	Occasional blowout	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Occasional
18	*If*	Occasional	&	Blowout	&	Can build dam	&	NOT Cannot build dam	, *then*	Rare
19	*If*	Occasional	&	Blowout	&	Probably can build dam	&	NOT Cannot build dam	, *then*	Rare
20	*If*	Frequent	&	Dam persists	&	Can build dam	&	Really flat	, *then*	Occasional
21	*If*	Frequent	&	Dam persists	&	Can build dam	&	Can build dam	, *then*	Frequent
22	*If*	Frequent	&	Dam persists	&	Can build dam	&	Probably can build dam	, *then*	Occasional
23	*If*	Frequent	&	Dam persists	&	Probably can build dam	&	Really flat	, *then*	Occasional
24	*If*	Frequent	&	Dam persists	&	Probably can build dam	&	Can build dam	, *then*	Frequent
25	*If*	Frequent	&	Dam persists	&	Probably can build dam	&	Probably can build dam	, *then*	Occasional
26	*If*	Frequent	&	Occasional breach	&	Can build dam	&	Really flat	, *then*	Occasional
27	*If*	Frequent	&	Occasional breach	&	Can build dam	&	Can build dam	, *then*	Frequent
28	*If*	Frequent	&	Occasional breach	&	Can build dam	&	Probably can build dam	, *then*	Occasional
29	*If*	Frequent	&	Occasional breach	&	Probably can build dam	&	Really flat	, *then*	Occasional
30	*If*	Frequent	&	Occasional breach	&	Probably can build dam	&	Can build dam	, *then*	Frequent
31	*If*	Frequent	&	Occasional breach	&	Probably can build dam	&	Probably can build dam	, *then*	Occasional
32	*If*	Frequent	&	Occasional blowout	&	Can build dam	&	Really flat	, *then*	Occasional
33	*If*	Frequent	&	Occasional blowout	&	Can build dam	&	Can build dam	, *then*	Frequent
34	*If*	Frequent	&	Occasional blowout	&	Can build dam	&	Probably can build dam	, *then*	Occasional
35	*If*	Frequent	&	Occasional blowout	&	Probably can build dam	&	Really flat	, *then*	Rare
36	*If*	Frequent	&	Occasional blowout	&	Probably can build dam	&	Can build dam	, *then*	Occasional
37	*If*	Frequent	&	Occasional blowout	&	Probably can build dam	&	Probably can build dam	, *then*	Rare
38	*If*	Frequent	&	Blowout	&	Can build dam	&	Really flat	, *then*	Rare
39	*If*	Frequent	&	Blowout	&	Can build dam	&	Can build dam	, *then*	Rare
40	*If*	Frequent	&	Blowout	&	Can build dam	&	Probably can build dam	, *then*	Rare
41	*If*	Frequent	&	Blowout	&	Probably can build dam	&	Really flat	, *then*	Rare
42	*If*	Frequent	&	Blowout	&	Probably can build dam	&	Can build dam	, *then*	Rare
43	*If*	Frequent	&	Blowout	&	Probably can build dam	&	Probably can build dam	, *then*	Rare
44	*If*	Pervasive	&	Dam persists	&	Can build dam	&	Really flat	, *then*	Frequent
45	*If*	Pervasive	&	Dam persists	&	Can build dam	&	Can build dam	, *then*	Pervasive
46	*If*	Pervasive	&	Dam persists	&	Can build dam	&	Probably can build dam	, *then*	Frequent
47	*If*	Pervasive	&	Dam persists	&	Probably can build dam	&	Really flat	, *then*	Frequent
48	*If*	Pervasive	&	Dam persists	&	Probably can build dam	&	Can build dam	, *then*	Pervasive
49	*If*	Pervasive	&	Dam persists	&	Probably can build dam	&	Probably can build dam	, *then*	Frequent
50	*If*	Pervasive	&	Occasional breach	&	Can build dam	&	Really flat	, *then*	Frequent
51	*If*	Pervasive	&	Occasional breach	&	Can build dam	&	Can build dam	, *then*	Pervasive
52	*If*	Pervasive	&	Occasional breach	&	Can build dam	&	Probably can build dam	, *then*	Frequent
53	*If*	Pervasive	&	Occasional breach	&	Probably can build dam	&	Really flat	, *then*	Frequent
54	*If*	Pervasive	&	Occasional breach	&	Probably can build dam	&	Can build dam	, *then*	Pervasive
55	*If*	Pervasive	&	Occasional breach	&	Probably can build dam	&	Probably can build dam	, *then*	Frequent
56	*If*	Pervasive	&	Occasional blowout	&	Can build dam	&	Really flat	, *then*	Frequent
57	*If*	Pervasive	&	Occasional blowout	&	Can build dam	&	Can build dam	, *then*	Pervasive
58	*If*	Pervasive	&	Occasional blowout	&	Can build dam	&	Probably can build dam	, *then*	Frequent
59	*If*	Pervasive	&	Occasional blowout	&	Probably can build dam	&	Really flat	, *then*	Occasional
60	*If*	Pervasive	&	Occasional blowout	&	Probably can build dam	&	Can build dam	, *then*	Frequent
61	*If*	Pervasive	&	Occasional blowout	&	Probably can build dam	&	Probably can build dam	, *then*	Occasional
62	*If*	Pervasive	&	Blowout	&	Can build dam	&	Really flat	, *then*	Occasional
63	*If*	Pervasive	&	Blowout	&	Can build dam	&	Can build dam	, *then*	Occasional
64	*If*	Pervasive	&	Blowout	&	Can build dam	&	Probably can build dam	, *then*	Rare
65	*If*	Pervasive	&	Blowout	&	Probably can build dam	&	Really flat	, *then*	Occasional
66	*If*	Pervasive	&	Blowout	&	Probably can build dam	&	Can build dam	, *then*	Occasional
67	*If*	Pervasive	&	Blowout	&	Probably can build dam	&	Probably can build dam	, *then*	Rare

BRAT OUTPUTS FOR UPPER HUMBOLDT WATERSHED

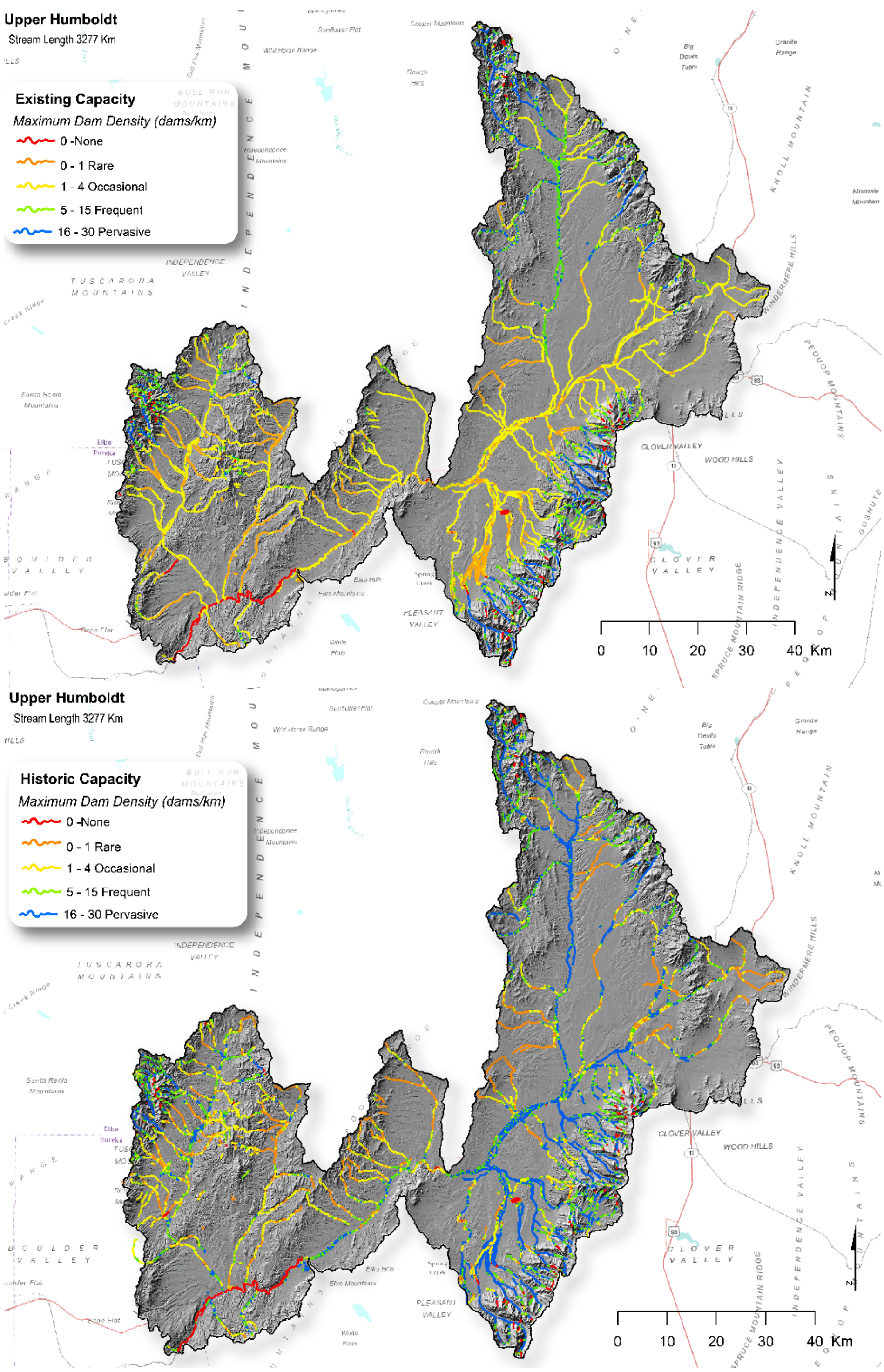


Figure 6 - Contrast in provisional (non-calibrated or validated) outputs of BRAT capacity model between existing (top) and estimated historic conditions (bottom) showing significant reductions in capacity in middle and lower parts of the watershed.

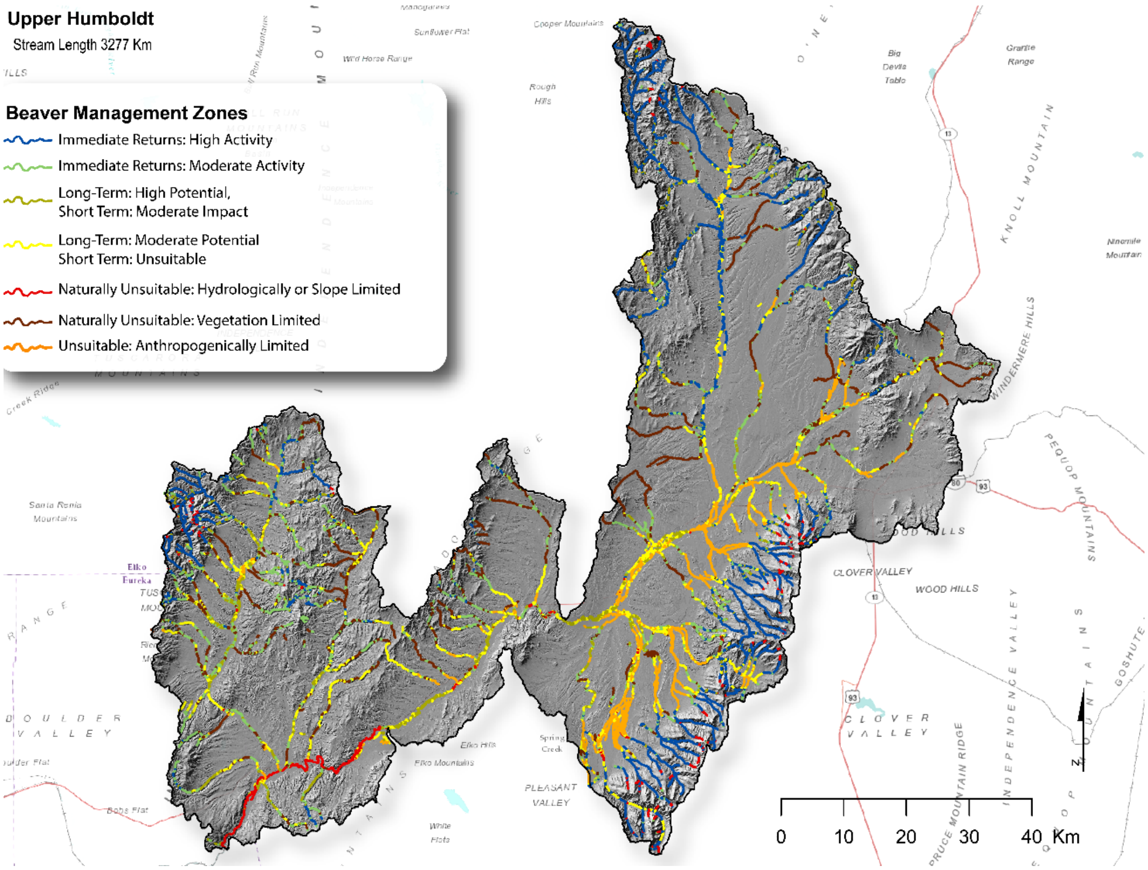


Figure 7 - A provisional automated generation of potential conservation and restoration zones (immediate returns vs. long-term) based on existing and historic capacities. NOTE: this DOES not constitute an actual management model.

RCAT OUTPUTS FOR POPO AGIE WATERSHED

Whereas BRAT focuses specifically on where and where not beaver might build dams and their appropriateness as a restoration tool, RCAT (Riparian Condition Assessment Tool: http://rcat.riverscapes.xyz) attempts to assess overall riparian condition and causes of degradation.

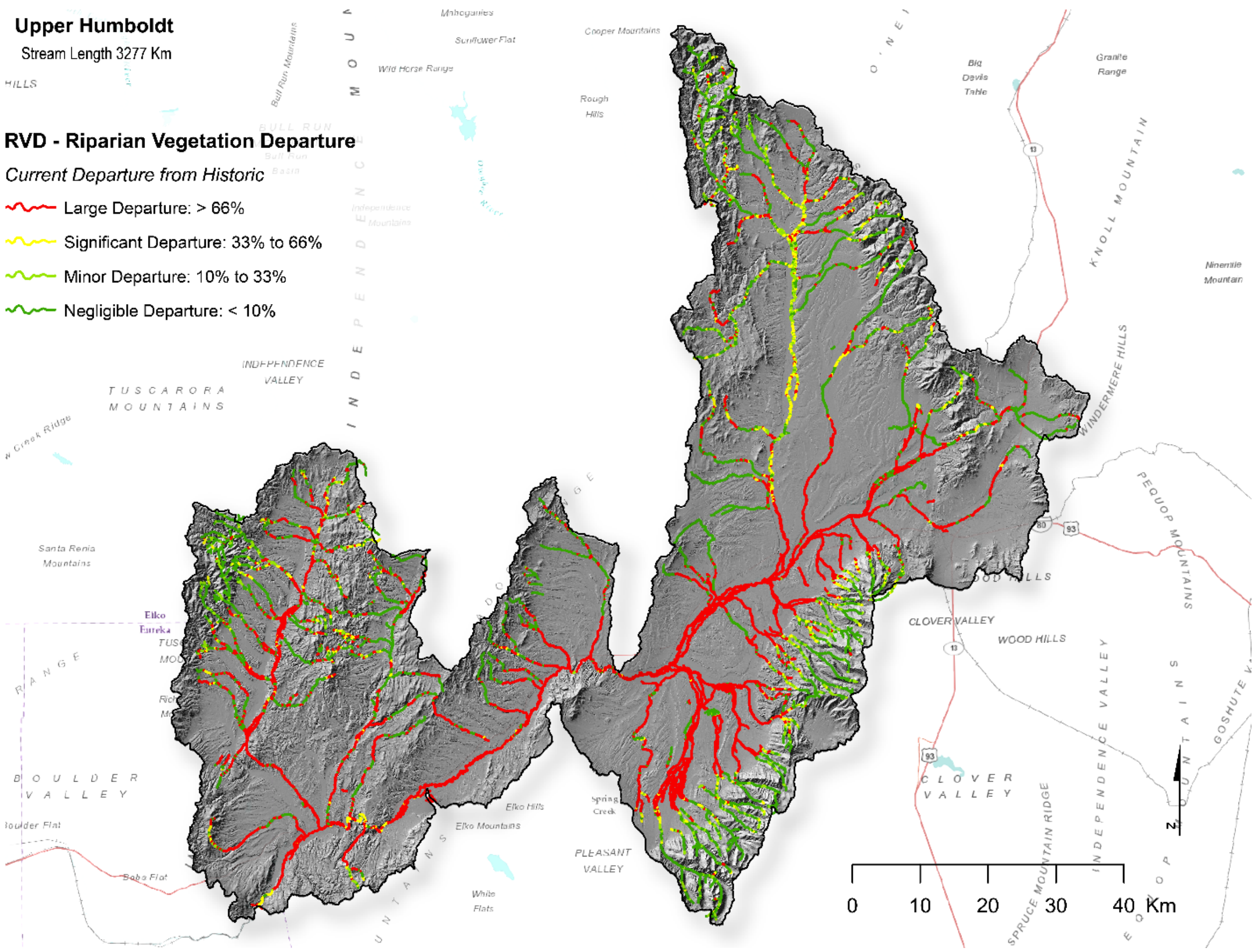
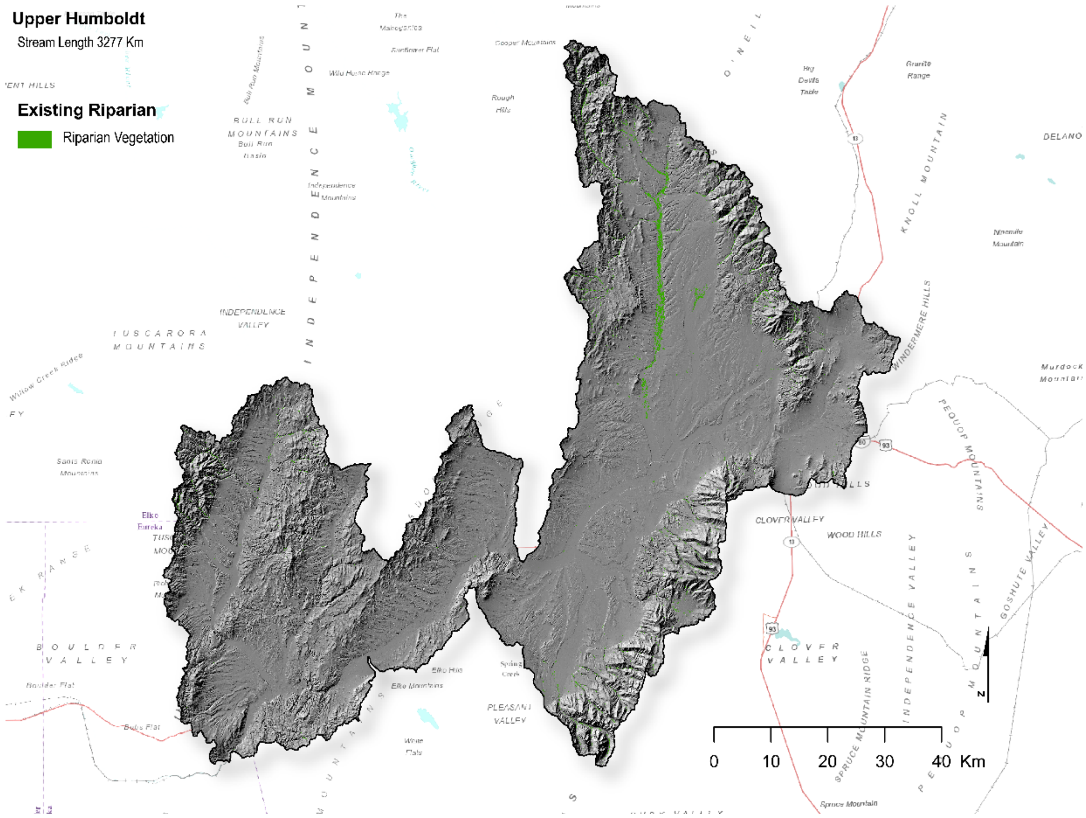


Figure 8 - One of the outputs of RCAT is an estimate of how much vegetation has been lost within the valley bottom relative to pre-European disturbance. We call this riparian vegetation departure and its reported as percent of original riparian extent. See Macfarlane et al. (2017).



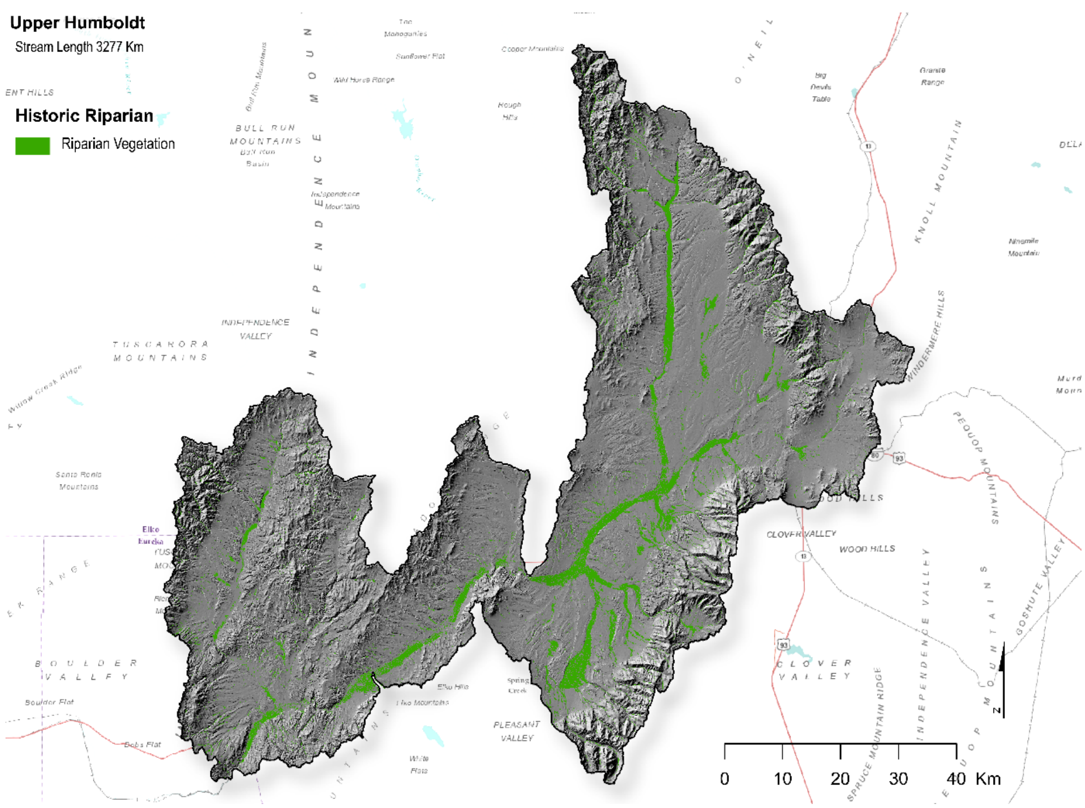


Figure 9 - Another way of visualizing what was presented in Figure 10 of the riparian vegetation departure is to look at the contrast between what riparian vegetation is left today (top) and what it once might have been (bottom).

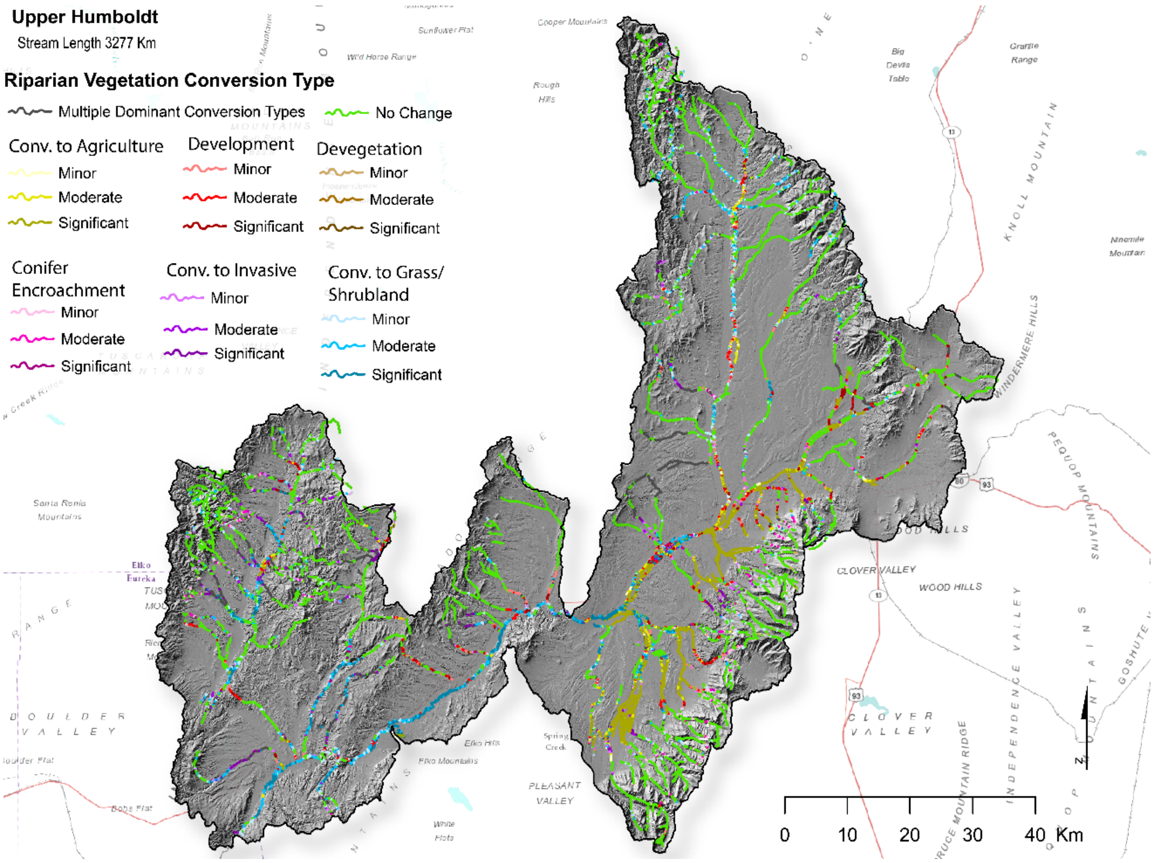


Figure 10 - We can take a closer look at the reaches that have experienced high riparian vegetation departure (i.e. non-green above) and what are the causes of that departure.

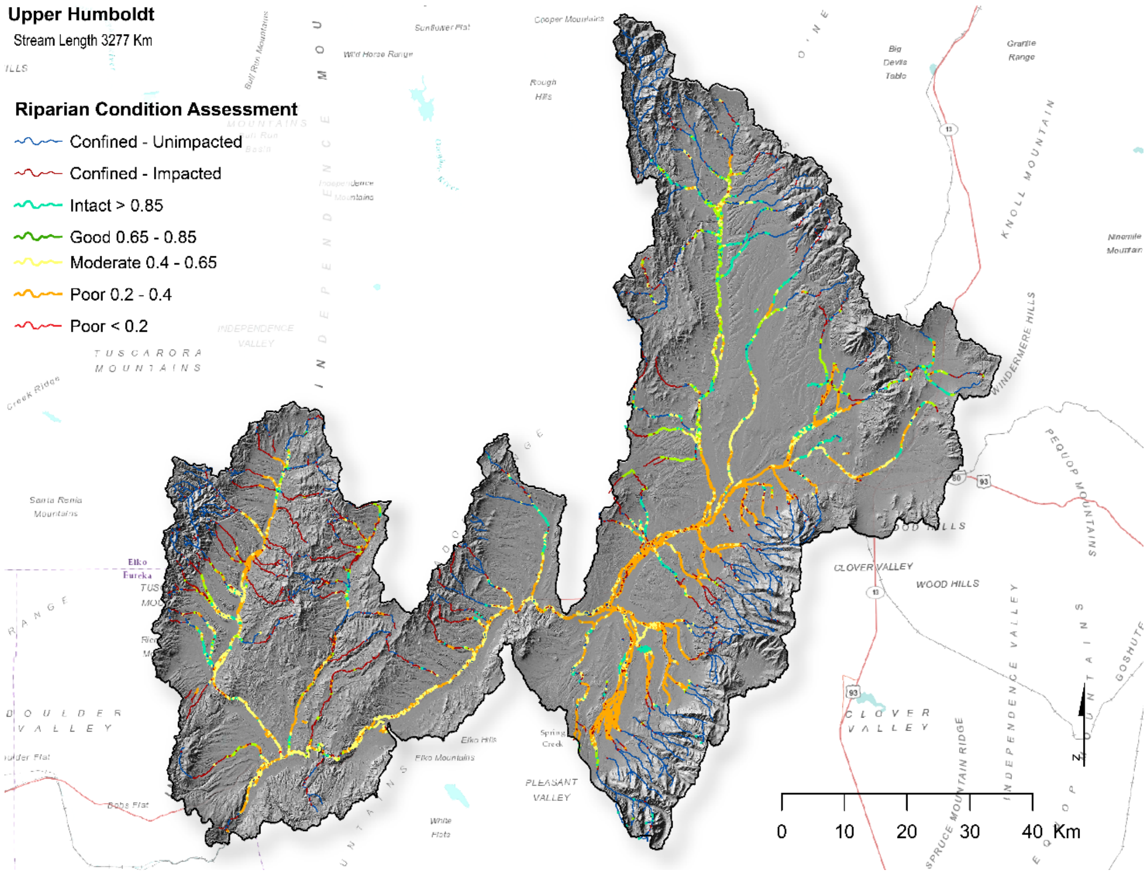


Figure 11 - Finally, we can combine the Riparian Vegetation Departure, with land use intensity, and floodplain accessibility to look at an overall score of riparian condition. See Macfarlane et al. (2018) for details.

MITIGATING SOME UNDESIREABLE BEAVER ACTIVITY

While the threats to infrastructure within Birch 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/

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).

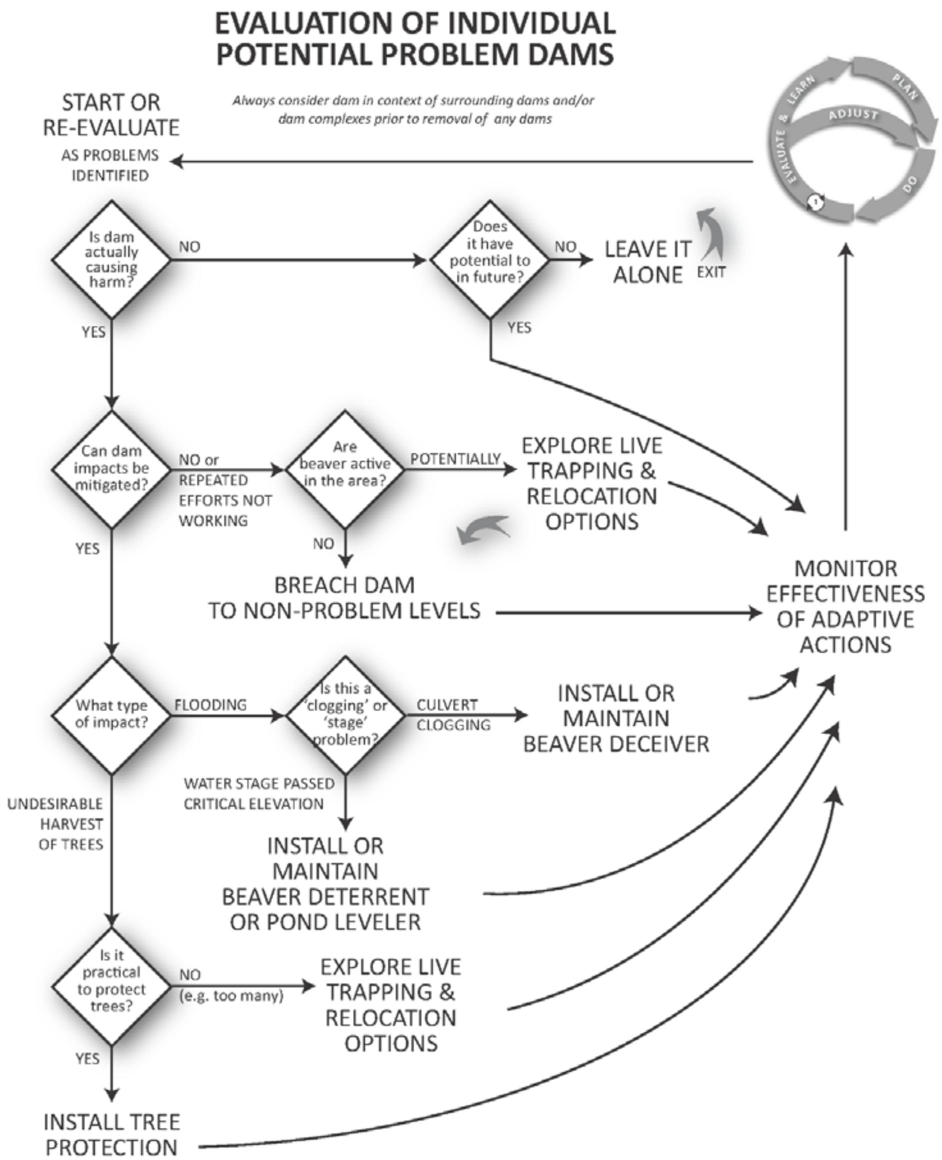
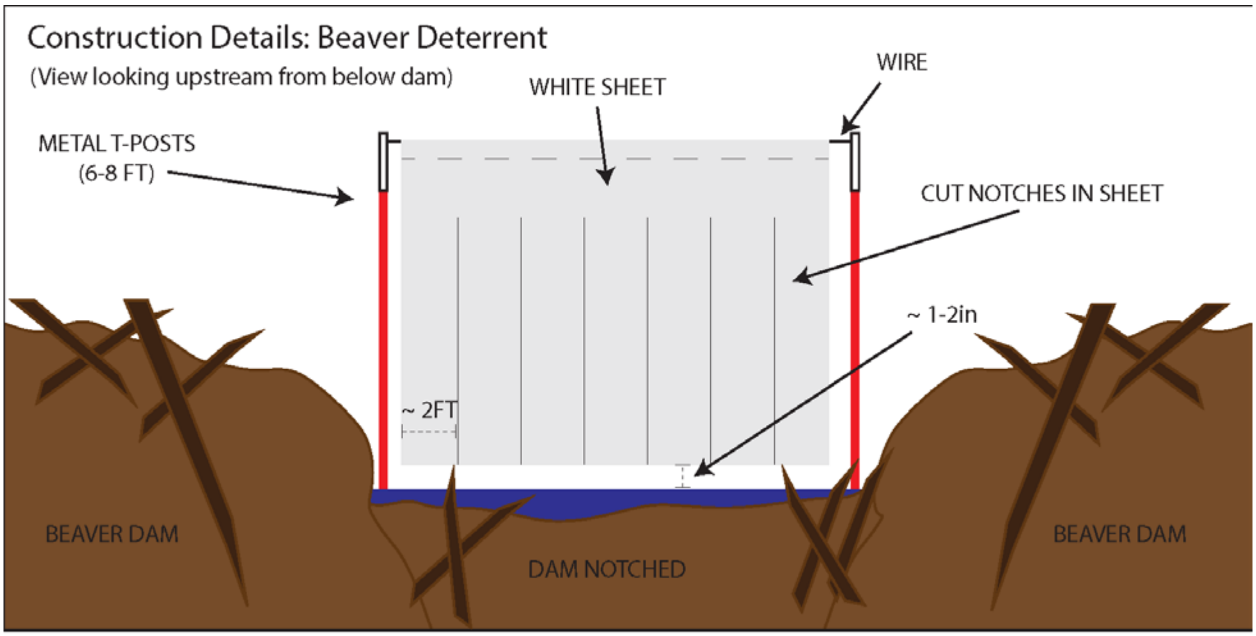


Figure 12 – Flow chart illustrating a monitoring and evaluation protocol for potential risk posed by beaver activity. Chart highlights decisions and evaluations in diamonds, and recommends management actions in CAPITALS. Figure from (Wheaton, 2013).

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.



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 13 – 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 14 – 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.

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

Previous workshop participants demonstrating improper PPE.

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

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

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

BDA Post Pounder Summary

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

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

	Driver	Power Supply
Type	**Hydraulic**	**Gas Generator**
Weight lbs.	**75**	**250**
Example Model	**LPD-T HBP**	**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) cab 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**

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

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

	Driver	Power Supply
Type	**Hydraulic**	**Gas Generator**
Weight lbs.	**70**	**100**
Example Model	**HP 20**	**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) cab 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**

BDA Post Pounder Summary

Brand **Rhino** Cost $ **2000**

Minimum Crew **1** Maximum Post Diameter **4 - 6**

	Driver	Power Supply
Type	**Pneumatic**	**Compressor**
Weight lbs.	**50 - 100**	**None**
Example Model	**PD 55**	**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**

Brand **Redi** Cost $ **1500 - 2500**

Minimum Crew **1** Maximum Post Diameter **3**

	Driver	Power Supply
Type	**Gas**	**Gas Engine**
Weight lbs.	**40**	**None**
Example Model	**Redi Classic**	**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/**

BDA Post Pounder Summary

Brand **Kiwi & others** Cost $ **2500 - 10,000**

Minimum Crew **1** Maximum Post Diameter **> 6**

	Driver	Power Supply
Type	**Tractor**	**Air/Hydraulic**
Weight lbs.	**> 100**	**> 500**
Example Model	**HP1000**	**NA**

Application

Good for tough jobs when road access is available

Comments

URL **http://www.kencove.com/fence/Post+Drivers_products.php**

POST-ASSISTED BEAVER DAM ANALOGUE RECIPE

For more information on BDAs, see:

- http://www.anabranchsolutions.com/beaver-dam-analogs.html
- Chapter 11 – Beaver Dam Analogues of Design Manual

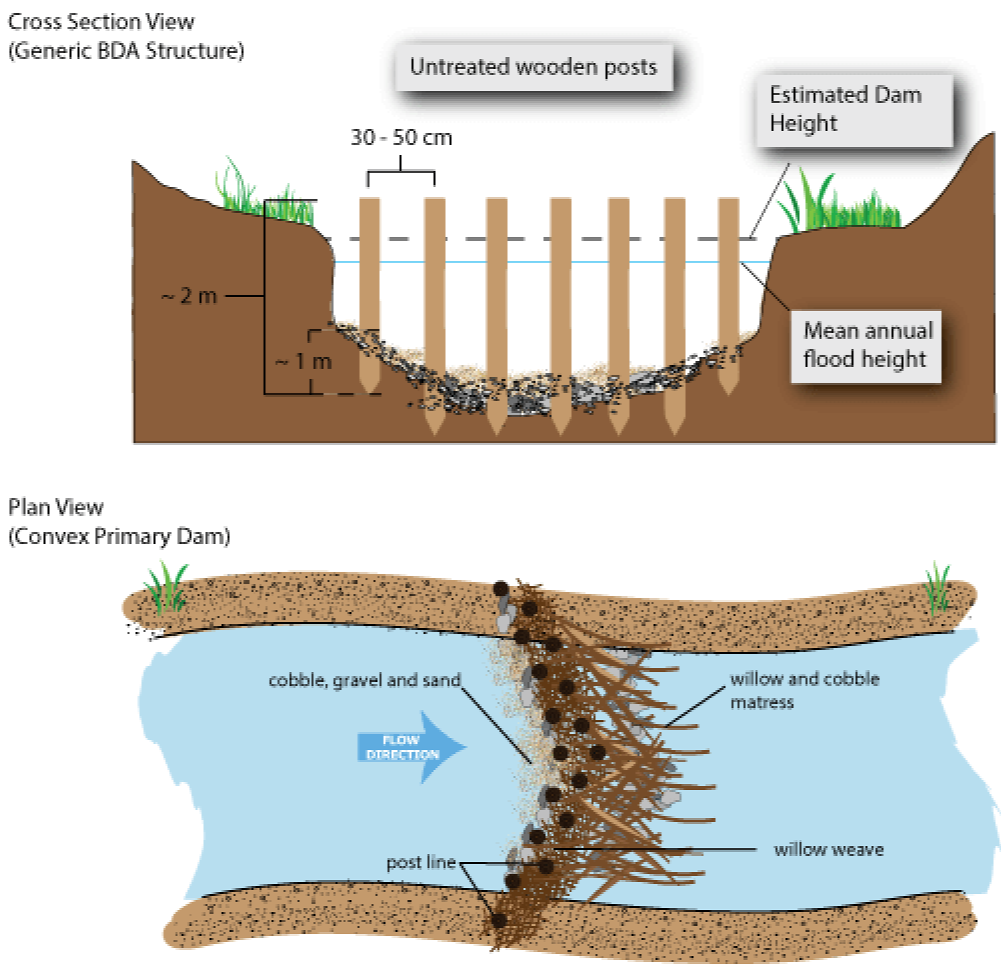


Figure 15 – One of the original BDA figures (drawn by Nick Weber)

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 covex 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 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

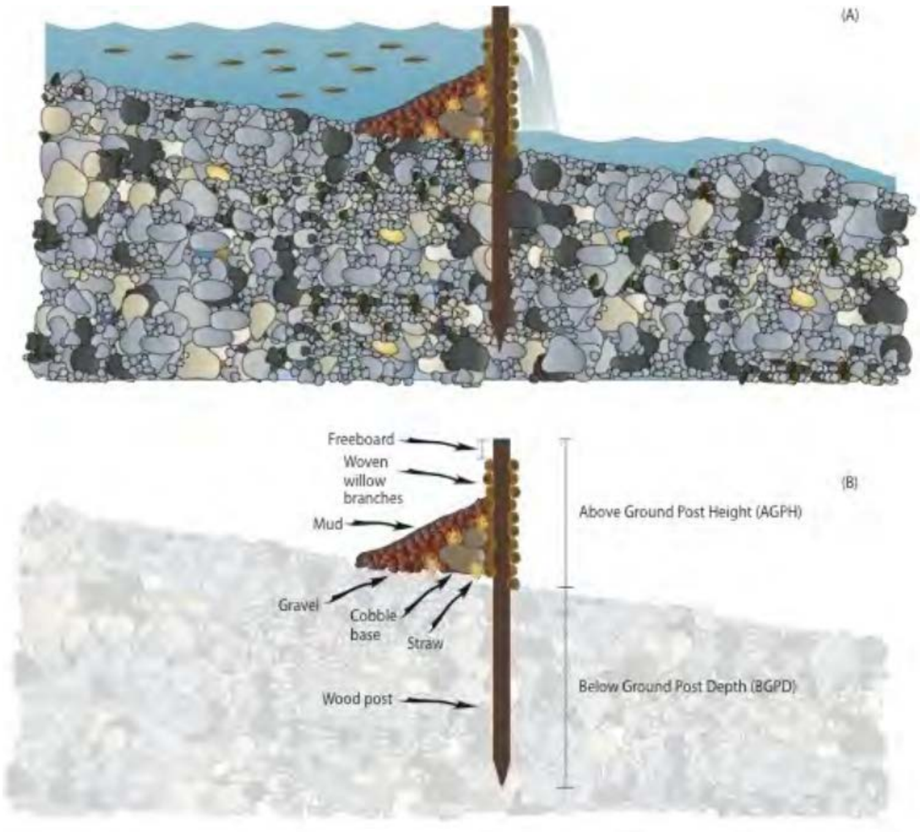


Figure 16 – Part of Figure 26 from Beaver Restoration Guidebook… Showing BDA as a wall. Figure 26 from Pollock et al. (2018).

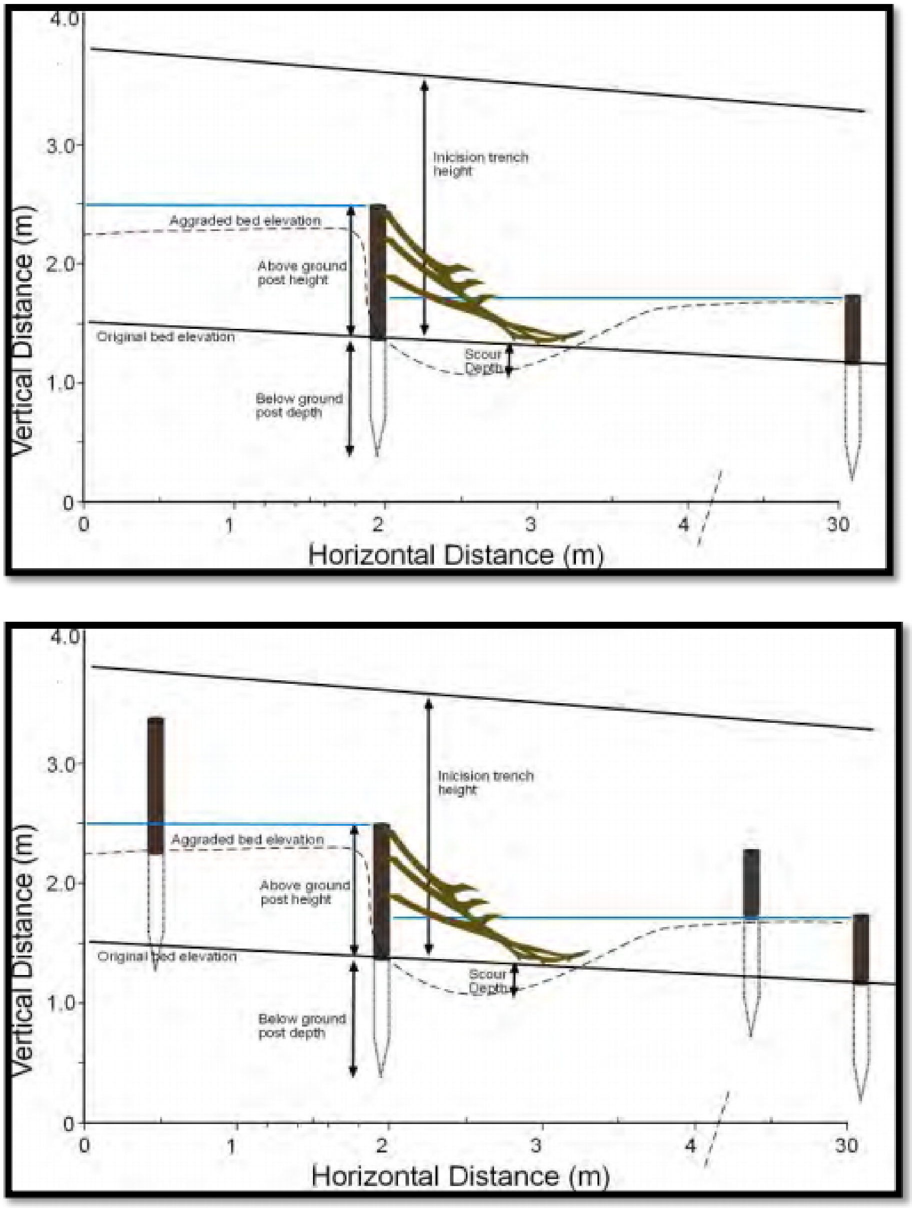


Figure 28: Side view of beaver dam analogues designed to aggrade a bed within an incision trench. (top) Year one placement. The downstream BDA backs up water to the upstream BDA, forming a water "pillow" that helps prevent overtopping scour below the upstream structure. Willow branches can be placed 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 scoured 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 scoured 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.

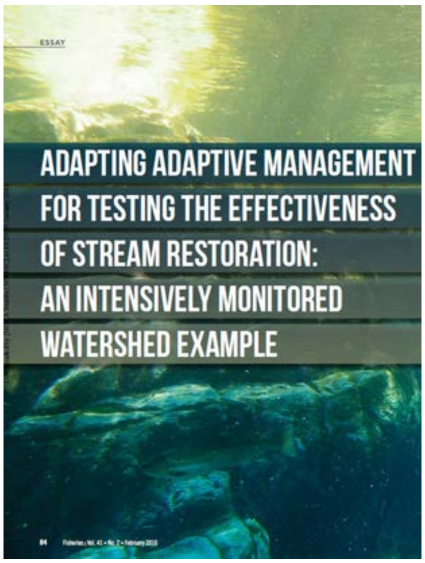
Figure 17 – Example of staged, implementation of BDAs on top of an old BDA complex once the ponds aggrade. Figure 28 from Pollock et al. (2018).

Figure 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.

Figure 18 – There are lots of ways to drive posts into as streambed, but hydraulic assistance is typically used. Hand operated post poudners 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 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).

ADAPTIVE MANAGEMENT OPTIONS

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.

- 2016. Bouwes N, Bennett S and Wheaton JM. Adapting Adaptive Management for Testing the Effectiveness of Stream Restoration: An Intensively Monitored Watershed Example. Fisheries. 41: 2: pp. 84-91. DOI: dx.doi.org/10.1080/03632415.2015.1127806

EXAMPLES OF ADAPTIVE MANAGEMENT PLANS

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- Shahverdian S, Macfarlane WW and Wheaton JM. 2016. MEMO: Westerly Creek Beaver Dam Capacity Assessment: Developing Realistic Expectations for Beaver Dam Activity. Prepared for Muller Engineering Company, Anabranch Solutions, Logan, UT, 24 pp. DOI: 10.13140/RG.2.2.34120.93446
- Portugal, E., Wheaton, JM., Sorenson, K., Majerova, M., Hunt, B., Bouwes, N. 2015. Hardware Ranch Adaptive Beaver Management Plan. Prepared for Utah Division of Wildlife Resources. Logan, Utah. 26 Pages. DOI: 10.13140/RG.2.2.29887.30883
- Portugal E., Wheaton, JM., Bouwes, N. 2015. Spring Creek Wetland Area Adaptive Beaver Management Plan. Prepared for Walmart Stores Inc. and the City of Logan. Logan, Utah. 25 Pages. DOI: 10.13140/RG.2.1.2075.3361
- Wheaton JM. 2013. Scoping Study and Recommendations for an Adaptive Beaver Management Plan. Prepared for Park City Municipal Corporation. Logan, Utah, 30 pp. DOI: 10.6084/m9.figshare.903648.
- Wheaton J, Bennett S, Bouwes N, and Camp R. 2012. Asotin Creek Intensively Monitored Watershed: Restoration Plan for North Fork Asotin, South Fork Asotin and Charlie Creeks, Eco Logical Research, Inc., Prepared for Snake River Salmon Recovery Board. Logan, UT, 125 pp.
- Pollock M, Wheaton JM, Bouwes N and Jordan CE. 2011. Working with Beaver to Restore Salmon Habitat in the Bridge Creek Intensively Monitored Watershed: Design Rationale and Hypotheses, Interim Report, NOAA Northwest Fisheries Science Center, Seattle, WA, 63 pp.

TRANSPARENT, REPEATABLE, HYPOTHESIS DRIVEN DESIGN

In 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.

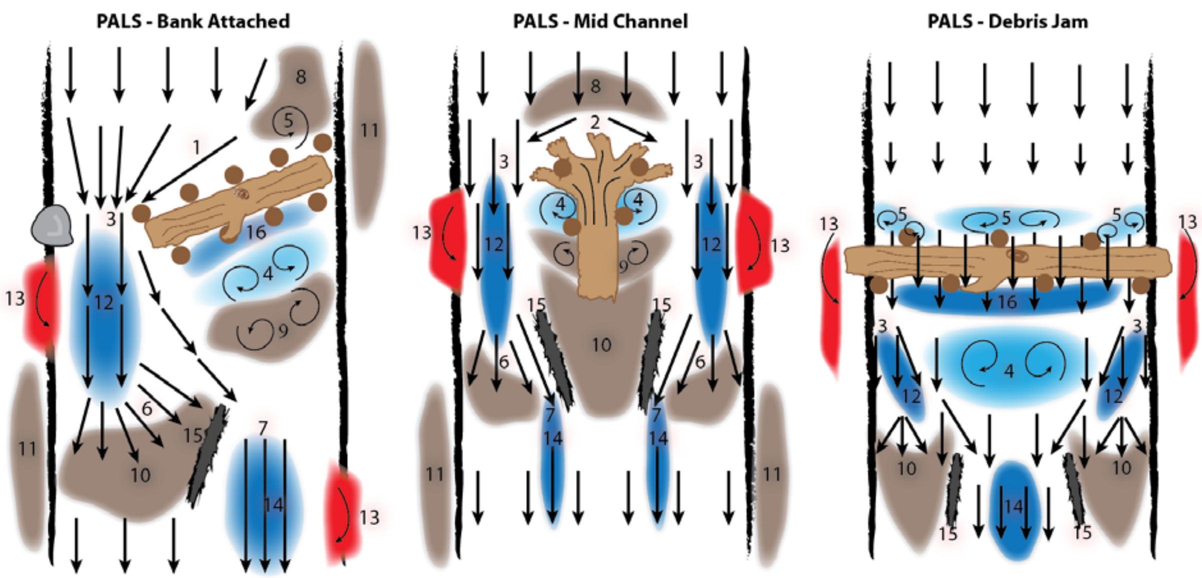
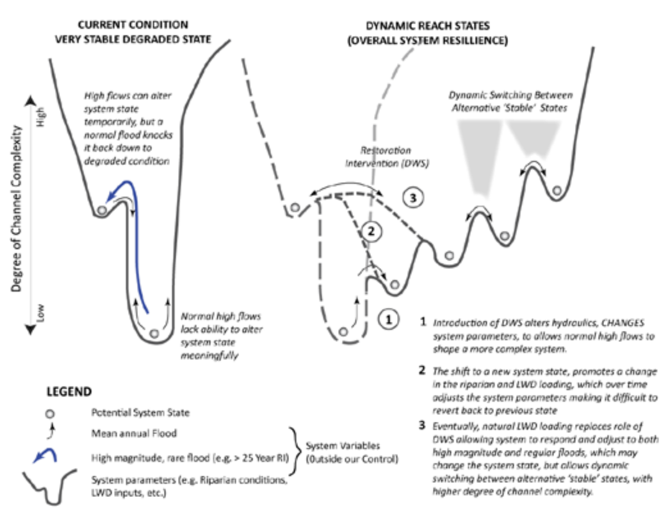


Figure 19 – Examples of predicted hydraulic and geomorphic responses associated with PALS (post assisted log structures) from (Camp, 2015).



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 CONSTRICTION (% 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
□ ______________________________

○ Materials Sourced on-site?
○ Materials Imported

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 ○ Minor Sedimentation
- ○ 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 ○ Minor Sedimentation
- ○ 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) ○ Sands
- ○ Gravels ○ Cobble
- ○ Food Cache & Fines

Expected Dominant Substrate Downstream of Structure

- ○ Fines (clays and silts) ○ Sands
- ○ Gravels ○ Cobble
- ○ 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

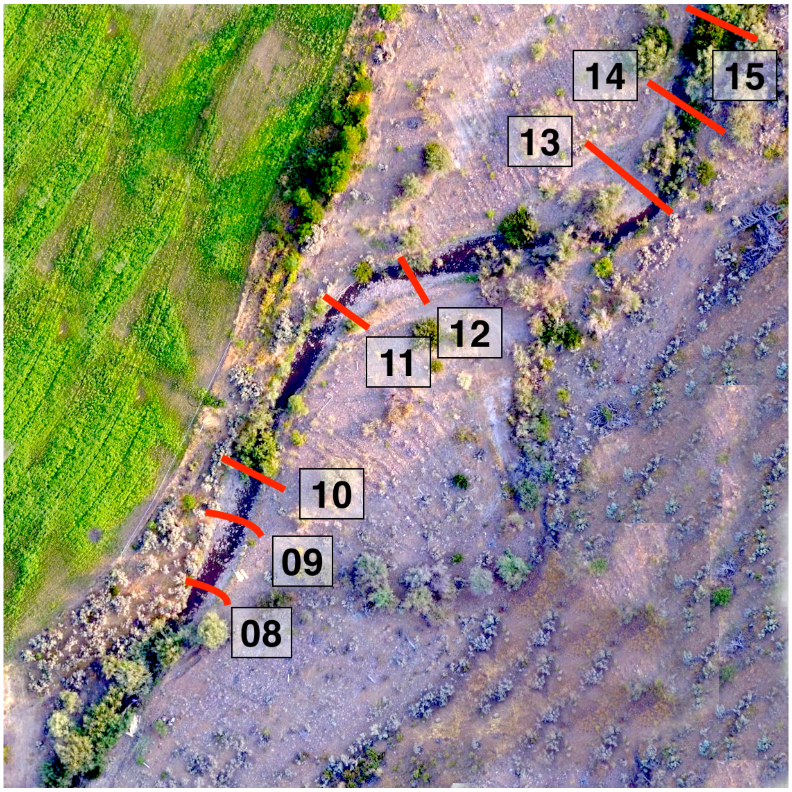
- □ Roots
- □ Live Trees/Shrubs
- □ Aquatic Vegetation
- □ Boulder(s)
- □ Woody Debris
- □ Wall: Bank
- □ Wall: Bar edge

How are above used? (accumulate remain, recruit)

NOTES & SKETCH

Complex 02

Bear Creek BDA Complex



Number of Structures 7

ID	Type	Year
08	Primary Ponding	2017
09	Primary Ponding	2017
10	Secondary Support	2017
11	Floodplain Expansion	2017
12	Secondary Support	2017
13	Primary Ponding	2017
14	Primary Ponding	2017
15	Secondary Support	2017

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 unconsolated 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.

Eco Logical Research

Complex 02 - Structure 08

Bear Creek BDA Design

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.

Eco Logical Research

Complex 02 - Structure 09

Bear Creek BDA Design

Structure Type Primary Ponding

Date Designed 7/28/17

Total Posts 30

Crest Elevation 0.33

Latitude 44.629727

Longitude -120.333195

Repeat Photo Location

Photo Facing **Upstream**

Standing **River Left**

Distance (m) **10**

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 terrrace 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.

Eco Logical Research

Complex 02 - Structure 10

Bear Creek BDA Design

Structure Type **Secondary Support**

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.

Eco Logical Research

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

Bear Creek BDA Design

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.

Eco Logical Research

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

Left: BDA complex built using posts and willow weave
Right: Postless BDA built using juniper

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

Post pounder access and transport can present a unique challenge. Left: hydraulic post-pounder is transported using a canoe. Pataha Creek, WA.

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

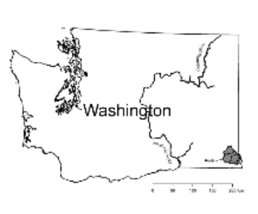
Group Management
- How many people are onsite?
- What level of training do they have?

Implementation
- Working upstream vs. working downstream
- High flow and low flow construction considerations

Asotin IMW Washington – Accomplishment Report

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

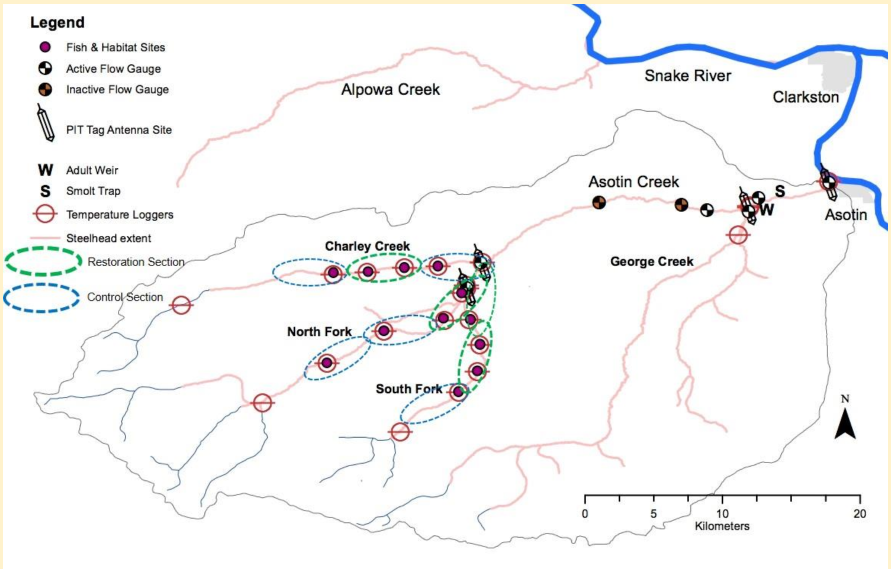


Experimental Design

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.

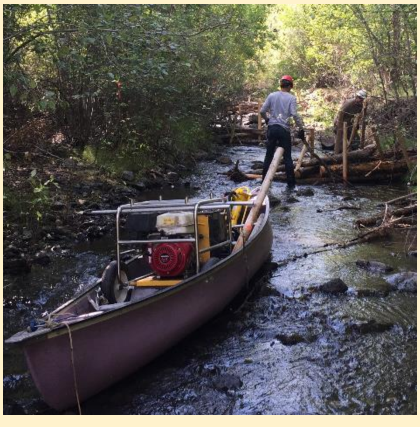


Experimental and monitoring design. Locations of fish and habitat sample sites, PIT tag arrays, discharge and temperature sites, smolt trap and adult weir.

Using mobile PIT-tag surveys to estimate seasonal survival

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.



Hand building post-assisted log structures (PALS) to protect riparian

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

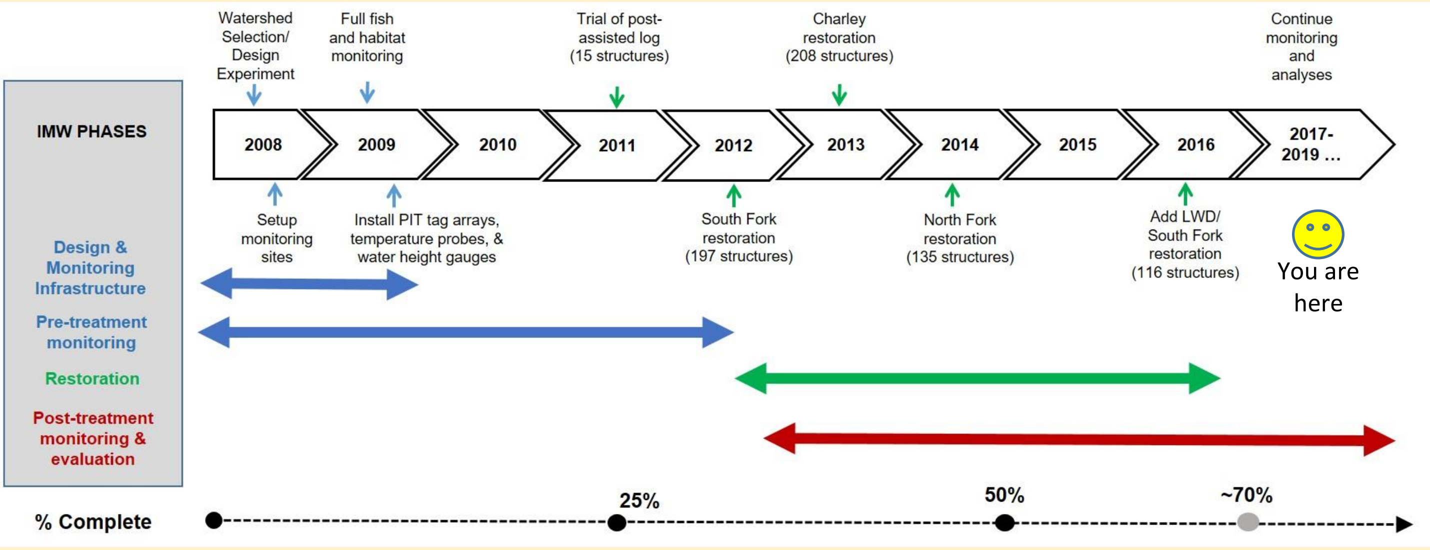
Low diversity, planebed channel pre-restoration

Planebed channel post-restoration

Habitat heterogeneity created after restoration: a) upstream bar, b) bank-attached PALS, c) eddy pool, d) scour pool, e) undercut bank, and f) riffle bar.

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



ISEMP and CHAMP PRODUCT SUMMARY

Bridge Creek Intensively Monitored Watershed

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

IMW

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

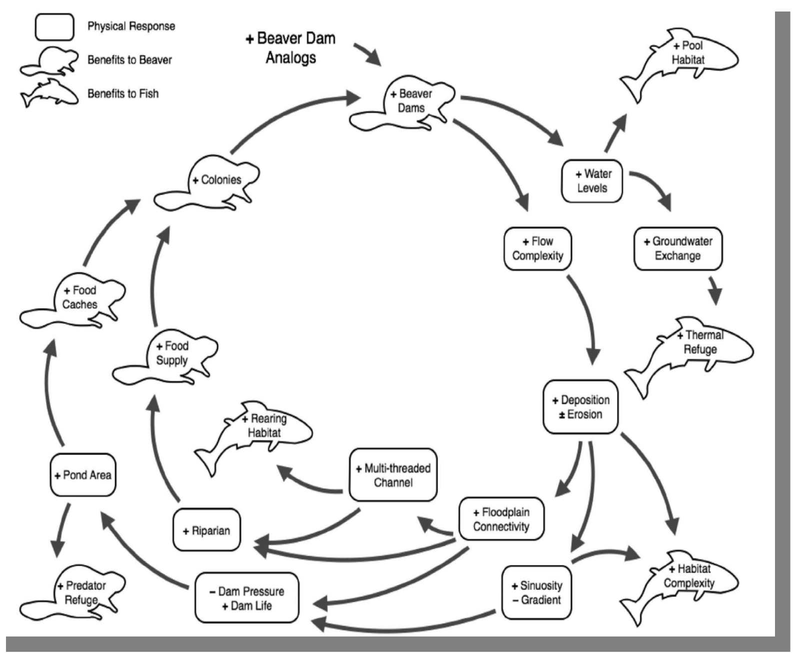
Development Team: Nick Bouwes, Chris Jordan, Michael Pollock, Carol Volk, Joe Wheaton, Nick Weber, Gus Wathen, Jake Wirtz

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.



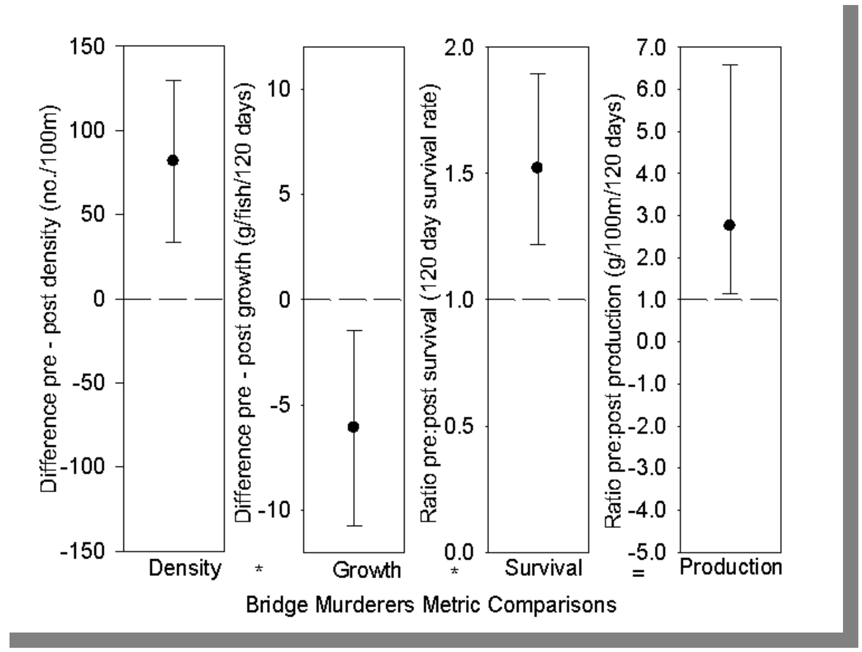


Figure 2. Summary of intervention analyses. On every sampling occasion, the control is subtracted (difference) or divided into (ratio) the treatment value. Next, the average difference pre-manipulation is subtracted (difference) or divided into (ratio) the post-manipulation value. Confidence intervals (90%) not overlapping zero for difference and 1 for ratio indicates significance at a = 0.1. Comparisons are made between Bridge Creek (treatment) and Murderers Creek (control), respectively. Results for difference in density (no./100m) and average growth (g/fish/120days), and ratio of survival (proportion surviving over 120 days) and production (total g/100m/120days) estimated as density*growth*survival are displayed.

MANAGEMENT APPLICATIONS

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.

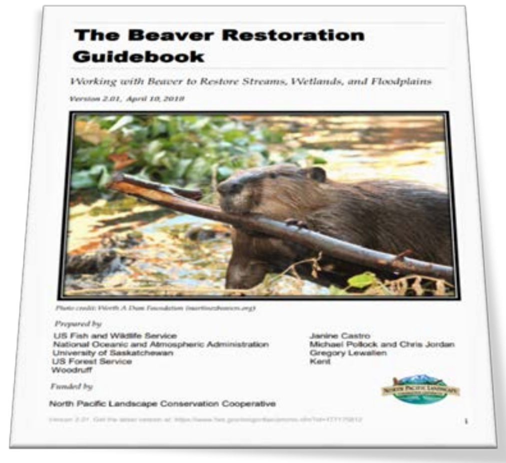
Citations: Bouwes, N., N. Weber, C. E. Jordan, W. C. Saunders, I. A. Tattam, C. Volk, J. M. Wheaton, and M. M. Pollock. 2016. Ecosystem experiment reveals benefits of natural and simulated beaver dams to a threatened population of steelhead (Oncorhynchus mykiss). Scientific Reports 6:28581.

Pollock, M. M., T. J. Beechie, J. M. Wheaton, C. E. Jordan, N. Bouwes, N. Weber, and C. Volk. 2014. Using Beaver Dams to Restore Incised Stream Ecosystems. Bioscience 64:279-290.

DESIGN MANUALS

BEAVER RESTORATION GUIDEBOOK

The Pollock et al. (2018) version 2 of the beaver restoration guidebook is a good source of basic information on beaver-based restoration techniques.


The Beaver Restoration Guidebook

Working with Beaver to Restore Streams, Wetlands, and Floodplains

Version 2.01, April 10, 2018

Prepared by

US Fish and Wildlife Service
National Oceanic and Atmospheric Administration
University of Saskatchewan
US Forest Service
Woodruff

Janine Castro
Michael Pollock and Chris Jordan
Gregory Lewallen
Kent

Funded by

North Pacific Landscape Conservation Cooperative

- Pollock, M.M., G.M. Lewallen, K. Woodruff, C.E. Jordan and J.M. Castro (Editors) 2018. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.01. United States Fish and Wildlife Service, Portland, Oregon. 189 pp. Online at: http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp

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.


TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE — STATE OF COLORADO — NATURAL RESOURCES CONSERVATION SERVICE

Range Technical Note No. 40

May 2018

Hand-Built Structures for Restoring Degraded Meadows in Sagebrush Rangelands

Examples and lessons learned from the Upper Gunnison River Basin, Colorado

Zeedyk rock structures installed to restore incised channel. Photo by: Nathan Seward

- Maestas, J. D., S. Conner, B. Zeedyk, B. Neely, R. Rondeau, N. Seward, T. Chapman, L. With, and R. Murph. 2018. Hand-built structures for restoring degraded meadows in sagebrush rangelands: Examples and lessons learned from the Upper Gunnison River Basin, Colorado. Range Technical Note No. 40. USDA-NRCS, Denver, CO.

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.

- Wheaton JM & Shahverdian S, (Editors). 2018. Riverscape Restoration Design Manual: A Guide to 'Cheap & Cheerful' Restoration. Prepared for Pheasants Forever, Sage Grouse Initiative, USDA Natural Resource Conservation Service, Utah Division of Wildlife Resources, and Utah's Watershed Restoration Initiative. Utah State University Wheaton Ecogeomorphology & Topographic Analysis Lab.

The chapters include:

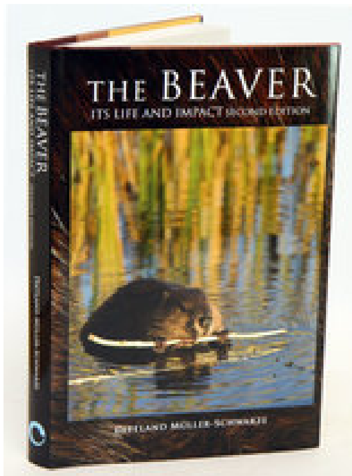
- Chapter 1 – Background and Purpose
- Chapter 2 – The Role of Meals and Exercise in Restoring Healthy Lifestyles for Riverscapes
- Chapter 3 – Impairments: what are they, how did we get here, and how can cheap and cheerful help?
- Chapter 4 - Condition Assessment
- Chapter 5 – Overview of Cheap & Cheerful 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 95
- Chapter 10 - Adaptive Management
- Chapter 11 – Beaver Dam Analogues
- Chapter 12 – High Density Large Woody Debris
- Appendices – Case Studies

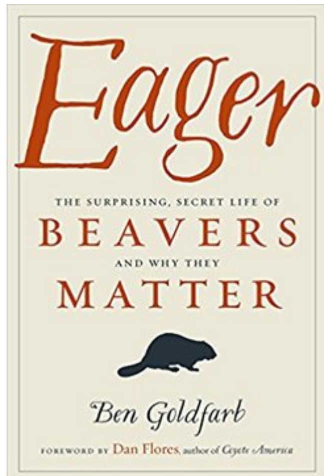
The manual is nearing completion and will be available later this Summer (2018) at:
http://beaver.joewheaton.org/restoration-manual.html

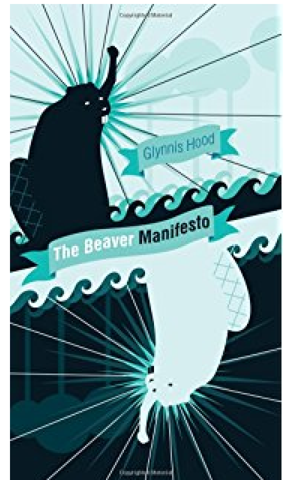
GOOD BOOKS ON BEAVER

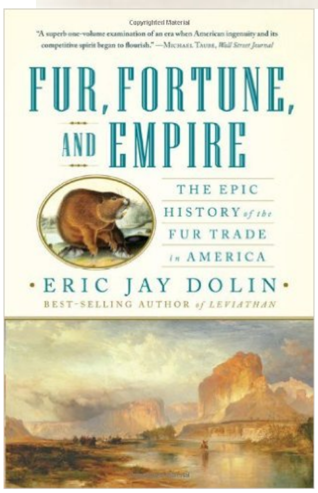
There are a variety of good books on beaver if you're interested. We maintain a list at:
http://beaver.joewheaton.org/beaver-literature.html

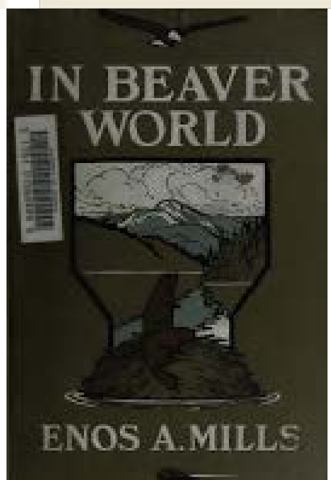
The most recent addition to the list is Ben Goldfarb's new Eager (announcement on following pages).

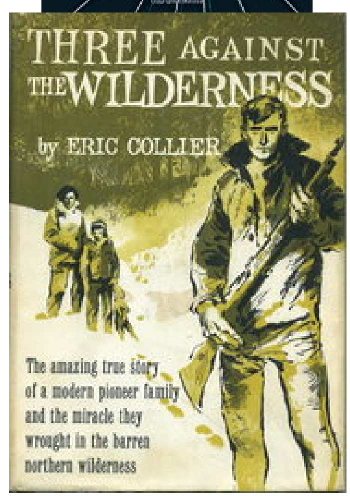


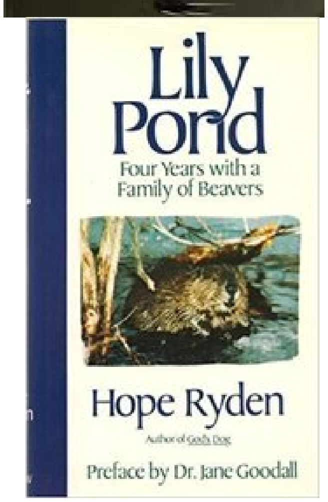


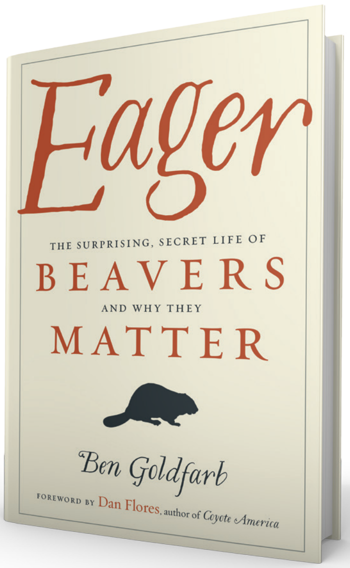












Eager

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
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For media inquiries contact
Christina Butt
cbutt@chelseagreen.com
802.295.6300 ext.127

For author events contact
Jenna Stewart
jstewart@chelseagreen.com
802.295.6300 ext.120

CHELSEA GREEN
PUBLISHING
the politics and practice of sustainable living

"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.

Ben Goldfarb is an environmental journalist who covers wildlife conservation, marine science, and public lands management, as well as an accomplished fiction writer. His work has been featured in *Science*, *Mother Jones*, *The Guardian*, *High Country News*, *VICE*, *Audubon Magazine*, *Modern Farmer*, *Orion*, *World Wildlife Magazine*, *Scientific American*, and many other publications.

http://media.chelseagreen.com/eager

Beaver Facts

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.

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!

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.

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 floodplains, and soaking it into the ground, beaver dams and ponds can reduce both the volume and speed of water, protecting downstream farms and towns.

In dry regions like the American West, beaver ponds store water during dry seasons, in some cases capturing hundreds of millions of gallons for the use of wildlife and farmers.

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

Eager

THE SURPRISING, SECRET LIFE OF BEAVERS AND WHY THEY MATTER

For more: @ben_a_goldfarb

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