Overview of BRAT

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DAM-BUILDING CAPACITY MODELING

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

BRAT… A BEAVER DAM CAPACITY MODEL

- Resolves **where** and at **what level** (within a drainage network) **beaver dams** can be built and sustained.

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Modeling the capacity of riverscapes to support beaver dams

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ABSTRACT

The construction of beaver dams facilitates a suite of hydrologic, hydraulic, geomorphic, and ecological feedbacks that increase stream complexity and channel–floodplain connectivity that benefit aquatic and terrestrial biota. Depending on where beaver build dams within a drainage network, they impact lateral and longitudinal connectivity by introducing roughness elements that fundamentally change the timing, delivery, and storage of water, sediment, nutrients, and organic matter. While the local effects of beaver dams on streams are well understood, broader coverage network models that predict where beaver dams can be built and highlight their impacts on connectivity across diverse drainage networks are lacking. Here we present a capacity model to assess the limits of riverscapes to support dam-building activities by beaver across physiographically diverse landscapes. We estimated dam capacity with freely and nationally-available inputs to evaluate seven lines of evidence: (1) reliable water source, (2) riparian vegetation conducive to foraging and dam building, (3) vegetation within 100 m of edge of stream to support expansion of dam complexes and maintain large colonies, (4) likelihood that channel-spanning dams could be built during low flows, (5) the likelihood that a beaver dam is likely to withstand typical floods, (6) a suitable stream gradient that is neither too low to limit dam density nor too high to preclude the building or persistence of dams, and (7) a suitable river that is not too large to restrict dam building or persistence. Fuzzy inference systems were used to combine these controlling factors in a framework that explicitly also accounts for model uncertainty. The model was run for 40,561 km of streams in Utah, USA, and portions of surrounding states, predicting an overall network capacity of 356,294 dams at an average capacity of 8.8 dams/km. We validated model performance using 2852 observed dams across 1947 km of streams. The model showed excellent agreement with observed dam densities where beaver dams were present. Model performance was spatially coherent and logical, with electivity indices that effectively segregated capacity categories. That is, beaver dams were not found where the model predicted no dams could be supported, beaver avoided segments that were predicted to support rare or occasional densities, and beaver preferentially occupied and built dams in areas predicted to have pervasive dam densities. The resulting spatially explicit reach-scale (250 m long reaches) data identifies where dam-building activity is sustainable, and at what densities dams can occur across a landscape. As such, model outputs can be used to determine where channel–floodplain and wetland connectivity are likely to persist or expand by promoting increases in beaver dam densities.

1. Introduction

Due to the suite of hydrologic, hydraulic, geomorphic, and ecological feedbacks associated with the dam-building activities of beaver, both *Castor canadensis* in North America and *Castor fiber* in Europe and Asia, are widely recognized as ecosystem engineers (Burchsted et al., 2010; Gurnell, 1998; Naiman et al., 1988; Rosell et al., 2005; Warren, 1927). As such, beaver dam building activities affect the lateral, longitudinal, vertical and temporal connectivity of stream channels, floodplains, and adjacent uplands. Beaver dams increase lateral connectivity by linking stream channels, floodplains, and adjacent uplands subsequently increasing longitudinal discontinuities downstream (Burchsted et al., 2010). Beaver dams can enhance vertical connectivity by increasing exchanges between surface and ground water (Majerova et al., 2015). Longitudinally, beaver dams disrupt the delivery of water, sediment, wood and nutrients (Wohl, 2013b), potentially dramatically altering the connectivity of upstream sediment sources to downstream sinks and providing greater variation in the residence time in sinks for sediment storage associated with beaver dams. Whereas dam breaches,

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- BRAT (**Beaver Restoration Assessment Tool**) is all about *how many* of these:

- Not how many of these:

BRAT http://brat.riverscapes.xyz

Macfarlane et al. (2016) DOI: [10.1016/j.geomorph.2015.11.019](https://doi.org/10.1016/j.geomorph.2015.11.019)

THE PRIMARY QUESTIONS WE ASK

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*?

Macfarlane et al. (2016) DOI: 10.1016/j.geomorph.2015.11.019

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

CAPACITY MODEL IN A NUTSHELL

- Beaver need water and wood…
- Type and extent of wood/vegetation matters most
- Flow regime act to potentially limit capacity

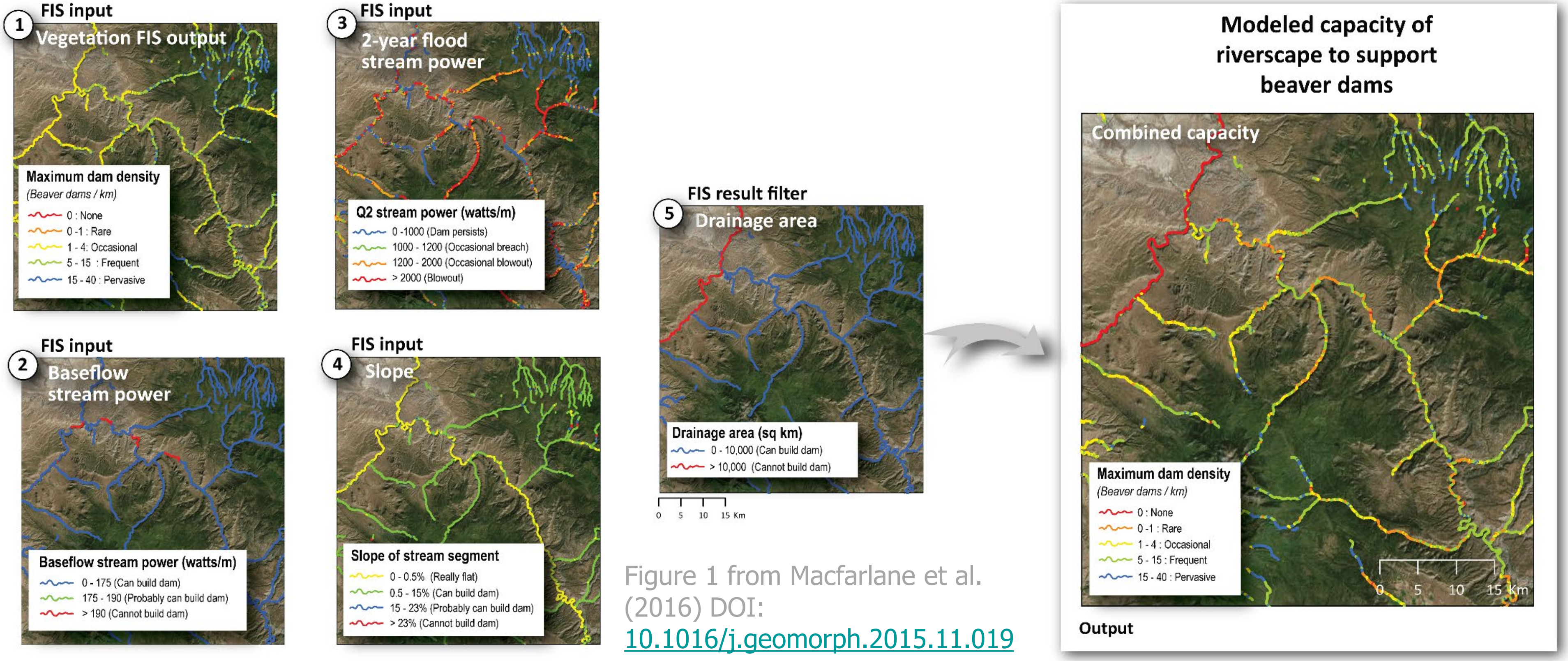


Figure 1 from Macfarlane et al. (2016) DOI: 10.1016/j.geomorph.2015.11.019

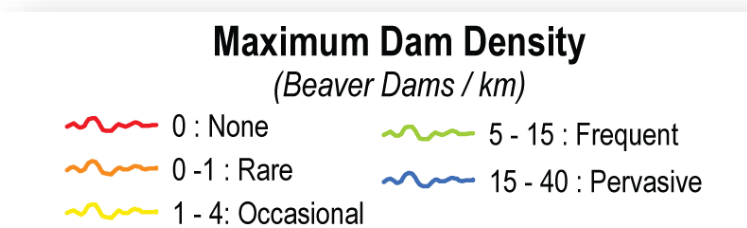
HOW MANY & WHERE?

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

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

Category	Stream length (km)	% of stream network	Estimated dam capacity
Pervasive	6219	15%	147,644
Frequent	18,162	45%	186,184
Occasional	8234	20%	21,544
Rare	3307	8%	922
None	4639	12%	–
Total	40,561		356,294

- Note: Utah is second driest state in US

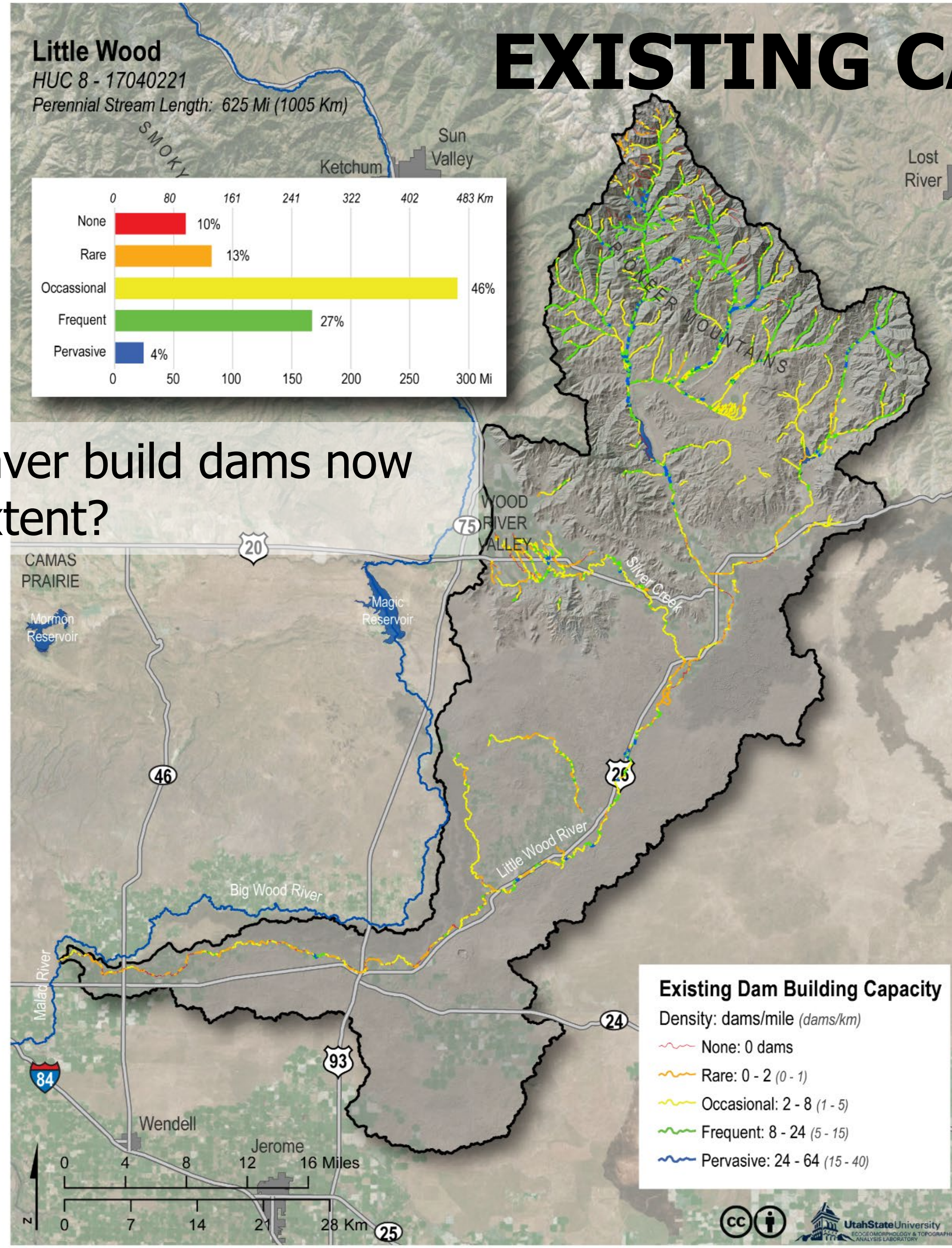


From Macfarlane et al. (2016) DOI: 10.1016/j.geomorph.2015.11.019

EXISTING CAPACITY

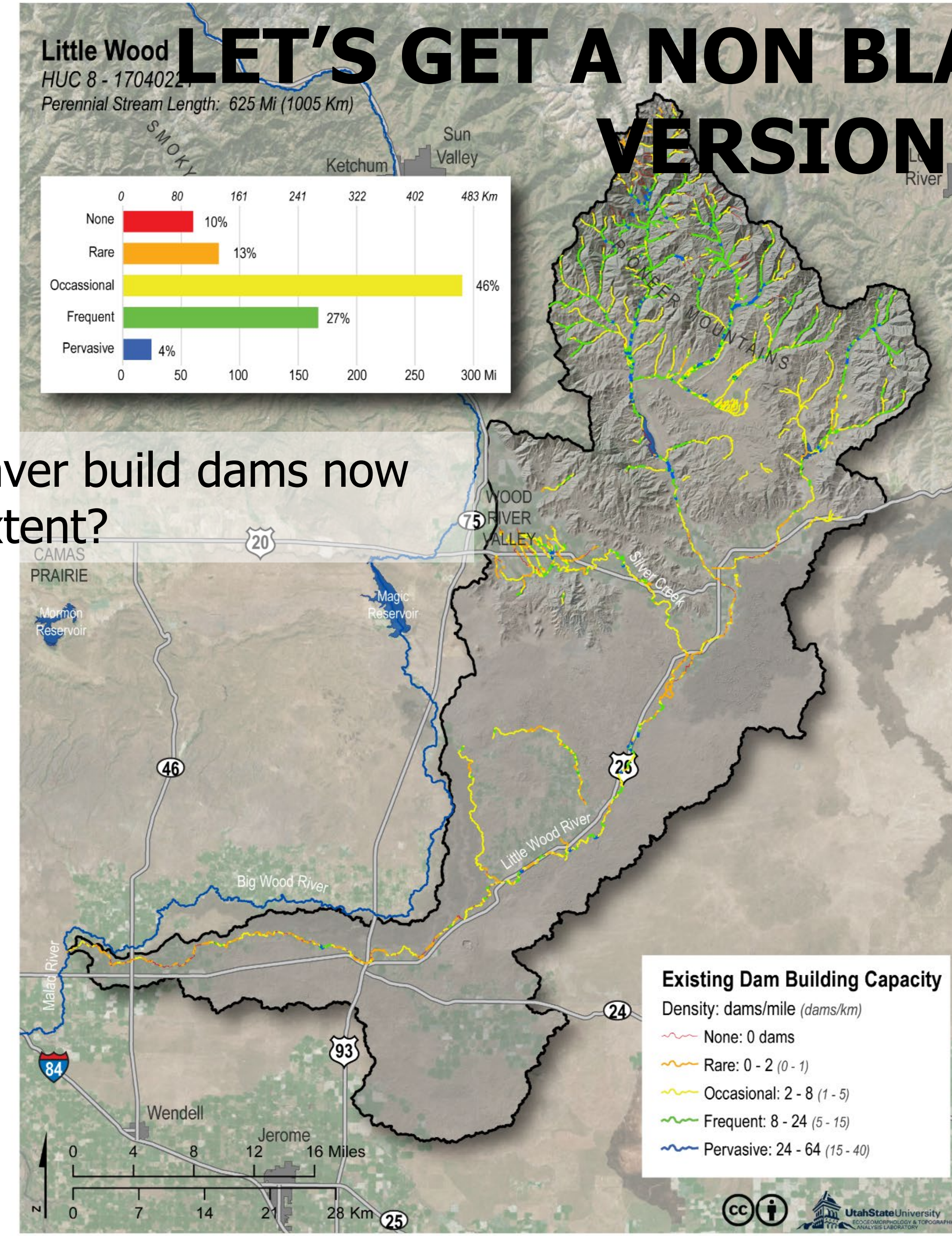
Where can beaver build dams now and to what extent?

Existing Capacity:
6,139 *dams*
~ 6 *dams/KM*



LET'S GET A NON BLACK-BOX VERSION OF THIS

Where can beaver build dams now and to what extent?



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CAPACITY… MAX NUMBER OF DAMS

- By answering the basic questions on this form & using the inference system tables we can estimate beaver dam capacity.

BRAT-cIS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC

OBSERVATION INFO

Observer Name: ________________________

Observation Date: ________________________

Reach ID: ________________________

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

- o Unsuitable
- o Barely Suitable
- o Moderately Suitable
- o Suitable
- o 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

- o Unsuitable
- o Barely Suitable
- o Moderately Suitable
- o Suitable
- o 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)

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

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

Can beaver build a dam at baseflows?

- o Probably can build dam
- o Can build dam
- o Can build dam (saw evidence of recent dams)
- o Could build dam at one time (saw evidence of relic dams)
- o 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)?

- o Blowout
- o Occasional Blowout
- o Occasional Breach
- o Dam Persists

How does the reach slope impact their ability or need to build dams?

- o So steep they cannot build a dam (e.g. > 20% slope)
- o Probably can build dam
- o Can build dam (inferred)
- o Can build dam (evidence or current or past dams)
- o 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)

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

Maximum Dam Density (dams/km)

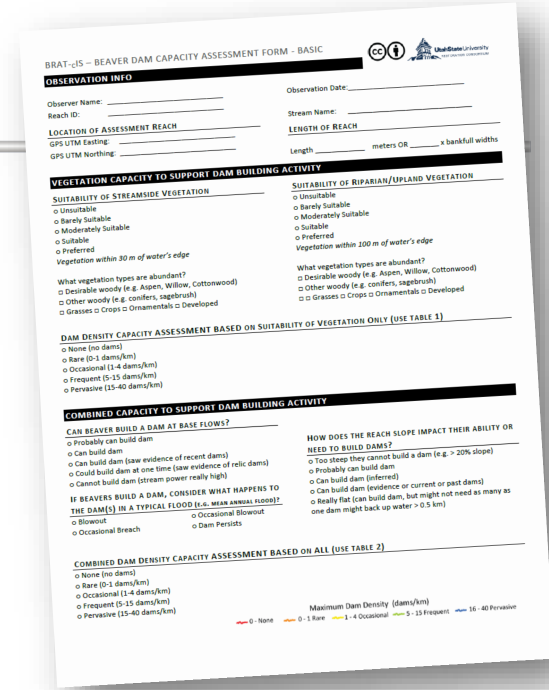
0 - None | 0 - 1 Rare | 1 - 4 Occasional | 5 - 15 Frequent | 16 - 40 Pervasive

Let’s go out in the field & “run” BRAT

•BRAT is a powerful planning tool that helps determine ***where and at what level*** dam-building activity might be sustainable for stream and riparian restoration.

BRAT - $_{C}$IS

Who?
Where?
When?


BRAT-cIS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC

OBSERVATION INFO

Observer Name: ____ Observation Date: ____
Reach ID: ____ 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
o Unsuitable
o Barely Suitable
o Moderately Suitable
o Suitable
o 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
o Unsuitable
o Barely Suitable
o Moderately Suitable
o Suitable
o 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)
o None (no dams)
o Rare (0-1 dams/km)
o Occasional (1-4 dams/km)
o Frequent (5-15 dams/km)
o Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?
o Probably can build dam
o Can build dam
o Can build dam (saw evidence of recent dams)
o Could build dam at one time (saw evidence of relic dams)
o 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)?
o Blowout
o Occasional Breach
o Occasional Blowout
o Dam Persists

HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?
o Too steep they cannot build a dam (e.g. > 20% slope)
o Probably can build dam
o Can build dam (inferred)
o Can build dam (evidence or current or past dams)
o 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)
o None (no dams)
o Rare (0-1 dams/km)
o Occasional (1-4 dams/km)
o Frequent (5-15 dams/km)
o Pervasive (15-40 dams/km)

BRAT-$_{C}$IS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC

OBSERVATION INFO

Observer Name: ______________________ Observation Date: ______________________

Reach ID: ______________________

Stream Name: ______________________

LOCATION OF ASSESSMENT REACH

GPS UTM Easting: ______________________

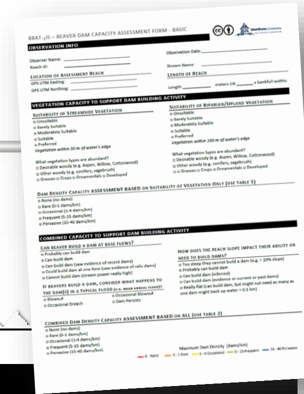
GPS UTM Northing: ______________________

LENGTH OF REACH

Length __________ meters OR ______ x bankfull widths

BRAT - $_{C}$IS

The veg questions… - dam building materials



VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

SUITABILITY OF STREAMSIDE VEGETATION

- o Unsuitable
- o Barely Suitable
- o Moderately Suitable
- o Suitable
- o 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

- o Unsuitable
- o Barely Suitable
- o Moderately Suitable
- o Suitable
- o 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)

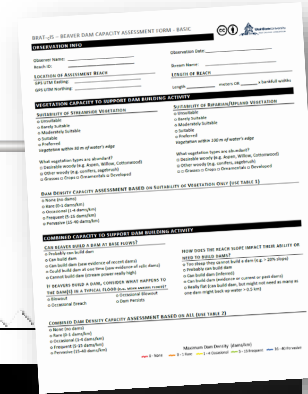
- o None (no dams)
- o Rare (0-1 dams/km)
- o Occasional (1-4 dams/km)
- o Frequent (5-15 dams/km)
- o Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?

BRAT - cIS

The inference system… look up table on back!



VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

Suitability of Streamside Vegetation

- o Unsuitable
- o Barely Suitable
- o Moderately Suitable
- ● Suitable
- o 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

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.

Rules	Inputs: Suitability of streamside vegetation	& Suitability of riparian/upland vegetation		Output: 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

Dam Density Capacity Assessment Based

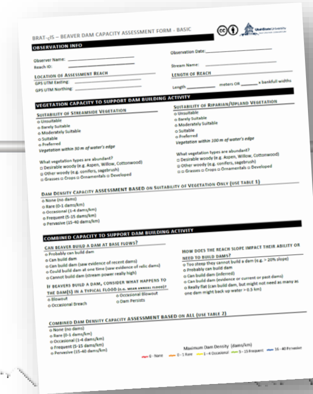
- o None (no dams)
- o Rare (0-1 dams/km)
- o Occasional (1-4 dams/km)
- o Frequent (5-15 dams/km)
- o Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM B

Can beaver build a dam at base flows?

BRAT - $_{c}$IS

Does hydrology (manifested as local hydraulics) limit this capacity?



COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

Can beaver build a dam at base flows?

- o Probably can build dam
- o Can build dam
- o Can build dam (saw evidence of recent dams)
- o Could build dam at one time (saw evidence of relic dams)
- o 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)?

- o Blowout
- o Occasional Breach
- o Occasional Blowout
- o Dam Persists

How does the reach slope impact their ability or need to build dams?

- o Too steep they cannot build a dam (e.g. > 20% slope)
- o Probably can build dam
- o Can build dam (inferred)
- o Can build dam (evidence or current or past dams)
- o 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)

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

Maximum Dam Density (dams/km)

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

BRAT - $_C$IS

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*	Oc					
18 *If*	Oc					
19 *If*	Oc					
20 *If*	Fre					
21 *If*	Fre					
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31 *If*	Fre					
32 *If*	Fre					
33 *If*	Fre					
34 *If*	Fre					
35 *If*	Fre					
36 *If*	Fre					
37 *If*	Fre					
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

	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

Uglier table… but simple to apply

Maximum Dam Density (dams/km)

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