Identifying Where to Place Beavers and When to Use Beaver Mimicry for Low Tech Restoration

Beaver Restoration Webinar Series

September 24, 2020

DOI: 10.13140/RG.2.2.31135.59045
Logistics – Getting the most out of your webinar

• Look in GoTo Chat window for link to PDF of Slides on ResearchGate

• Look in GoTo Handouts for a BRAT cIS form (for exercise)... printr have

• We will take questions at three different points (queue them up in GoTo Questions window)

• Slides are littered with hyperlinks (clickable in PDF) to cited works, datasets, examples and other talks, resources, & training materials

DOI: 10.13140/RG.2.2.31135.59045
Purpose of Webinar

Expectation management around beaver as a restoration/conservation partner, vs. mitigating their impacts in riverscapes

Mimic → Promote → Sustain

When, where and how to play the beaver cards?

From Beaver Gang Card Game

From Goldfarb (2018) Science: http://science.sciencemag.org/content/360/6393/1058
OUTLINE

Identifying Where to Place Beavers and When to Use Beaver Mimicry for Low Tech Restoration

I. Background & Other Resources
II. Dam Building Focus – Expectations
III. Contextualizing Risk
IV. Prioritizing Opportunities
V. Partnering with Beaver… A people business
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   V. Riverscape restoration with LTPBR
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What’s a Riverscape?

We know that our rivers and streams are critically important to our fresh-water ecosystems.
Riverscapes span the network across a watershed.

Riverscapes are the part of the landscape that could plausibly flood by their rivers & streams in the natural flow regime.
The Water Magic Trick – Beaver Induced Flooding

- Inundation types great proxy for residence time…

Karen Bartelt
Identifying Where to Place Beavers and When to Use Beaver Mimicry for Low Tech Restoration

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Global threat to river biodiversity

Figure 6 from Vörösmarty et al. (2010)
DOI: 10.1038/nature09440
Problem is Simple to State...

Scope of riverscape degradation is massive

- ~ Multi-Billions spent annually, but barely scratching surface
- We spend disproportionate $$ on too few kilometers of streams and rivers
- Leaving tens of millions of miles neglected...
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We forgot what valley bottoms could be & that STAGE 0 was NOT an anomaly!

Stage 0 or 8
Anastomosing

From: Cluer & Throne (2013)
DOI: 10.1602/rra.2631

Adapted from Figure 1.7 (p 36) of Shahverdian et al. (2019) – Chapter 1 LTPBR Manual DOI: 10.13140/RG.2.2.14138.03529
So many places to go…
For why beaver…

Five scientists and a hairdresser taking a bite out of climate change one stick at a time.
Beaver Dam Building can Benefit Endangered Species

- Restoration using BDAs & beaver as restoration agent produced a population level increase in density, survival and production of ESA listed salmon

From Bouwes et al. (2016)
DOI: 10.1038/srep28581
The American West is ablaze with fires fueled by climate change and a century of misguided fire suppression. In California, wildfire has blackened more than three million acres; in Oregon, a once-in-a-generation crisis has forced half a million people to flee their homes. All the while, one of our most valuable firefighting allies has remained overlooked: The beaver.

A new study concludes that, by building dams, forming ponds, and digging canals, beavers irrigate vast stream corridors and create fireproof refuges in which plants and animals can shelter. In some cases, the rodents’ engineering can even stop fire in its tracks.

“It doesn’t matter if there’s a wildfire right next door,” says study leader Emily Fairfax, an ecologist at California State University Channel Islands. “Beaver-dammed areas are green and happy and healthy-looking.”
Beaver increase riverscape resiliency to fire!

Fairfax & Whittle (2020) - Smokey the Beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western USA. DOI: 10.1002/eap.2225
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Beaver Management / Restoration Strategies

1. **Conservation** / Promotion (leave them alone or protect)
2. **Living with beaver**
3. **Translocation** to areas with suitable capacity → BDAs for release
4. Restore riparian → Followed by Translocation
5. Help beaver out — **Beaver Dam Analogues** → *Facilitated dispersal of opportunistic species*
6. Mimic Beaver Dam Activity — *construction & maintenance* (low-tech... NOT PBR)
Conservation - Passive Beaver Strategies

Beaver protection - work with wildlife departments to get temporary or permeant closures for trapping in targeted areas
Translocation – *or “Forced Dispersal”*

- Find a source population of nuisance beaver OR area with ample population...
- Relocate to areas with no or limited population & high capacity to support dam building activity

![Image of man setting traps with beavers in cages]

Kent Sorenson
(UDWR)

See [Kent & Amy’s Webinar](#) in this ASWM Series
Beaver Restoration Guidelines

Using Beaver Dam Analogues for Fish and Wildlife Recovery on Public and Private Rangelands in Eastern Oregon
Rachael Davee, Hannah Gosnell, and Susan Chemley

The Beaver Restoration Guidebook
Working with Beaver to Restore Streams, Wetlands, and Floodplains
Version 2.0, June 30, 2017

Davee et al. (2019).
Pollock et al. (2017).
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Recognizing beaver can cause damage, builds your credibility – empathize with the impacted.

No denying, beaver can:
• cause flooding
• block culverts, which wash out roads
• chop down ornamental landscape trees
• impact irrigation diversions
Living With Beaver Strategies…

- Is problem real or perceived?
- If real:
  - ‘Beaver Deceivers’
  - ‘Pond Levelers’
  - ‘Caging’ or painting trees
  - All require maintenance
- If those don’t work, live trap and relocation
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Low-tech process-based restoration

noun
1. A practice of using simple, low unit-cost, structural additions (e.g., wood and beaver dams) to riverscapes to mimic functions and promote specific processes. Hallmarks of this approach include an explicit focus on the promoting geomorphic and fluvial processes, a conscious effort to use cost-effective, low-tech treatments (e.g., hand-built, natural materials, non-engineered, short-term design life-spans) because of the need to efficiently scale-up application, and ‘Letting the system do the work’, which defers critical decision making to riverscapes and beaver.
Key Processes to **DESIGN & SOLVE** for!!!

**WOOD ACCUMULATION on a Post-Assisted Log Structure (PALS)**

**BEAVER DAM ACTIVITY on a beaver dam analogue (BDA)**

From Shahveridan et al. (2019)
Chap 4 LTPBR Manual
DOI: [10.13140/RG.2.2.22526.64324](10.13140/RG.2.2.22526.64324)
PALS and BDAs

PALS

POST-ASSISTED LOG STRUCTURES

- PALS are handbuilt structures that mimic and promote the processes of wood accumulation.
- Woody material of various sizes pinned together with untreated wooden posts driven into the substrate.

BDAs

BEAVER DAM ANALOGUES

- BDAs are handbuilt structures that mimic and promote the processes of beaver dam activity.
- BDAs are a permeable, channel-spanning structure with a constant crest elevation, constructed with a mixture of woody debris and fill material to promote temporary ponding of water.

DOI: 10.13140/RG.2.2.29622.111283
LOW-TECH PROCESS-BASED RESTORATION OF RIVERSCAPES

- Manual defines LTPBR Standard of Practice
- Print version now available for $60 on Amazon

Free Digitally @: http://lowtechpbr.restoration.usu.edu
Build the workforce!

We’ve taught over 20 LTPBR workshops

See Wheaton et al. (2019, p. 283) Chapter 7 of LTPBR Manual
DOI: 10.13140/RG.2.2.18332.33922.
Free Self-Paced Workshop Modules

Modules on:
1. Intro to LTPBR
2. Science
3. Planning
4. Design
5. Implementation

http://lowtechpbr.restoration.usu.edu
A Lot of Amazing People are behind LTPBR:

An incomplete acknowledgement...
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Really... Remember the Principles

Take some time to pause and focus on health, healing & hope

Recognizing what Healthy looks like

What we can do to let it get to healthy

A whole day to say what we cover in 4 pages and a top 10 list...

Free Digitally @: http://lowtechpbr.restoration.usu.edu
What constitutes a healthy riverscape?

RIVERSCAPES PRINCIPLES
1. Streams need **space**
2. Structure forces **complexity** and builds **resilience**
3. The importance of structure **varies** (3a & 3b)
4. **Inefficient** conveyance of water is **healthy**

Riverscapes Principles

From pages 3-4 of Pocket Guide; Wheaton et al. (2019)
DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123)
See Wheaton et al. (2019, p 60): Chapter 2 LTPBR Manual for Principles
DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)
Low-Tech Restoration Principles

5. It's okay to be **messy**
6. There is strength in **numbers**
7. Use **natural** building materials
8. Let the system **do the work**
9. **Defer** decision making to the system
10. **Self-sustaining** systems are the solution

From pages 3-4 of Pocket Guide; Wheaton et al. (2019)
DOI: [10.13140/RG.2.2.28222.13123/1](10.13140/RG.2.2.28222.13123/1)
See Wheaton et al. (2019, p 72)
Chapter 2 LTPBR Manual for Principles
DOI: [10.13140/RG.2.2.34270.69447](10.13140/RG.2.2.34270.69447)
Beaver Like to Make Messes… So can you

- And it is precisely that messiness, that is so critical to ecosystem health
- So why not take a cue from the rodent?
Transfer decision making & liability to the ecosystem engineer

Pocket Guide; Wheaton et al. (2019, p. 3-4)
DOI: 10.13140/RG.2.2.28222.13123/1

See Wheaton et al. (2019, p 77)
Chapter 2 LTPBR Manual for Principles
DOI: 10.13140/RG.2.2.34270.69447
10. Self-Sustaining Systems are the Solution

From Goldfarb (2018) Science:
http://science.sciencemag.org/content/360/6393/1058

Adding dams
Beaver trapping and overgrazing have caused countless creeks to cut deep trenches and water tables to drop, drying floodplains. Installing BDAs can help.

Widening the trench
BDAs divert flows, causing streams to cut into banks, widening the incised channel, and creating a supply of sediment that helps raise the stream bed.

Beavers return
As BDAs trap sediment, the stream bed rebuilds and forces water onto the floodplain, recharging groundwater. Slower flows allow beavers to recolonize.

A complex haven
Re-established beavers raise water tables, irrigate new stands of willow and alder, and create a maze of pools and side channels for fish and wildlife.

What’s your exit strategy?
Mimic → Promote → Sustain
So back to the title and purpose?

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Expectation management around beaver as a restoration/conservation partner, vs. mitigating their impacts in riverscapes

Mimic → Promote → Sustain

When, where and how to play the beaver cards?

From Goldfarb (2018) Science: http://science.sciencemag.org/content/360/6393/1058
Meet the BRAT

Beaver Restoration Assessment Tool

Build your understanding of BRAT for:

- conservation/restoration planning & prioritization
- risk/opportunity assessment
- expectation management

Beaver Management / Restoration Strategies

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6. Mimic Beaver Dam Activity – construction & maintenance (low-tech… NOT PBR)
Just a tool... we’ll use it to organize our thoughts, but don’t get obsessed with having the tool run
Acknowledging ‘WE’ from USU & NAR Development Team…

- Wally Macfarlane (USU)
- Philip Bailey (NAR)
- Matt Reimer (NAR)
- Sara Bangen (USU)
- Jordan Gilbert (USU)
- Maggie Hallerud (USU)
- Tyler Hatch (USU)
- Cashe Rasmussen (USU)
- Chalese Hafen (USU)
- Mic Albonico (USU)
- Braden Anderson (USU)
- Karen Bartelt (USU)
- Josh Gilbert (USU)
- Konrad Hafen (USU)
- Elijah Portugal (USU)
- Nick Bouwes (ELR/USU)
- Matt Meier (USU)
- Nick Weber (ELR/Anabranch)
- Scott Shahveridan (USU/Anabranch)

- And many others… we are neglecting
Conservation Planning Process

Phase 1 – Planning
Phase 2 – Design
Phase 3 – Implementation

Covered in Detail in Module 3

Figure 3.1 (p. 89) from Bennett et al. (2019)

Chapter 3 LTPBR Manual
DOI: 10.13140/RG.2.2.15815.75680
FOCUS on Key Questions related to Low-Tech Process-Based Restoration

Figure 3.20 from Bennett et al. (2019, p 115)  
Chapter 3 LTPBR Manual  
DOI: 10.13140/RG.2.2.15815.75680
PHASE 1 with Low-Tech

PHASE 1
Collection & Analysis
Understanding Problems & Opportunities

1. Identify Problems & Opportunities
2. Determine Objectives
3. Inventory Resources
4. Analyze Resource Data

Q: What are broad management goals?

Q: What part of valley bottom is available?

Evaluate Risks

Do opportunities outweigh risks?

YES

CONSIDER NON LOW-TECH TREATMENTS

NO

EXIT

Is the riverscape structurally starved?

YES

LOW-TECH NOT APPROPRIATE CONSIDER OTHER TREATMENTS

NO

EXIT

Q: What is recovery potential?

Q: What are current riverscape conditions?
Geomorphically?
Riparian?
to sustain wood accumulation and/or beaver dam activity

Figure 3.3 (p. 91) from Bennett et al. (2019)
Chapter 3 LTPBR Manual
DOI: 10.13140/RG.2.2.15815.75680
Take a Moment to Consider...

Q: What are current riverscape conditions? Geomorphically? Riparian? to sustain wood accumulation and/or beaver dam activity
Q: What is recovery potential?

Mimic → Promote → Sustain

1. Are the woody or vegetative resources present to support process of wood accumulation?
2. Could beaver dam activity be supported?
Could beaver dam activity be supported?

- If beaver dams are present...
- If so, to what degree?
- How much beaver dam activity?
- How much more?

See Appendix 3F (p 127) in Bennett et al. (2019)
Chapter 3 LTPBR Manual
DOI: 10.13140/RG.2.2.15815.75680

BRAT

See: http://brat.riverscapes.xyz

Q: What are current riverscape conditions?
   Geomorphically? Riparian?
   - to sustain wood accumulation and/or beaver dam activity

Q: What is recovery potential?
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Dam-Building Capacity Modeling

- **Beaver dams**, not beavers themselves, provide the desired impacts to habitat
- While beavers can survive in a wide range of conditions, **where they build dams is more limited**
- Dam building activity varies dramatically according to availability of **dam building materials & flow regime**
Capacity Model In A Nutshell

Dam building beaver need water and wood…

- Type and extent of wood/vegetation matters most
- Flow regime act to potentially limit capacity
The Primary Questions We Ask

1. Is there enough water present to maintain a pond?

2. Are enough and the right type of woody resources present to support dam building?

3. Can they build a dam at base flows?

4. Are dams likely to withstand typical floods?

Some nationally-available lines of evidence to address questions:

- NHD – perennial streams (1:24K)
- LANDFIRE - vegetation type (EVT)
- USGS Regional Curves for
  - Baseflow statistics
  - $Q_2$
- USGS NED 10 m DEM – derive reach slope and estimate stream power

Macfarlane et al. (2016) DOI: 10.1016/j.geomorph.2015.11.019
BRAT Dam Capacity Model

- Resolves **where** and at **what level** (within a drainage network) beaver dams can be built and sustained.
How many Dams? Capacity is upper limit?

Joe Wheaton @flu... · May 31
How many beaver dams do you think you see in Spawn Creek and that tributary (you’re looking at 0.5 mile of trib up center of photo and about ~ 1 mile flowing from left to right)?

- There aren't any dams: 4.2%
- 5-10 beaver dams: 16.7%
- **10-50 beaver dams**: 62.5%
- > 50: 16.7%

24 votes · Final results

Joe Wheaton @fluvialwheaton

Thanks to those of you that weighed in. Either 10-50 or > 50 are good answers. All the blue dots are what I counted... ~ 47. There are a lot more both upstream and downstream (left and right) out of view.

11:12 AM · Jun 3, 2020 · Twitter Web App
How Many & Where?

• Existing capacity: 356,294 dams
• 8.3 dams/km

Table 4
Summary of existing beaver dam gross modeled capacity estimates by capacity categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>Stream lengths (km)</th>
<th>% of stream network</th>
<th>Estimated dam capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pervasive</td>
<td>6219</td>
<td>15%</td>
<td>147,664</td>
</tr>
<tr>
<td>Frequent</td>
<td>18,162</td>
<td>45%</td>
<td>186,184</td>
</tr>
<tr>
<td>Occasional</td>
<td>8234</td>
<td>20%</td>
<td>21,544</td>
</tr>
<tr>
<td>Rare</td>
<td>3367</td>
<td>8%</td>
<td>922</td>
</tr>
<tr>
<td>None</td>
<td>4639</td>
<td>1.2%</td>
<td>356,294</td>
</tr>
<tr>
<td>Total</td>
<td>40,561</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Note: Utah is second driest state in US

From Macfarlane et al. (2016) DOI: 10.1016/j.geomorph.2015.11.019
Resolution of BRAT

• At a scale that is still meaningful on the ground (250 m reaches)
• Just because BRAT predicts high capacity, does not mean it will be realized... but it does define a plausible upper limit
• In many places, at some point in time this upper limit is reached... just never all at once
The Questions

1. Is there **enough water** present to maintain a pond?

2. Are **enough and the right type of woody resources** present to support dam building?

3. Can they **build a dam at base flows**?

4. Are dams likely to withstand **typical floods**?
The perennial network is a conservative estimate of where water exists to make a pond.
THE QUESTIONS

1. Is there enough water present to maintain a pond?

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After perennial... proceed with veg

Figure 2 from Macfarlane et al. (2016)
DOI: 10.1016/j.geomorph.2015.11.019
VEGETATION CLASSIFICATION

Based on: Beaver preferences & ability of material to support dam-building activities

**LANDFIRE VEG Layer**

Classify

- **4- Preferred Material**
  - Aspen
  - Cottonwood
  - Willow
- **3- Suitable Material**
  - Other deciduous trees
  - Conifer/Aspen
- **2-Moderately Suitable**
  - Conifer
  - Invasive riparian Woodland
- **1-Barely Suitable**
  - Shrubland
  - Sagebrush steppe
  - Herbaceous wetlands/riparian
- **0- Unsuitable Material**
  - Barren
  - Developed
  - Agriculture
  - Grassland
Appropriate Spatial Sampling Converts Categorical Pixels To Continuous Measure

A. 30 vs. 100 m stream network buffer (300 m reaches)
B. Classified LANDFIRE raster-- shows dam building suitability from 0 (unsuitable) to 4 (optimal)
C. Averaged values for the 30 m buffer (300 m reaches)
D. Averaged values for the 100 m buffer (300 m reaches)

Figure 3 from Macfarlane et al. (2016)
DOI: 10.1016/j.geomorph.2015.11.019
Inference System – (Simple Rules)

<table>
<thead>
<tr>
<th>RULES</th>
<th>INPUTS</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Suitability of Streamside Vegetation</td>
<td>Suitability of Riparian/Upland Vegetation</td>
</tr>
<tr>
<td>12</td>
<td>Barely Suitable &amp; Moderately Suitable</td>
<td>Occasional</td>
</tr>
<tr>
<td>13</td>
<td>Moderately Suitable &amp; Moderately Suitable</td>
<td>Frequent</td>
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<tr>
<td>14</td>
<td>Suitable &amp; Moderately Suitable</td>
<td>Frequent</td>
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<td>15</td>
<td>Preferred &amp; Moderately Suitable</td>
<td>Frequent</td>
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<td>23</td>
<td>Moderately Suitable &amp; Preferred</td>
<td>Frequent</td>
</tr>
<tr>
<td>24</td>
<td>Suitable &amp; Preferred</td>
<td>Pervasive</td>
</tr>
<tr>
<td>25</td>
<td>Preferred &amp; Preferred</td>
<td>Pervasive</td>
</tr>
</tbody>
</table>
MADE FIS – BY FUZZY MEMBERSHIP FUNCTIONS

Inputs

Fuzzy Inference System
Type: Mamandi
And Method: Min
Or Method: Max
Implication: Min
Aggregation: Max
Defuzz Method: Centroid

Output

Figure 4 from Macfarlane et al. (2016)
DOI: 10.1016/j.geomorph.2015.11.019
Dam Density Output Categories:

- **None** – 0 dams: segments deemed *not capable* of supporting dam building activity
- **Rare** – 1 dam/km: segments *barely capable* of supporting dam building activity; likely used by dispersing beaver
- **Occasional** – 2-4 dams/km: segments that are *not ideal*, but can support an occasional dam or even a small colony
- **Frequent** – 5-15 dams/km: segments that can support multiple colonies and dam complexes, but may be *slightly resource limited*
- **Pervasive** – 16-40 dams/km: segments that can support extensive dam complexes and many colonies
If you don’t believe me on dam density

> 100 dams/km ... but closer to 40 dams/km/thread (i.e. 1 dam every 25 m)
Classify existing vegetation as dam building material suitability for beaver.
Classify historic vegetation estimate (BPS) as dam building material suitability for beaver.
Apply FIS Model → Network

Evaluate existing capacity strictly on vegetation availability along network.
THE QUESTIONS

1. Is there **enough** water present to maintain a pond?

2. Are enough and the right type of woody resources present to support dam building?

3. Can they **build a dam** at base flows?

4. Are dams likely to withstand **typical floods**?
Baseflow Stream Power

1. Calculate Q @ baseflow for each reach based on drainage area and USGS regional curves
2. Multiply Q by slope (S) ($\Omega = \rho g Q S$)
THE QUESTIONS

1. Is there enough water present to maintain a pond?
2. Are enough and the right type of woody resources present to support dam building?
3. Can they build a dam at base flows?
4. Are dams likely to withstand typical floods?
Typical Floods?

Same calculation, but for $Q_2$

Highflow Stream Power

Stream Power (watts)

- Green: Dam Persists: 0 - 1100
- Yellow: Potential Dam Breach: 1100 - 1400
- Orange: Potential Dam Blowout: 1400 - 2200
- Red: Dam Blowout: > 2200

μ Membership

- Dam persists
- Occasional breach
- Occasional blowout
- Blowout

Q2 Stream power (watts/m)
Put the other inputs together

1. Is their *enough* water present to maintain a pond?
2. Are *enough* and the *right* type of *woody* resources present to support dam building?
3. Can they build a *dam* at *base flows*?
4. Are dams likely to withstand *typical floods*?

Figure 6 from Macfarlane et al. (2016)
DOI: 10.1016/j.geomorph.2015.11.019
Existing Capacity

Where can beaver build dams now & what extent?

### Existing Dam Building Capacity

- **Density:** dams/mile (dams/km)
- **None:** 0 dams
- **Rare:** 0 - 2 (0 - 1)
- **Occasional:** 2 - 8 (1 - 5)
- **Frequent:** 8 - 24 (5 - 15)
- **Pervasive:** 24 - 64 (15 - 40)
Answer questions for:
- Historic conditions
- What is possible (i.e. upper limit of recovery potential)
Capacity... Max Number Of Dams

- You can do this..
- You will answer those basic questions... and the inference system
- With the actual model, we approximate quantitative answers to those with GIS data

https://tinyurl.com/y4osd5wu
Desktop – BRAT cIS Evaluation

- You will evaluate how many beaver dams (max) could this reach support
BRAT - cIS

Who?
Where?
When?
**BRAT - cIS**

The veg questions... - dam building materials

---

### 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)
- □ Grasess □ 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 base flows?**
Suitability Of Vegetation As Dam Building Material

Based on: Beaver preferences & ability of material to support dam-building activities

LANDFIRE VEG Layer

Classify

4- Preferred Material
- Aspen
- Cottonwood
- Willow

3- Suitable Material
- Other deciduous trees
- Conifer/Aspen

2- Moderately Suitable
- Conifer
- Invasive riparian
- Woodland

1- Barely Suitable
- Shrubland
- Sagebrush steppe
- Herbaceous wetlands/riparian

0- Unsuitable Material
- Barren
- Developed
- Agriculture
- Grassland
Desktop – BRAT cIS Evaluation

- For vegetation question, answer separately within 30 m vs. 100 m buffer:
  - Proportion of building material
    - Unsuitable (0)
    - Barely Suitable (1)
    - Moderately Suitable (2)
    - Suitable (3)
    - Preferred (4)

- And estimate an area weighted average (between 0 & 4), then choose closest category
BRAT - CIS

The inference system... look up table!

**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

**Dam Density Capacity Assessment Base**
- 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**

**Can Beaver build a dam at base flows?**

**Suitability of Riparian/Upland Vegetation**
- **Unsuitable**

**Inference System of Capacity Based on Vegetation Only**

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Suitability of Streamside Vegetation</th>
<th>Suitability of Riparian/Upland Vegetation</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unsuitable</td>
<td>Unsuitable</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Unsuitable</td>
<td>Barely Suitable</td>
<td>Rare</td>
</tr>
<tr>
<td>3</td>
<td>Unsuitable</td>
<td>Moderately Suitable</td>
<td>Occasional</td>
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<tr>
<td>4</td>
<td>Unsuitable</td>
<td>Preferred</td>
<td>Frequent</td>
</tr>
<tr>
<td>5</td>
<td>Barely suitable</td>
<td>Unsuitable</td>
<td>Occasional</td>
</tr>
<tr>
<td>6</td>
<td>Barely suitable</td>
<td>Barely Suitable</td>
<td>Rare</td>
</tr>
<tr>
<td>7</td>
<td>Barely suitable</td>
<td>Moderately Suitable</td>
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<td>Frequent</td>
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<td>Moderately suitable</td>
<td>Preferred</td>
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<td>12</td>
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<td>Preferred</td>
<td>Preferred</td>
<td>Frequent</td>
</tr>
<tr>
<td>25</td>
<td>Preferred</td>
<td>Preferred</td>
<td>Frequent</td>
</tr>
</tbody>
</table>
BRAT - cIS

Does hydrology (manifested as local hydraulics and approximated with stream power) limit this capacity?

<table>
<thead>
<tr>
<th>COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CAN BEAVER BUILD A DAM AT BASE FLOWS?</strong></td>
</tr>
<tr>
<td>- Probably can build dam</td>
</tr>
<tr>
<td>- Can build dam</td>
</tr>
<tr>
<td>- Can build dam (saw evidence of recent dams)</td>
</tr>
<tr>
<td>- Could build dam at one time (saw evidence of relic dams)</td>
</tr>
<tr>
<td>- Cannot build dam (stream power really high)</td>
</tr>
<tr>
<td><strong>IF BEAVERS BUILD A DAM, CONSIDER WHAT HAPPENS TO THE DAM(S) IN A TYPICAL FLOOD (E.G. MEAN ANNUAL FLOOD)?</strong></td>
</tr>
<tr>
<td>- Blowout</td>
</tr>
<tr>
<td>- Occasional Breach</td>
</tr>
<tr>
<td>- Occasional Blowout</td>
</tr>
<tr>
<td>- Dam Persists</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Too steep they cannot build a dam (e.g. &gt; 20% slope)</td>
</tr>
<tr>
<td>- Probably can build dam</td>
</tr>
<tr>
<td>- Can build dam (inferred)</td>
</tr>
<tr>
<td>- Can build dam (evidence or current or past dams)</td>
</tr>
<tr>
<td>- Really flat (can build dam, but might not need as many as one dam might back up water &gt; 0.5 km)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMBINED DAM DENSITY CAPACITY ASSESSMENT BASED ON ALL (USE TABLE 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- None (no dams)</td>
</tr>
<tr>
<td>- Rare (0-1 dams/km)</td>
</tr>
<tr>
<td>- Occasional (1-4 dams/km)</td>
</tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum Dam Density (dams/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - None</td>
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<td>1 - 4 Occasional</td>
</tr>
<tr>
<td>5 - 15 Frequent</td>
</tr>
<tr>
<td>16 - 40 Pervasive</td>
</tr>
</tbody>
</table>
Uglier table... but simple to apply
**BRAT - cIS**

Answer is?  
Still **occasional**  
But if blowout drops to **rare**

### Combined Capacity to Support Dam Building Activity

**Can Beaver Build a Dam at Base Flows?**
- 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 (stream power 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 Breach
- Occasional Blowout
- Dam Persists

### How Does the Reach Slope Impact Their Ability or Need to Build Dams?
- Too 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)
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<th>16 - 40 Pervasive</th>
</tr>
</thead>
</table>
AP Evidence Vs. LANDFIRE Evidence

BRAT Tool Parameters

Perennial Network
- 30 m Buffer
- 100 m Buffer

Existing LANDFIRE Vegetation

LANDFIRE Classname

- Rocky Mountain Aspen Forest and Woodland
- Northern Rocky Mountain Dry/Mixed-Montane Mixed Evergreen Forest
- Rocky Mountain Lodgepole Pine Forest
- Northern Rocky Mountain Pinus Pinaster Woodland and Scrubland
- Rocky Mountain Subalpine Dry/Mixed-Space-Fill Forest and Woodland
- Northern Rocky Mountain Montane-Foothill Deciduous Broadleaf
- Douglas Fir-Ponderosa Pine Scrubland
- Coastal Pines - Short-Leaf Pine Scrubland

- Northern Rocky Mountain Lower Meadow-foothill-Valley Grassland
- Rocky Mountain Montane-Riparian Forest and Woodland
- Mixed Conifer Forests
- Western Coniferous Forests
- Western Coniferous Temperate Hardwood Forest
- Western Coniferous Temperate Deciduous Rangeland
- Temperate Deciduous Rangeland
- Temperate Broadleaf Rangeland
- Temperate Mixed Conifer Rangeland
- Temperate Mixed Conifer Deciduous Rangeland
- Temperate Mixed Conifer
- Temperate Coniferous

Middle Fork John Day Zoom in Huc 8 - 17070203
ANOTHER...

North Fork John Day Zoom in
Huc 8 - 17070202

BRAT Tool Parameters
Perennial Network
- 30 m Buffer
- 100 m Buffer

North Fork John Day Zoom in
Huc 8 - 17070202

BRAT Tool Parameters
Perennial Network
- 30 m Buffer
- 100 m Buffer

Existing LANDFIRE Vegetation
LANDFIRE Classes:
- Columbia Plateau Low Sagebrush Steppe
- Columbia Plateau Sagebrush and Grassland
- Dry-mesa Montane Douglas-fir Forest
- Broad-Mountain Basins Big Sagebrush Steppes
- Broad-Mountain Basins Montane Sagebrush Steppes
- High-Mountain Douglas-fir Forest
- Northern Rocky Mountain Dry-Alpine Montane Mixed Conifer Forest
- Northern Rocky Mountain Lower Montane-Foothill Valley Grassland
- Northern Rocky Mountain Rangeland Pine Woodland and Grassland
- Rocky Mountain Subalpine Montane Mixed Meadow

0 100 200 300 400 500 Feet
0 20 40 60 80 100 Meters
Surveying Dams... Gives you data in same currency of density (dams/km)
Can be done at broader scales...

- 9048 dams from desktop census
- Statewide current capacity is 994,299 (i.e. < 1%) or 8 dams/km
- Historic was 1.7 million
Dam Surveys in Field

BEAVER DAM MONITORING FORM - BASIC

OBSERVATION INFO

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

BEAVER BUILT DAM?

- Beaver Dam
- Beaver Dam Analogue (manmade)

DAM TYPE:

- Primary (has lodge... typically larger)
- Secondary (typically smaller – part of complex)

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

GPS UTM Easting: ____________________________
GPS UTM Northing: ____________________________
Stream Name: ____________________________

NOTES &/OR SKETCH
## Monitoring Complexes in Field Is Quicker

### 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

#### 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

---

---
Same Thing but as Survey 123 App

No substitute for thinking...
What’s Limiting?

Where beaver cannot build dams and why?

Unsuitable/Limited Dam Building Opportunities

- Anthropogenically Limited
- Stream Power Limited
- Slope Limited
- Naturally Vegetation Limited
- Stream Size Limited
- Dam Building Possible

![Yellowstone Headwaters Map](image)

- Yellowstone Headwaters
- HUC 8 - 10070001
- Perennial Stream Length: 2867 Mi (4646 Km)

- Anthopogenically Limited: < 1%
- Stream Power: 3%
- Slope: 7%
- Vegetation: < 1%
- Stream Size: 3%

*“Dam Building Possible” values excluded from chart. Percent perennial stream length for this category is 87%*
Identifying Where to Place Beavers and When to Use Beaver Mimicry for Low Tech Restoration

I. Background & Other Resources
II. Dam Building Focus – Expectations
III. Contextualizing Risk
IV. Prioritizing Opportunities
V. Partnering with Beaver… A people business
Let’s start with the areas beavers could impact: Valley bottoms
RECALL, Streams need space (i.e. their valley bottoms)

RIVERSCAPES PRINCIPLES
1. Streams need space
2. Structure forces complexity and builds resilience
3. The importance of structure varies (3a & 3b)
4. Inefficient conveyance of water is healthy

DOI: 10.13140/RG.2.2.19590.63049/1
**V-BET: VALLEY BOTTOM EXTRACTION TOOL**

- From topography (e.g. USGS 10 m NED or LiDAR) & V-BET

From: Gilbert et al. (2016) – Computers & Geosciences ;
DOI: [10.1016/j.cageo.2016.07.014](http://dx.doi.org/10.1016/j.cageo.2016.07.014)
http://rcat.riverscapes.xyz
State-Wide or Watershed Wide: VALLEY BOTTOMS

- Tool can run @ broad spatial scales from DEM

(e.g. here for Utah over 25,000 km of riverscape in a region ~ 220,000 km²; by comparison Upper yellow River is about 140,00 to 178,000 km²)
Making Investment

Through data QA/QC, curation, no “Warning label”, necessary as model outputs will have been verified.
Land Use Intensity

- Land use intensity is easily derived from LANDFIRE
Within Valley Bottom: Land Use Intensity

- Considered within valley bottom
- More intensive land uses more likely to have human-beaver conflicts

Land use intensity on network

An average land use intensity within the valley bottom of each reach can be easily calculated.
Next, we can look at how close we are to infrastructure beaver could flood or damage: roads, railroads, canals
Canals

Generally, beaver are not welcome or useful additions to irrigation canals.

There are a lot of irrigation ditches... evaluating distance from canals can be cast in terms of ‘beaver distances’.
Roads?

The black lines are roads (note the extremely high density in headwaters)
A RISK WITH ROADS... CROSSINGS

- Simply looking at road crossings and distance from that can help evaluate potential ‘clogging’ locations.
- A large bridge with plenty of clearance is not necessarily a problem...
- A small culvert might be
Distance to road vs. Road in valley bottom

While roads can also be looked at in terms of distance from the channel, if we’re interested in road flooding problem, we just care about roads in the valley bottom.
Bringing All These Together

- Proximity to ‘floodable’ or ‘clogable’ infrastructure:
  - Roads
  - Road Crossings
  - Canals
  - Railroads
- How far to closest threat?
Nearest Infrastructure

We can synthesize all these by calculating the distance to closest infrastructure (i.e. road in valley bottom, road crossing, railroad, or canal)
But, this is unrealistically pessimistic

• This is just how close is the stream to these things!
• NOT how close will beaver be
• Setting aside undesirable harvest of vegetation/trees, main impact of beavers is damming
• So just look at where proximity is higher, and where beaver are likely to build dams
More Focused Look @ “Risk”

Where could there be some risks of human-beaver conflict?

- Assuming that beaver are present in that reach & they decide to build dam & it actually causes impact... (i.e. very conservative over-prediction)
Identifying Where to Place Beavers and When to Use Beaver Mimicry for Low Tech Restoration

I. Background & Other Resources
II. Dam Building Focus – Expectations
III. Contextualizing Risk
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V. Partnering with Beaver… A people business
With risks considered, where are the restoration & conservation opportunities?

- Be conservative:
  - Only look in areas of:
    - Minor risk
    - Negligible risk

- Avoid high intensity land use:
  - Low
  - Very low
Restoration & Conservation Opportunities

- Areas with limited ‘risk’ of human-beaver conflict & some ex. capacity.
  - **Low Hanging Fruit** has capacity, just needs some beaver!

- **Quick Return** is currently occasional but historically higher

- **Strategic** is currently hammered but historically was high

These areas typically need long-term riparian recovery first (e.g. grazing management)
Restoration & Conservation Opportunities

Where are low-risk beaver restoration & conservation opportunities located?

Possible Beaver Dam Conservation/Restoration Opportunities

- Easiest - Low-Hanging Fruit: 52%
- Straight Forward - Quick Return: 5%
- Strategic - Long-Term Investment: 1%
- Other: 43%
Restoration & Conservation Opportunities

Little Wood watershed has more interesting results

Possible Beaver Dam Conservation/Restoration Opportunities
- Easiest - Low-Hanging Fruit
- Straight Forward - Quick Return
- Strategic - Long-Term Investment
- Other
So where should you work?

- What are you trying to do?
- What impairments are you trying to address?
- What species are you trying to benefit?
- What uplift or improvement (e.g. in quantity of mesic habitat) are you trying to get?
- What risks should you be aware of, mitigate and/or avoid?
Difference between conservation & restoration

• Compare realized dam counts to existing capacity
• In reaches @ or near capacity & in ‘low hanging fruit’
  • Flag as conservation (e.g. trapping closure)
• In reaches with no realized-capacity or under-utilized-capacity:
  • Target for restoration and/or translocation
  • Maybe use BDAs to promote beaver to stick
• In quick-return areas, use low-tech PBR & better land management to improve conditions and try to get beaver to help
• If ‘long-term’ areas are important, strategically invest to improve riparian conditions
Identifying Where to Place Beavers and When to Use Beaver Mimicry for Low Tech Restoration

I. Background & Other Resources
II. Dam Building Focus – Expectations
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Examples of how to do AM...

Lays out an adaptive management response to beaver problems...

http://lowtechpbr.restoration.usu.edu/resources/adaptiveemgt.html
Park City Story

• Good old days of traditional, undocumented beaver management
• Change of mgmt...
• Beaver come back
• Beaver cause flooding problems
• City removes (traditional mgmt.)
• But people liked the beaver... and complained
• CONFLICT!
Simple Decision Points — By Water Course

• Cheaper and more effective then just lethal treatment everywhere...

Wheaton (2013)
DOI: 10.6084/m9.figshare.903648
Adaptive Beaver Management Plan

Beaver Conservation Zone
Living with Beaver Zone
Nuisance Beaver Zone
Non-Beaver Bearing
Culvert or Bridge

PCMC BEAVER ADAPTIVE MANAGEMENT PLAN
IDENTIFY PROBLEM
PERIODICALLY REVIEW EFFECTIVENESS OF BEAVER MANAGEMENT PLAN (Every 5 Years)
DO
DOCUMENT MONITORING & ACTIONS
EVALUATE & LEARN
ADJUST

PCMC GOALS & OBJECTIVES
Reduce damages caused by beaver activity
Balance fiscal needs of beaver and its ecosystem in need of care provided by beaver
Wildfire prevention, public and private property and infrastructure
DEVELOP LIVING WITH BEAVER STRATEGIES & RELOCATION OR RESTORATION STRATEGIES (2013)

Legend
Park City - City Limits
Potential Areas of Management Concern
PCMC Adaptive Management Categories
Beaver Conservation Zone
Living with Beaver Zone
Nuisance Beaver Zone
Non-Beaver Bearing
Culvert or Bridge

EVALUATION OF REACHES & DAMS
Annually or during spring flood to spring runoff & in fall (after peak of summer flooding and cooling)
OR
As individual events as triggered by nuisance companies

IMPLEMENT LIVING WITH BEAVER STRATEGIES & RELOCATION OR RESTORATION STRATEGIES
Primarily Recreational Areas

IMPLEMENT MONITORING PROGRAM
Base Area of and Reservoir Monitoring

Silver Creek
Beaver power provides year-long water to Idaho ranch

Beavers? You read that right. Here’s how four-legged engineers helped restore an Idaho ranch.

By Brianna Randall | Feb 20, 2020

Jay Wilde’s story of restoring perennial flow to his creek using beaver...
Virtual Field Trip to Birch Creek

Normally, in our in-person workshops, we like to take participants in the field to see an actual low-tech process-based restoration (LTPBR) project on the ground. This helps you see first-hand a real riverscape subjected to "structural starvation", and for which a LTPBR project was successfully completed.

There is no substitute for meeting Jay Wilde in person and seeing what the beaver have done to Birch Creek, Idaho because of his efforts. Tromping around in the water and mud and experiencing this for yourself really helps the concepts and the scope of what is possible sink in. This page attempts to reproduce as much of that experience as we can virtually for you in Birch Creek.

Birch Creek Virtual Tour

In this 90 minute video, you are invited to a series of stops up and down Birch Creek. The conversation between Jay Wilde and Joe Wheeler is similar to the conversation we have when we take a whole class out. Unlike the real field trip, where when you've had enough you can just hang back and wander around on your own, with this one you can fast forward if you get bored.

Birch Creek Beaver Assisted Restoration - Virtual Field Tour
So where has pyBRAT 3.0 been run? Is the tool the GIS tool or the outputs? Or the thought process?

http://brat.riverscapes.xyz/BRATData/
Everything Is Open-source... But

WHY YOU'RE REALLY HERE... THE TOOLS

OUR TOOLS - YOUR RIVERSCAPES...

Our consortium has been focused on developing the science and theoretical underpinnings essential to understanding and explaining how riverscapes work and are organized across a range of nested, hierarchical spatial scales. We have also committed to building open-source algorithms, models and GIS tools to make it easier for researchers, professionals, practitioners and students to apply those concepts to their own riverscapes.

All of our tools are based on peer-reviewed methods. When we have developed the methods ourselves, we aim to have them vetted, published and disseminated in the peer-reviewed literature. We then also make sure to have a well-documented website (you'll find them from RC).

http://riverscapes.xyz
https://github.com/Riverscapes
pyBRAT is just Operational Grade Tool

http://brat.riverscapes.xyz
BRAT is one of several tools developed by the Riverscapes Consortium. This report card communicates BRAT’s compliance with the Riverscape Consortium’s published tool standards.

Report Card Summary

<table>
<thead>
<tr>
<th>Tool</th>
<th>BRAT - Beaver Restoration Assessment Tool</th>
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<tbody>
<tr>
<td>Version</td>
<td>3.1.00</td>
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<tr>
<td>Date</td>
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<td>Assessment Team</td>
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<td>Current Assessment</td>
<td>Operational Grade</td>
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<td>Target Status</td>
<td>Commercial Grade</td>
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<td>RiverScapes Compliance</td>
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BRAT has been applied extensively throughout the Western US and in the UK. It has been used extensively to inform policy and planning and state-wide, regional and watershed extents, but also to inform restoration planning and design at the reach-scale. Others have applied the model, but for the most part it has been implemented by the USU ETAL team. It is well deserving of an Operational Grade.
Glorified Housekeeping?

Yes, but who has time for it? Going to the effort of making your tool riverscapes-compliant turns the process of file management and metadata production and curation automatic for every analysis and write operation in your tools.

http://rave.riverscapes.xyz
Map Example – Network Going to sqlBRAT 4.0 – Don’t need to be a GIS user

Will be available next year (thank you BLM) at: https://maps.riverscapes.xyz
If there isn’t a run in my area...

1. Struggle through teaching yourself ArcPy and running GIS yourself
2. Just manually assess using cIS
3. Pay someone to run it for you

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<tr>
<th>BRAT cIS</th>
<th>BRAT 2.x</th>
<th>PyBRAT 3.x</th>
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**Cost for**

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Contact Us for more information.
While we wait for Commercial Grade, YOU can help crowd source this & GET BRAT for your AREA

- As little as $120 for a HUC 12 if you let us make it publicly available

https://north-arrow-research.myshopify.com/
Conclusions

**Beaver Restoration Assessment Tool**

Build your understanding of BRAT for:

- conservation/restoration planning & prioritization
- risk/opportunity assessment
- expectation management

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**Beaver Management / Restoration Strategies**

1. **Conservation** / Promotion (leave them alone or protect)
2. **Living with beaver**
3. **Translocation** to areas with suitable capacity → BDAs for release
4. Restore riparian → Followed by Translocation
5. Help beaver out – **Beaver Dam Analogues** → Facilitated dispersal of opportunistic species
6. Mimic Beaver Dam Activity – construction & maintenance (low-tech… NOT PBR)
Questions?

- BRAT: http://brat.riverscapes.xyz/
- Crowd Source it: https://north-arrow-research.myshopify.com/
- Low-Tech Process-Based Restoration: http://lowtechpbr.restoration.usu.edu

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1913 vs. 2018