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PARTNERING WITH BEAVER IN RESTORATION

WATS 6860



SEMINAR NEXT WEDNESDAY

- Feb 15: 12:30 PM in NR105
- Kendrick Hafen, Water Rights Attorney (Konrad's Dad)
- Talk: "Utah's Water Regulatory Agencies in the Context of the Hydrologic Cycle"





RESTORATION ALTERNATIVES WITH BEAVER

Joe Wheaton
Nick Bouwes



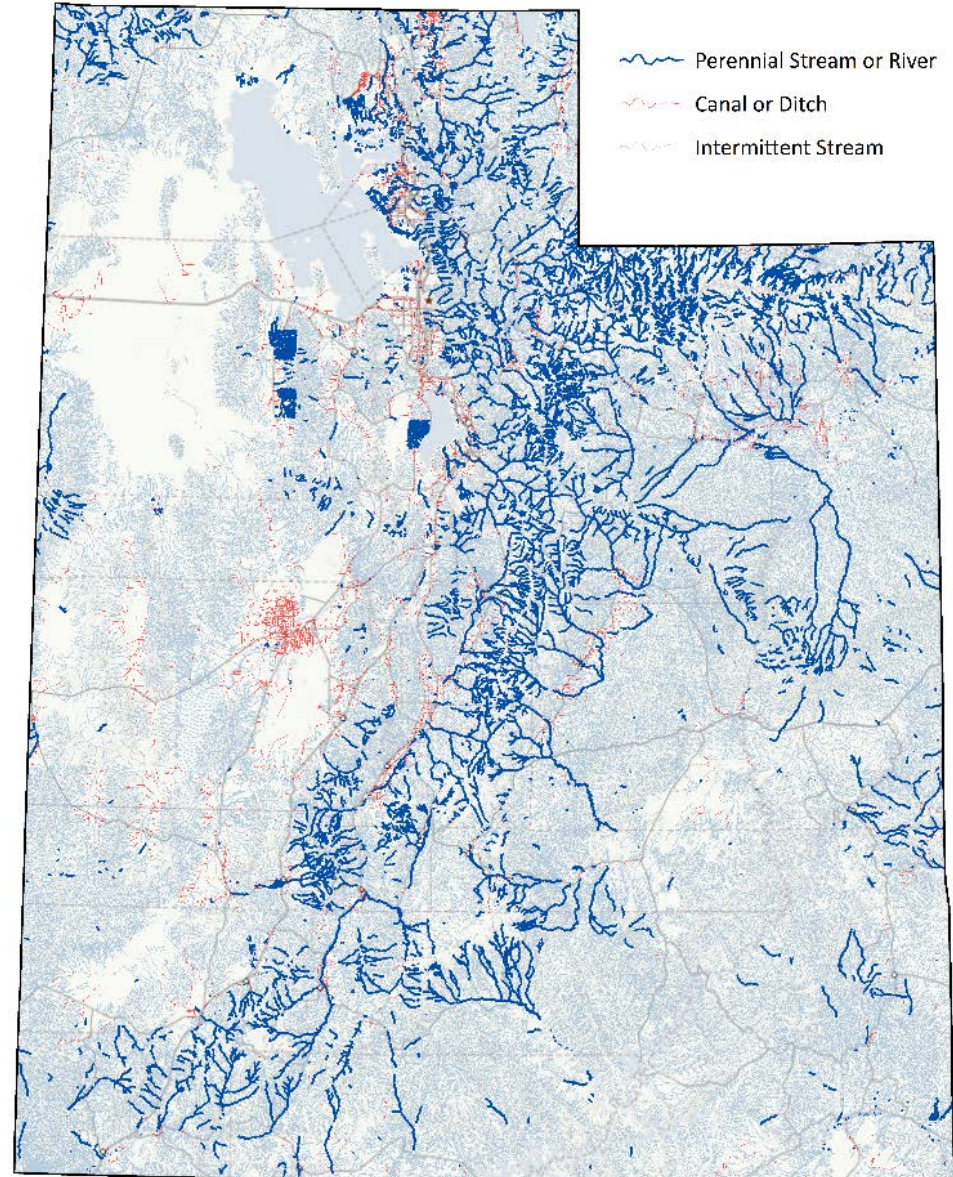
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IN UTAH...

- We have over 85,000 miles of rivers and streams
 - 81% (65,000 miles) are non-perennial
 - 16,000 miles perennial
- Historically...
 - Beaver were everywhere
- Today...
 - At least 43% of streams are impaired



WHY ALWAYS TONKA TOYS?



DYNAMIC STREAMS = HEALTHY ECOSYSTEMS



- To keep varied habitat, we need dynamic streams
- Yet, we're not very good at restoring dynamism



WHAT IS BROKEN (RIVERSCAPE-CENTRIC)?

- Hydrology
 - Flooding
 - Water timing /water storage
- Floodplain loss/disconnection
 - Incised Channels
- Riparian degradation
- Wetland loss/degradation
- Impaired Water Quality
- Degraded Habitat
 - Homogenized habitats
 - Aquatic (in channel, fish)
 - Riparian (birds, wildlife)
 - Upland (game, livestock, wildlife forage)
- Threatened & Endangered Species

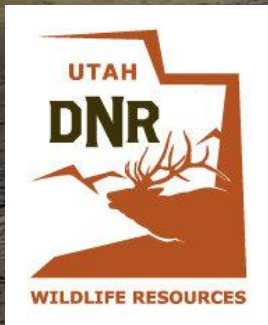


WHAT ABOUT SAGE GROUSE?

- Restoring beaver, could restore riparian zones, that could act as important **brood rearing** habitat
- Fringe between sage brush and riparian is critical



- Kent Sorenson (UDWR)
- Nate Hough-Snee (USU)



WHAT ABOUT PJ – JUNIPER REMOVAL?

- Many upland restoration efforts focused on removing PJ
- **Can we use the juniper for posts or fill material?**



Mike Kuhns & Darren McAvoy

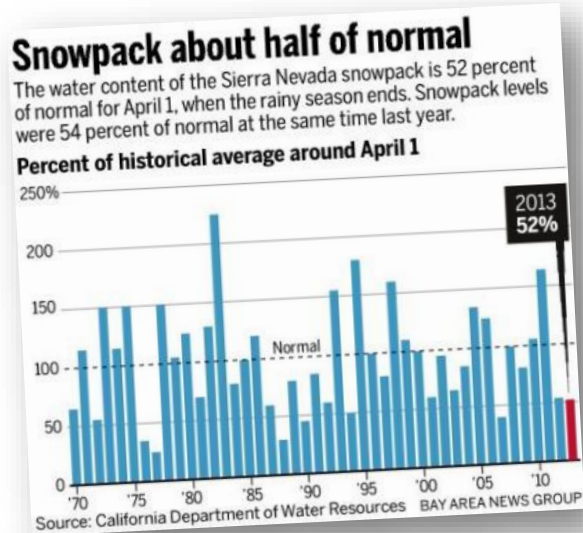
WHAT ABOUT ASPEN REGENERATION?

- Healthy aspen need disturbance
 - Can be fire, can be coppicing, can be disease or....



WHAT ABOUT DECLINING SNOWPACK?

- Could we get enough beaver dams back on landscape to mitigate this?

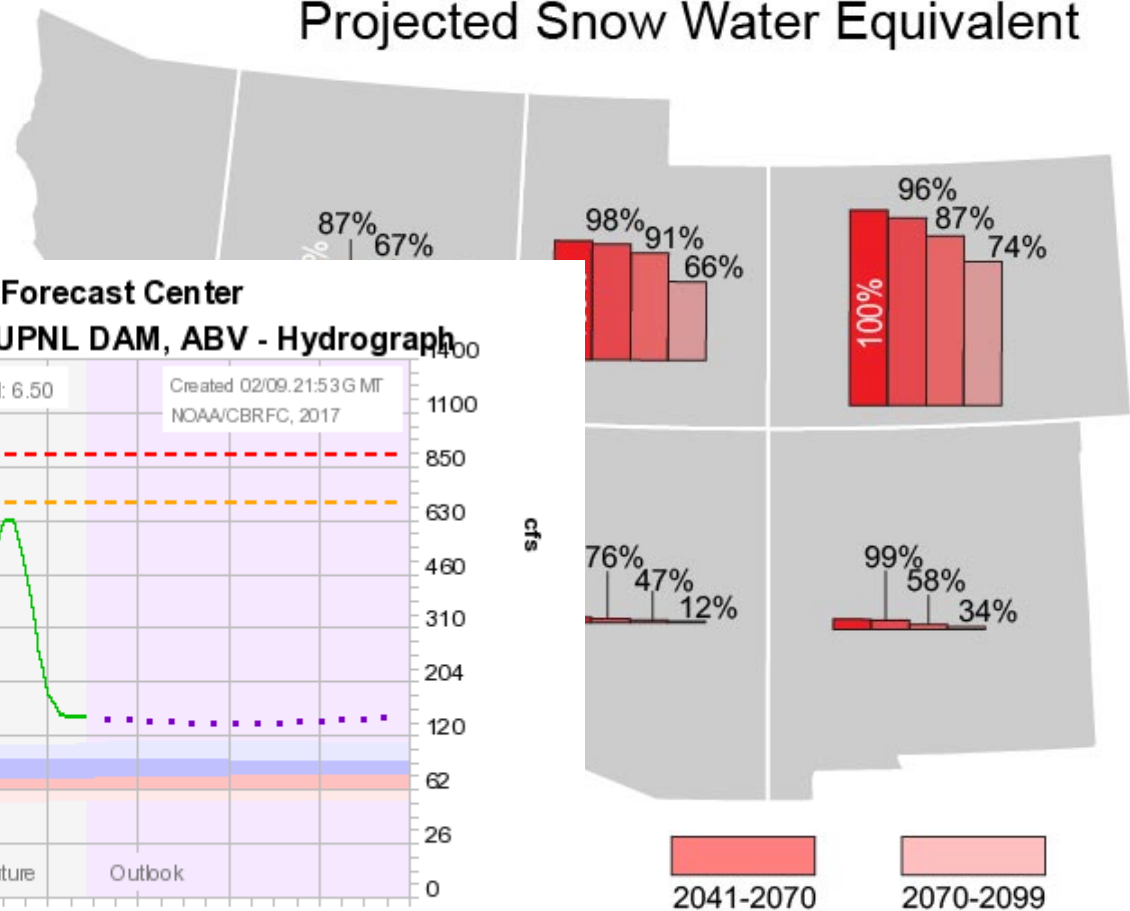


- We desperately need research to better quantify hydrologic impacts of beaver dams and how they scale up

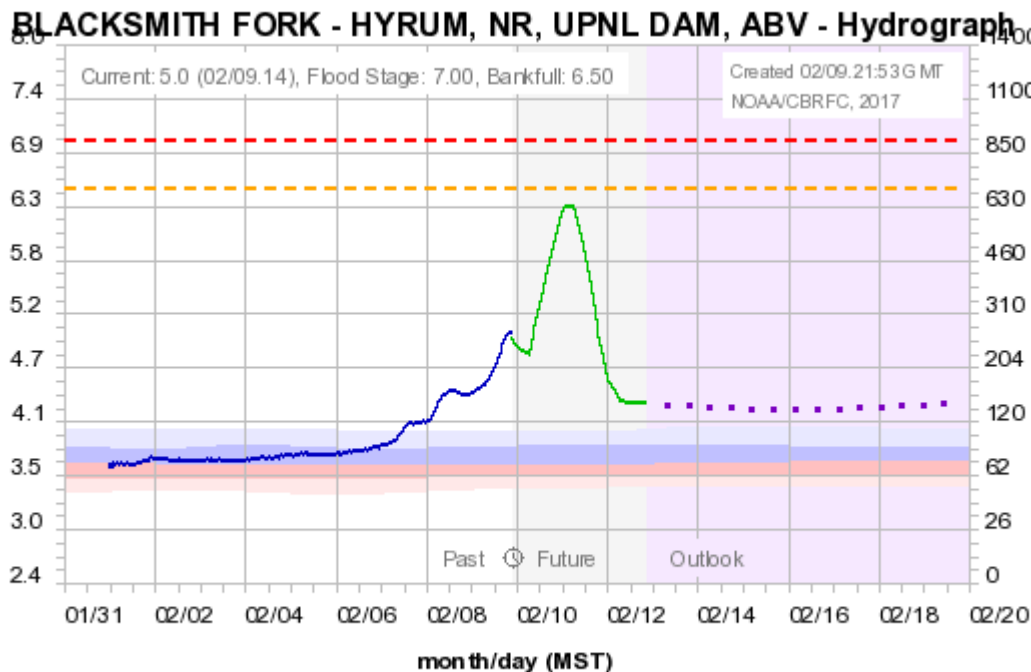
EXAMPLE KEY MESSAGES FOR SOUTHWEST

- Reduced Snowpack and Streamflows

Projected Snow Water Equivalent



Colorado Basin River Forecast Center



Observed — Forecast (02/09.16:00) — Outlook (increasing uncertainty) — Bankfull 6.50 — Flood 7.0 —
Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10%

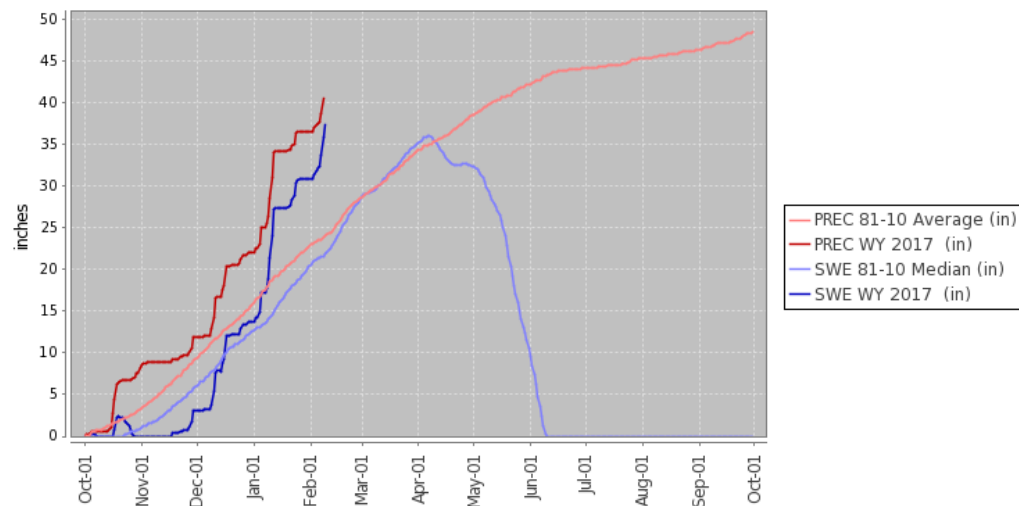
Melillo et al. (2014) DOI: 10.7930/J0Z31WJ2

<http://nca2014.globalchange.gov/>

NOT RIGHT

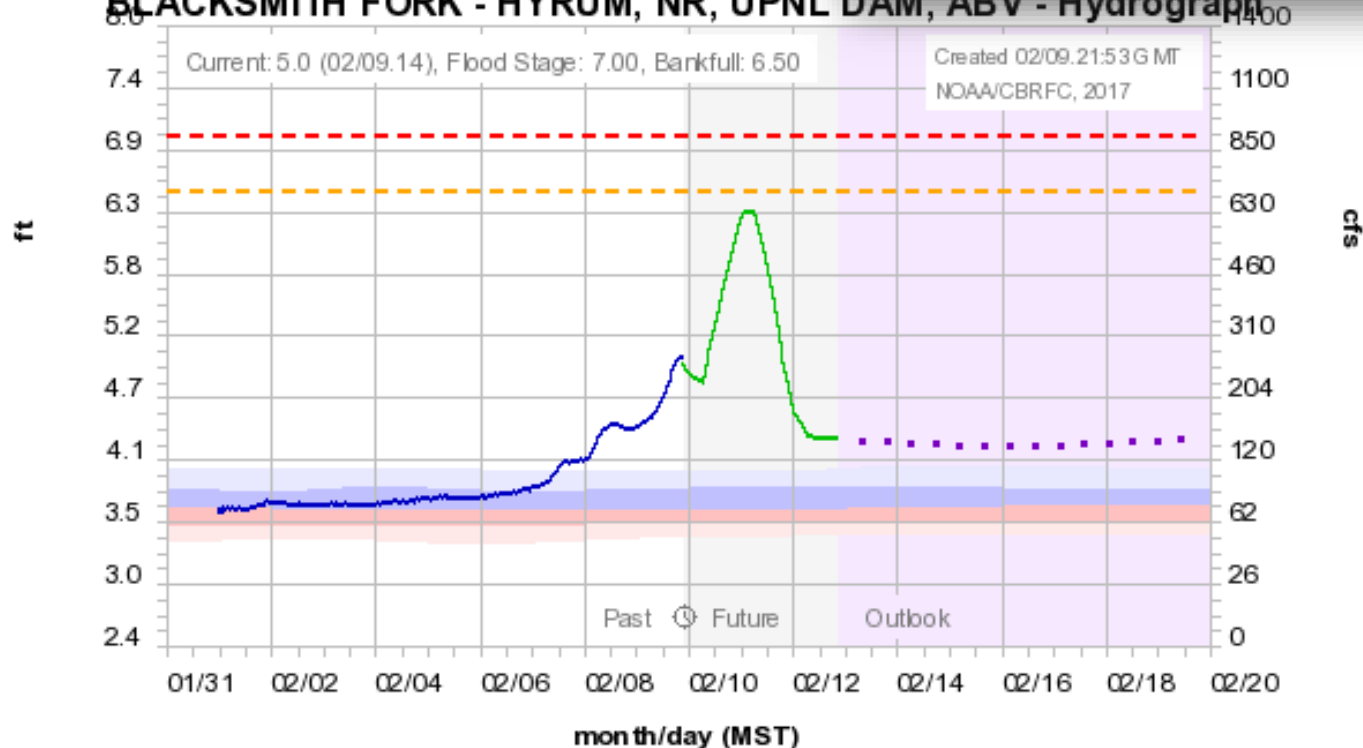
- The new 'normal'

Station (823) WATERYEAR=2017 (Daily) NRCS National Water and Climate Center - Provisional Data - subject to revision
Thu Feb 09 13:55:31 GMT-08:00 2017



Colorado Basin River Forecast

BLACKSMITH FORK - HYRUM, NR, UPNL DAM, ABV - Hydrograph



Observed — Forecast (02/09.16:00) — Outlook (increasing uncertainty) — Bankfull 6.50 — Flood 7.0 —
Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10% 10-0%

BEAVER & CLIMATE CHANGE

- They've weathered many ups and downs in climate
- They were pushed to brink of extinction and extirpated and came back
- Their systems have been shown to mitigate impacts of droughts
- They've been shown to maintain wetlands through droughts



BIOLOGICAL CONSERVATION 141 (2008) 556–567



available at www.sciencedirect.com



journal homepage: www.elsevier.com/locate/biocon



Beaver (*Castor canadensis*) mitigate the effects of climate on the area of open water in boreal wetlands in western Canada

Glynnis A. Hood^{a,b,*}, Suzanne E. Bayley^a

^aDepartment of Biological Sciences, CW 405, Biological Sciences Center, University of Alberta, Edmonton, Alberta, Canada T6G 2E9

^bDepartment of Science, Augustana Faculty, University of Alberta, 4901-49 Avenue, Camrose, Alberta, Canada T4V 2R3

ARTICLE INFO

Article history:

Received 19 July 2007

Received in revised form

25 November 2007

Accepted 5 December 2007

Available online 18 January 2008

Keywords:

Beaver

Castor canadensis

Drought

East-central Alberta

Elk Island National Park

Mixed-wood boreal

Wetland conservation

ABSTRACT

Shallow open water wetlands provide critical habitat for numerous species, yet they have become increasingly vulnerable to drought and warming temperatures and are often reduced in size and depth or disappear during drought. We examined how temperature, precipitation and beaver (*Castor canadensis*) activity influenced the area of open water in wetlands over a 54-year period in the mixed-wood boreal region of east-central Alberta, Canada. This entire glacial landscape with intermittently connected drainage patterns and shallow wetland lakes with few streams lost all beaver in the 19th century, with beaver returning to the study area in 1954. We assessed the area of open water in wetlands using 12 aerial photo mosaics from 1948 to 2002, which covered wet and dry periods, when beaver were absent on the landscape to a time when they had become well established. The number of active beaver lodges explained over 80% of the variability in the area of open water during that period. Temperature, precipitation and climatic variables were much less important than beaver in maintaining open water areas. In addition, during wet and dry years, the presence of beaver was associated with a 9-fold increase in open water area when compared to a period when beaver were absent from those same sites. Thus, beaver have a dramatic influence on the creation and maintenance of wetlands even during extreme drought. Given the important role of beaver in wetland preservation and in light of a drying climate in this region, their removal should be considered a wetland disturbance that should be avoided.

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1. Introduction

During times of drought, the loss of water resources has devastating effects on both agricultural and natural resources (deMenocal, 2001; Schindler and Donahue, 2006), to the point of being considered a "landscape hazard" in situations where aridity is directly linked to soil erosion (Sauchyn et al., 2002). Although various data, including paleoclimatic (Laird et al., 2003), tree ring (Sauchyn et al., 2003), and anthropological

data (deMenocal, 2001), suggest that decadal and multicentennial scale droughts have occurred in North America for at least two millennia; climate models predict the incidence of drought in some regions in the world, including parts of North America, will increase in frequency and duration over the next 100 years (Moore et al., 1997; Hengeveld, 2000; Hogg and Bernier, 2005; Schindler and Donahue, 2006). The combined impact of drought and anthropogenic wetland losses, with intensified industrial, urban and agricultural demands

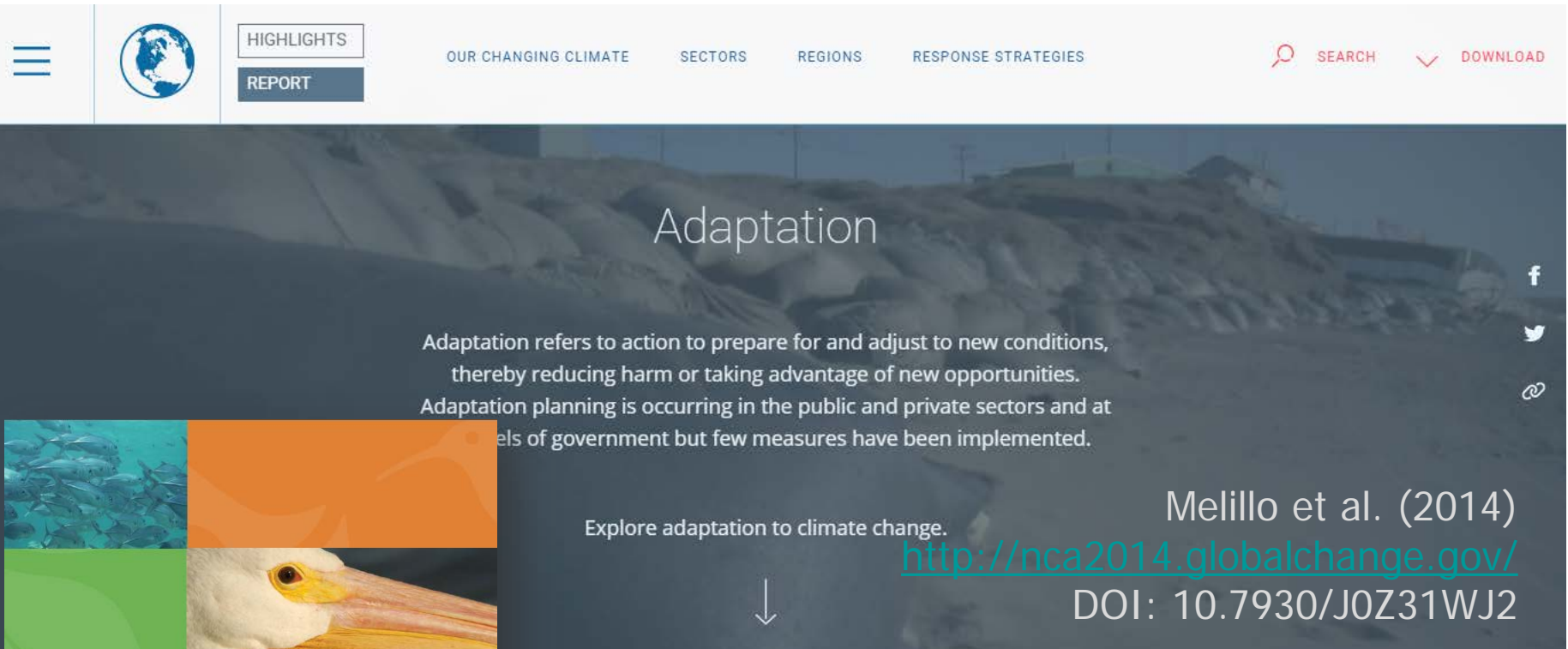
* Corresponding author. Address: Department of Science, University of Alberta, Augustana Faculty, 4901-46 Avenue, Camrose, Alberta, Canada T4V 2R3. Tel.: +1 780 679 1556; fax: +1 780 679 1590.

E-mail addresses: glynnis.hood@ualberta.ca (G.A. Hood), sbayley@ualberta.ca (S.E. Bayley).

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doi:10.1016/j.biocon.2007.12.003

ADAPTATION INCREASINGLY EMPHASIZED



The screenshot shows the NOAA website's 'Adaptation' page. The header includes a hamburger menu, a globe icon, and navigation links for 'HIGHLIGHTS', 'REPORT', 'OUR CHANGING CLIMATE', 'SECTORS', 'REGIONS', and 'RESPONSE STRATEGIES'. A search bar and a download link are also present. The main content area features a large background image of a desert landscape with the word 'Adaptation' in white text. Below this, a definition of adaptation is provided: 'Adaptation refers to action to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Adaptation planning is occurring in the public and private sectors and at all levels of government but few measures have been implemented.' To the right of the text are social media icons for Facebook, Twitter, and LinkedIn. Below the definition, a link is provided: 'Explore adaptation to climate change. <http://nca2014.globalchange.gov/> DOI: 10.7930/J0Z31WJ2'. A downward arrow points from the link to the bottom of the page.

Adaptation

Adaptation refers to action to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Adaptation planning is occurring in the public and private sectors and at all levels of government but few measures have been implemented.

Explore adaptation to climate change.
<http://nca2014.globalchange.gov/>
DOI: 10.7930/J0Z31WJ2



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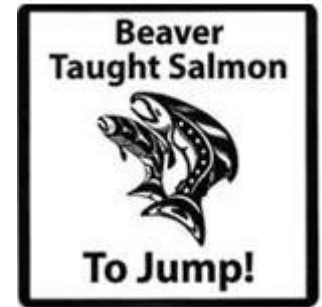
TOP STORIES IN LIFE & CULTURE 1 of 12

 **Groceries Become a Guy Thing**

 **A Security Line With Mood Lighting**

 **Ready for More From Liz and Dick?**

 **What If the 'Right Way' Is Wrong?**



A-HEd

With Trouble on the Range, Ranchers Wish They Could Leave It to Beavers

Critters, Once Reviled, Gain Popularity With 'Believers'; a Good Rodent Is Hard to Find

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By **JOEL MILLMAN**

August 30, 2011

Clyde Woolery wants his beavers back.


Mr. Woolery's ranch on Beaver Creek outside Kinnear, Wyo., has been beaver-free for decades, but he could sure use their help now. A small beaver colony, he says, would engineer dams that raise the water table under his pastures, opening up drinking holes for his cattle.



The Beaver Solution Team live traps beavers on properties where they are causing damage and relocates them to places where they can do good.

So the 64-year-old rancher put himself on a waiting list this year hoping state officials would bring him a beaver or two. Wyoming's Game and Fish Commission periodically plucks the rodents from drainage culverts.


It's a bit of a turnabout in these parts, where beavers have long been considered something of a nuisance—blamed for

 **npr**

Beavers Offer Solution to Climate Change


by **DAVID MALAKOFF**

May 03, 2008 4:00 PM

 [Listen to the Story](#)

All Things Considered

In the Southwest U.S., biologists are talking about returning beavers to rivers they once inhabited in order to fight droughts — which are expected to get worse as the globe warms. Beaver dams create great sponges that store lots of water.

 **Transcript**

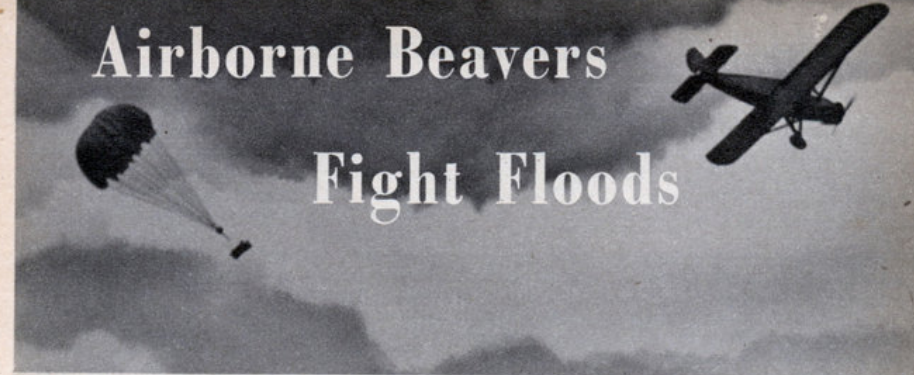
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ITS NOT NEW

- The example involving this rodent is not new...



Airborne Beavers Fight Floods

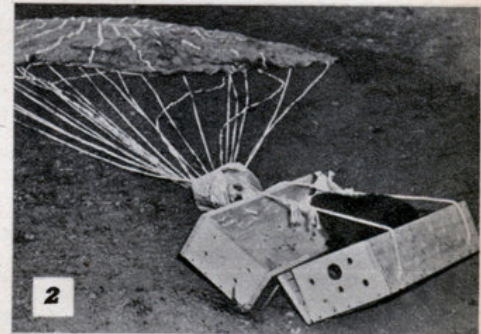


OUT in Idaho, the Department of Fish and Game is teaching eager beavers to yell "Geronimo!" These busy little creatures are being dropped by parachute to terrain where they can do their bit in the conservation battle.

Idaho state caretakers trap unwanted beavers which may be a nuisance in certain areas, round them up at central points and pack them in pairs in specially constructed wooden crates. After they are dropped, the boxes remain closed as long as there's some tension on the parachute shrouds but pull open as soon as the chute collapses on the ground. Then, out crawl Mama and Papa beaver, ready to start work.

After they're settled, the 40-pound, web-footed rodents multiply and become outpost agents of flood control and soil conservation. Fur supervisor John Smith reports that in carefully observed early operations, the beavers headed straight for water and started building a new dam within a couple of days.

However, one problem still remains to be solved—a question of ethics more than conservation. Are these eager beavers *bona fide* members of the Caterpillar Club? •



1. Boxed for travel, this beaver is placed in a crate designed by Scotty Heter, left.
2. Rubber bands pull the box apart when the chute hits the ground, freeing the animals.
3. Heading for water, the airborne beavers start working like beavers on their new dam.

ACTUALLY WORKED WELL

- Fall 1948, 76 live nuisance beaver from McCall parachuted with only one casualty (Heter, 1950)
- Cost per beaver transplant: < \$16/beaver



BEAVER RESTORATION TOOLBOX

- Prepared by Kirk Malcom @ USFS
- Annotated Bibliography and links

Available from:

<http://www.martinezbeavers.org/wordpress/wp-content/uploads/2013/10/Beaver-Restoration-Toolbox-Karl-Malcolm-2013.pdf>



Beaver Restoration Toolbox

A collection of insights, resources, and expert contacts to guide riparian restoration projects that capitalize on the engineering capacity of the North American beaver

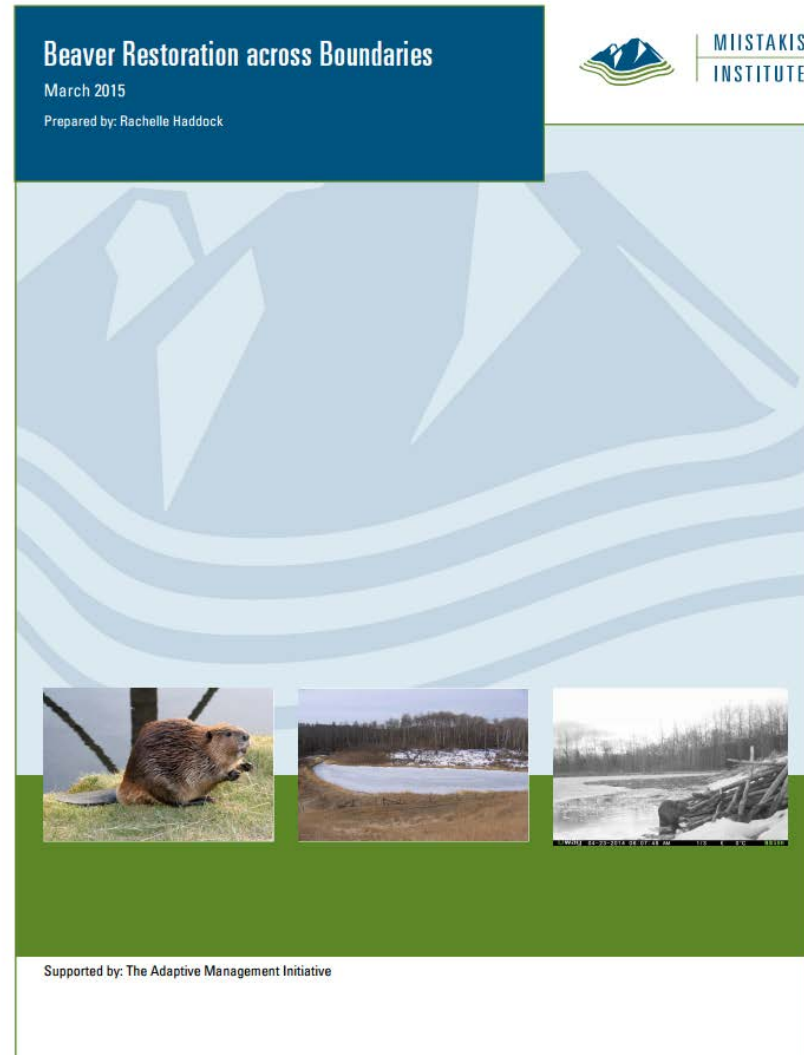


BEAVER RESTORATION ACROSS BOUNDARIES

- Prepared by Rachelle Haddock
- Miistakis Institute
- Synthesis of lessons learnt & interviews on Beaver Restoration in Western States & use as a climate change adaptation strategy

Available from:

http://www.rockies.ca/project_info/Beaver%20Restoration%20Across%20Boundaries_Mar_26_2015.pdf



BEAVER: DRIVER OF THE RIVER DISCONTINUUM

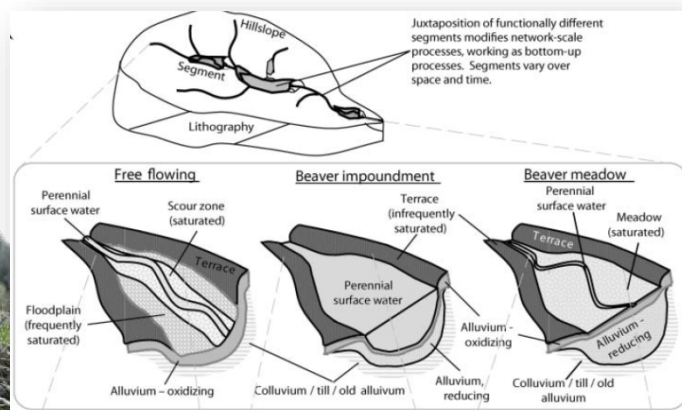
Table 1. Comparison of beaver and run-of-the-river human dams as an example of human-built replacement of one type of preexisting discontinuity along the river corridor.

Parameter	Run-of-the-river human dam	Intact beaver dam
Permeability	Impermeable	Leaky or somewhat permeable
Structure longevity	100 to 1000 years	10 to 100 years
Number of spillways or downstream channels	One	One or more
Crest geometry	Simple, usually linear	Complex, irregular
Hydraulic cross section at the spillway crest	Uniformly fast and shallow	Variable, with concentrations of faster and deeper water, often with multiple spillways; flow may be entirely through the dam
Low-flow water passage	Little to no release	Water continues to leak through dam
Upstream water level variability	Little to none	Variable over the water year
Upstream littoral zone	Narrow	Wide

Note: Run-of-the-river dams are the most common existing and removed dam type in the United States (Poff and Hart 2002).
Source: Müller-Schwarze and Sun 2003, Burchsted et al. 2009.



Figure 1. Examples of headwater segment types classified in this article: (a) free flowing, (b) beaver meadow, (c) valley beaver impoundment, and (d) in-channel beaver impoundment.



Articles

The River Discontinuum: Applying Beaver Modifications to Baseline Conditions for Restoration of Forested Headwaters

DENISE BURCHSTED, MELINDA DANIELS, ROBERT THORSON, AND JASON VOKOUN

Billions of dollars are being spent in the United States to restore rivers to a desired, yet often unknown, reference condition. In lieu of a known reference, practitioners typically assume the paradigm of a connected watercourse. Geological and ecological processes, however, create patchy and discontinuous fluvial systems. One of these processes, dam building by North American beavers (*Castor canadensis*), generated discontinuities throughout precolonial river systems of northern North America. Under modern conditions, beaver dams create dynamic sequences of ponds and wet meadows among free-flowing segments. One beaver impoundment alone can exceed 1000 meters along the river, flood the valley laterally, and fundamentally alter biogeochemical cycles and ecological structures. In this article, we use hierarchical patch dynamics to investigate beaver-mediated discontinuity across spatial and temporal scales. We then use this conceptual model to generate testable hypotheses addressing channel geomorphology, natural flow regime, water quality, and biota, given the importance of these factors in river restoration.

Keywords: fluvial geomorphology, hierarchical patch dynamics, stream ecology, river continuum concept, river restoration

Priate and public agencies across the United States spend billions of dollars on river restoration (Bernhardt et al. 2005) in attempts to return targeted systems to a state similar to that before disturbance. Our understanding of the pre-disturbance system, however, is framed by recent human alterations (e.g., Walter and Merritts 2008). To successfully implement a project that achieves even partial restoration, it is essential to understand the baseline conditions (Wohl 2005).

The baseline typically used in river restoration is a continuous, free-flowing system (FISRWG 1998). However, in catchments with limited modern human impact, the presumed continuity of headwaters is fragmented by bedrock, colluvium, large wood, past glacial scouring and deposition, and North American beaver (*Castor canadensis*) dams (Naiman et al. 1988, Ballantyne 2002, Benda et al. 2005), among other discontinuities. These components increase longitudinal heterogeneity by generating a stepped channel-bed profile in place of the continuous slope of the reference condition, with shallower gradients, slower velocities, and the accumulation of sediment upstream of blockages, and with scouring downstream of them. River discontinuities increase lateral heterogeneity by maintaining upstream floodplains, scouring additional downstream channels, and causing channel avulsions.

River obstructions and their impacts also vary over time, with the temporal scale depending on the type of discontinuity. Bedrock discontinuities are created and destroyed at the longest time scale. Glacial scouring and deposition occurs within the temporal and spatial discontinuities set by bedrock. Following glacial retreat, paraglacial modification continues for tens of thousands of years (Ballantyne 2002). Sediment, debris, and beaver dams modify the river corridor at a still smaller scale, with creation and destruction by stochastic events such as fire and floods (Benda et al. 2004) and beaver activity, and time scales of persistence as short as years to decades.

These discontinuities have been largely removed from rivers in the United States through recent human activities such as bedrock blasting, debris-dam removal, other channel homogenization for log drives, placer mining, logging of forests that once supplied major debris dams, beaver trapping, and floodplain reclamation (Lichtowich 1999, Wohl 2005). Many of the remaining preexisting discontinuities have been modified—and new ones created—by human dam and road construction. For example, table 1 compares beaver dams with run-of-the-river human dams; run-of-the-river dams are the most common existing and removed dams in the United States (Poff and Hart 2002). However, rather than viewing

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908 BioScience • December 2010 / Vol. 60 No. 11

www.biosciencemag.org

THE BEAVER RESTORATION GUIDEBOOK

The Beaver Restoration Guidebook

Working with Beaver to Restore Streams, Wetlands, and Floodplains

Version 1.02, July 14, 2015



Photo credit: Worth A Dam Foundation (martinezbeavers.org)

Prepared by

US Fish and Wildlife Service
National Oceanic and Atmospheric Administration
Portland State University
US Forest Service

Janine Castro
Michael Pollock and Chris Jordan
Gregory Lewallen
Kent Woodruff

Funded by

North Pacific Landscape Conservation Cooperative



Version 1.02. Get the latest version at: <http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp>

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 (Groszholz and Gallo 2006, Westbrook et al. 2006, Jeffries et al. 2008, Wohl 2011, Bellmore et al. 2012, Cluer and Thorne 2014, Pohl 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

BioScience XX: 1–12. Published by Oxford University Press on behalf of the American Institute of Biological Sciences 2014. This work is written by US Government employees and is in the public domain in the US.
doi:10.1093/biosci/biut036

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AT LEAST 6 TYPES OF 'BEAVER' RESTORATION



1. 'Allow' beaver to stay & promote/protect them (i.e. living with beaver / conservation)
2. Accidental Beaver Restoration
3. Transplant beaver from one area to an area where they are not currently & let them have at it
4. Riparian restoration & land use changes followed by transplanting beaver
5. In areas where beaver alone are not enough, help out with beaver dam analogues (BDAs), then hope beaver take over maintenance
6. Mimic beaver dam impacts with BDAs and artificially maintain...



RESTORATION & CONSERVATION WITH BEAVER

I. Underlying Principles

II. Various Alternatives

I. Conservation / Promotion

II. Accidental Restoration

III. Transplant to area that with suitable capacity

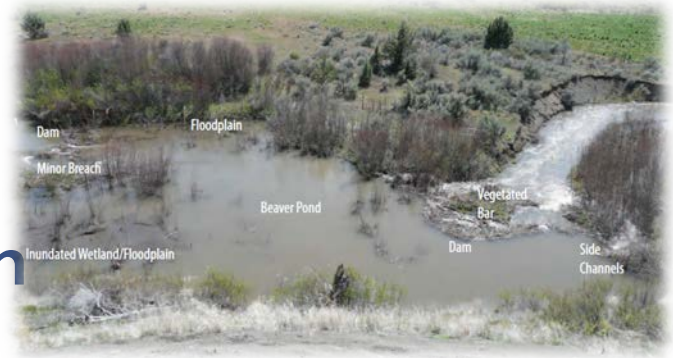
IV. Restore riparian -> Followed by Transplant

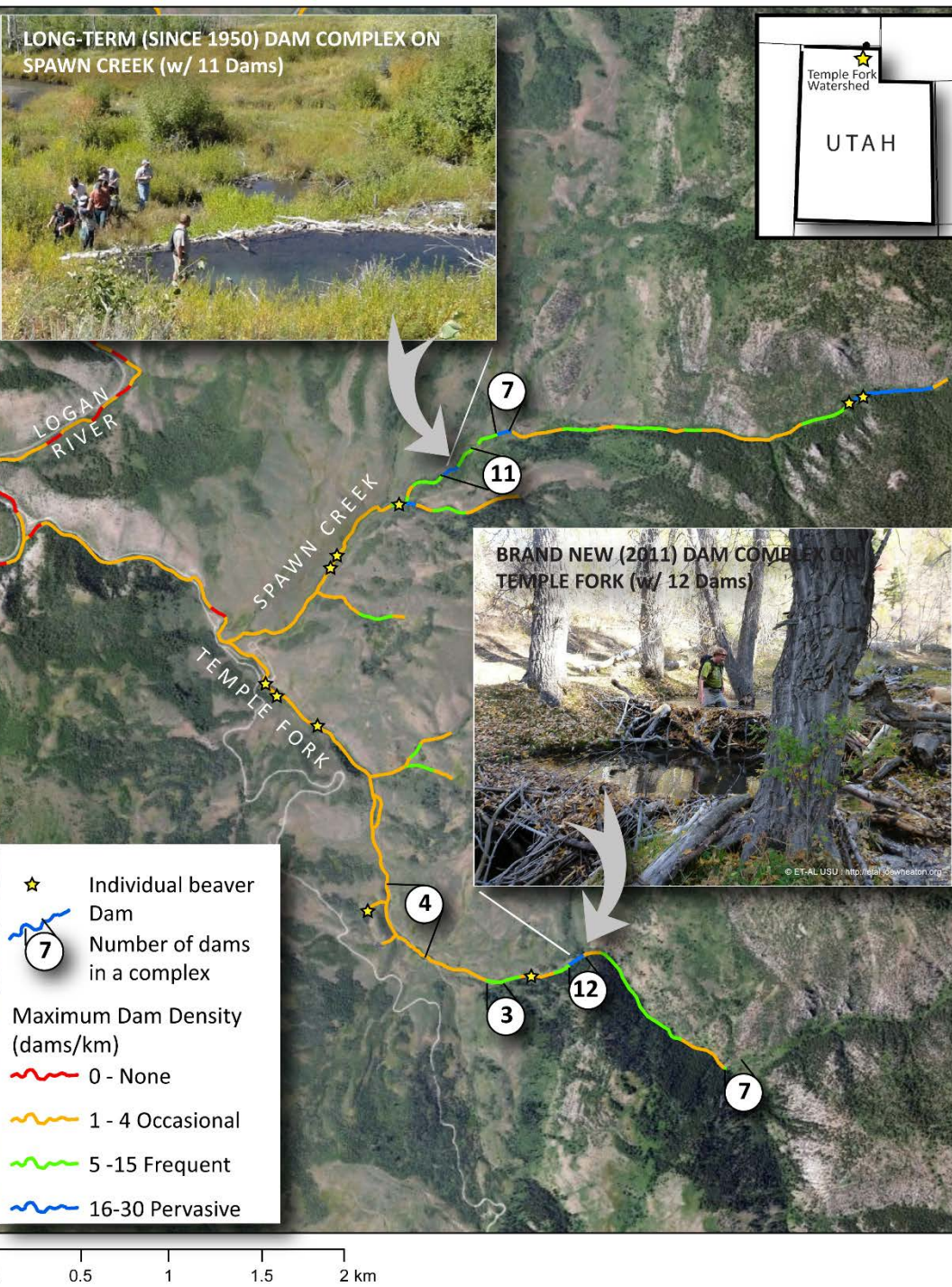
V. Help beaver out – Beaver Dam Analogues

VI. Mimic Beaver....

III. Call for Adaptations to Recipes

IV. Take Aways





FIND AN AREA IN GOOD SHAPE

Wrap it up and put a bow on it...

What to look for...

- Area with moderate to high densities of dams & high capacity to support 'rotations'
- Keep eye on conservation measures to sustain:
 - Grazing management
 - Harvest management/protection

LOOKS GOOD.... BUT...

- Part of this is the result of a grazing exclosure in 2005
- & perimitee is still grazing



RESTORATION & CONSERVATION WITH BEAVER

I. Underlying Principles

II. Various Alternatives

I. Conservation / Promotion

II. Accidental Restoration

III. Transplant to area that with suitable capacity

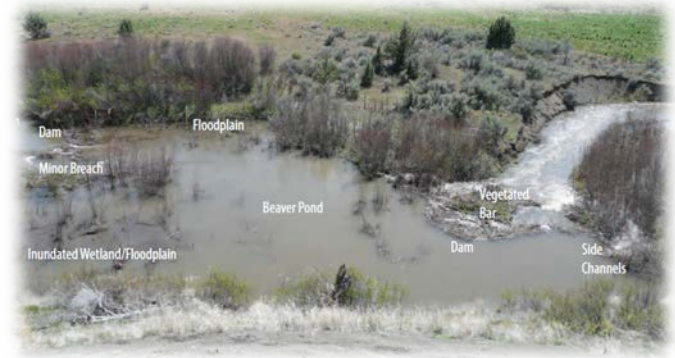
IV. Restore riparian -> Followed by Transplant

V. Help beaver out – Beaver Dam Analogues

VI. Mimic Beaver....

III. Call for Adaptations to Recipes

IV. Take Aways



CURTIS CREEK

- Stream was restored in 2004ish using a Rosgen Restoration...
- Beaver came along and made it better...



CURTIS CREEK – DELIBERATE VS. ACCIDENTAL RESTORATION

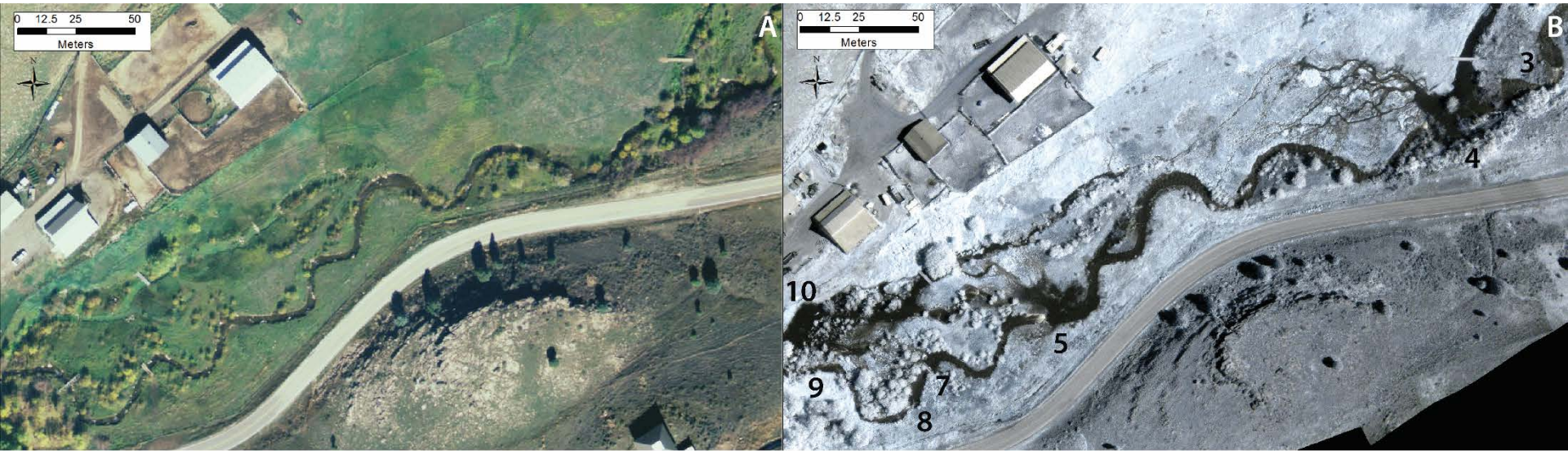


Figure 2. A) Aerial image of lower section of Curtis Creek study reach showing the channel in 2006 (before beaver colonization). B) Aerial near infrared image of Curtis Creek study reach in spring 2011 showing new beaver dams, ponds, and flow paths created over the study period.

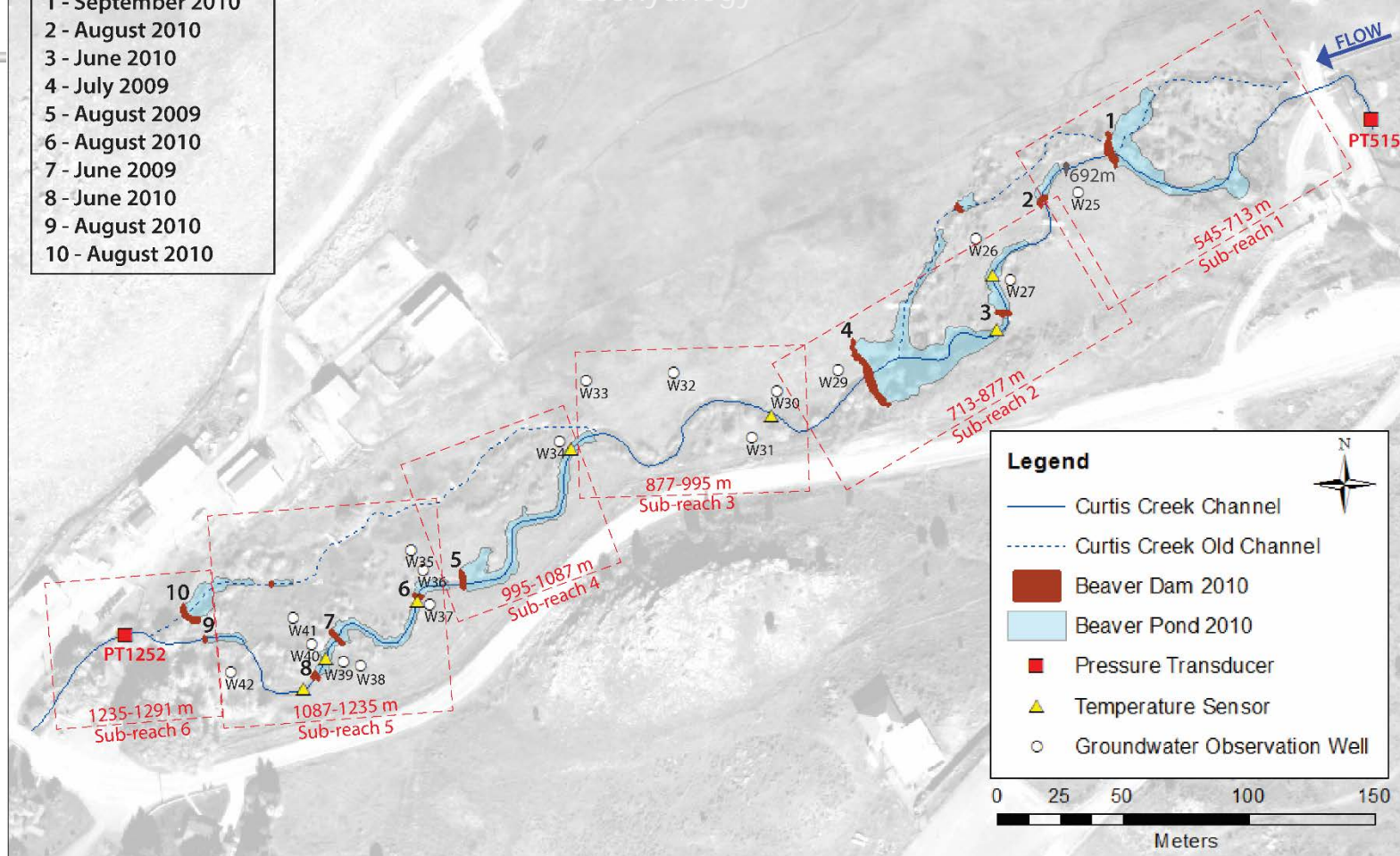


From: Majerova et al (In Review): Submitted to
Ecohyrlogy: DOI: [10.5194/hessd-12-839-2015](https://doi.org/10.5194/hessd-12-839-2015)



Beaver dams built:

- 1 - September 2010
- 2 - August 2010
- 3 - June 2010
- 4 - July 2009
- 5 - August 2009
- 6 - August 2010
- 7 - June 2009
- 8 - June 2010
- 9 - August 2010
- 10 - August 2010



SPATIAL SCALE DIAGRAM FOR CURTIS CREEK

REACH SCALE

SUB-REACH SCALE

BEAVER DAM SCALE

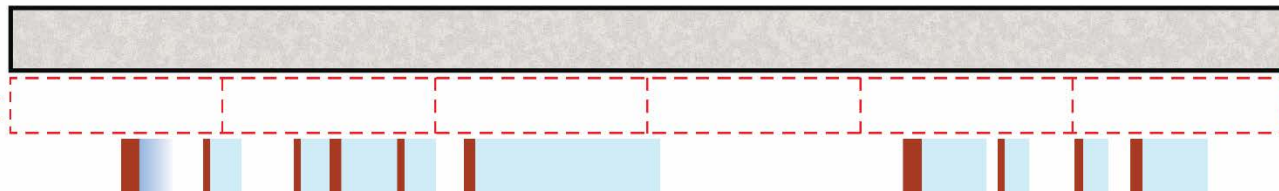


Figure 1. Aerial image from 2006 and beaver dams (also visible in Figure 2B) constructed between 2009 and 2010. The main beaver dams are numbered from 1 to 10 from upstream to downstream and the time of dam construction is noted in the table. The study reach was further divided into 6 sub-reaches. The spatial scales investigated are illustrated below the map.

SUMMER CHANGES IN FLOW & TEMP

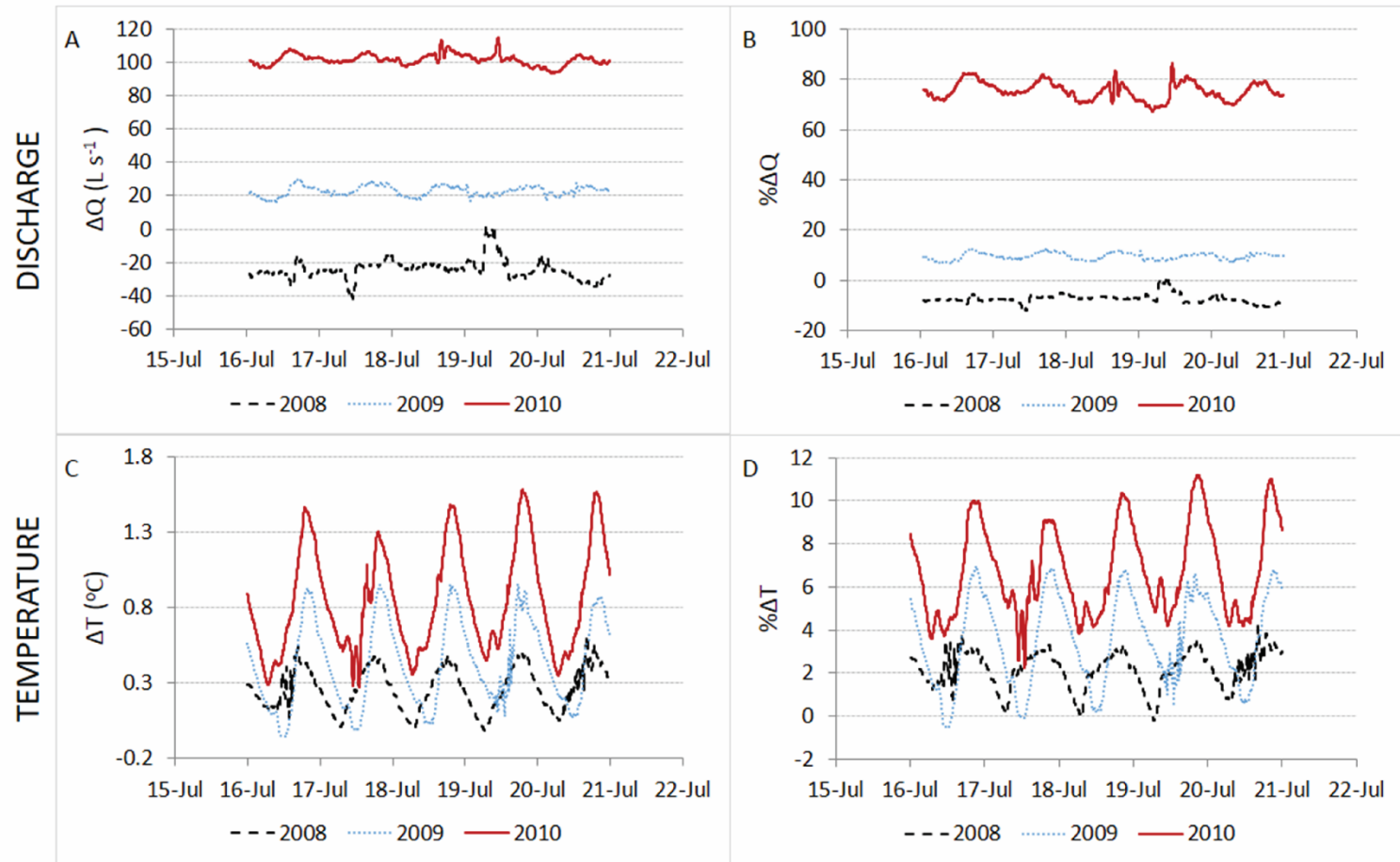


Figure 7. Change in discharge (ΔQ) and temperature (ΔT) over the study reach from 2008 to 2010. The % ΔQ and % ΔT are relative to the discharge and temperature at PT515. The % ΔQ were averaged over a one hour interval, while % ΔT represents 5-minute temperature values.

RESTORATION & CONSERVATION WITH BEAVER

I. Underlying Principles

II. Various Alternatives

I. Conservation / Promotion

II. Accidental Restoration

III. Transplant to area that with suitable capacity

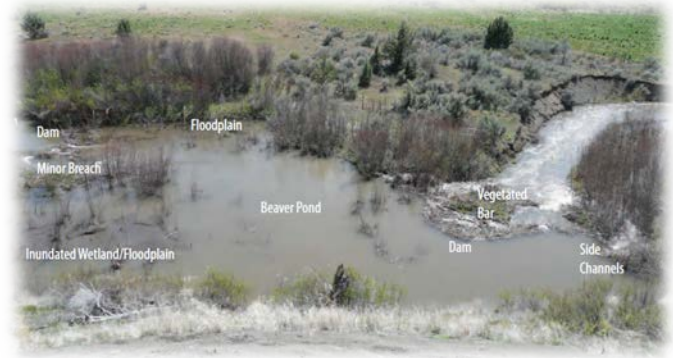
IV. Restore riparian -> Followed by Transplant

V. Help beaver out – Beaver Dam Analogues

VI. Mimic Beaver....

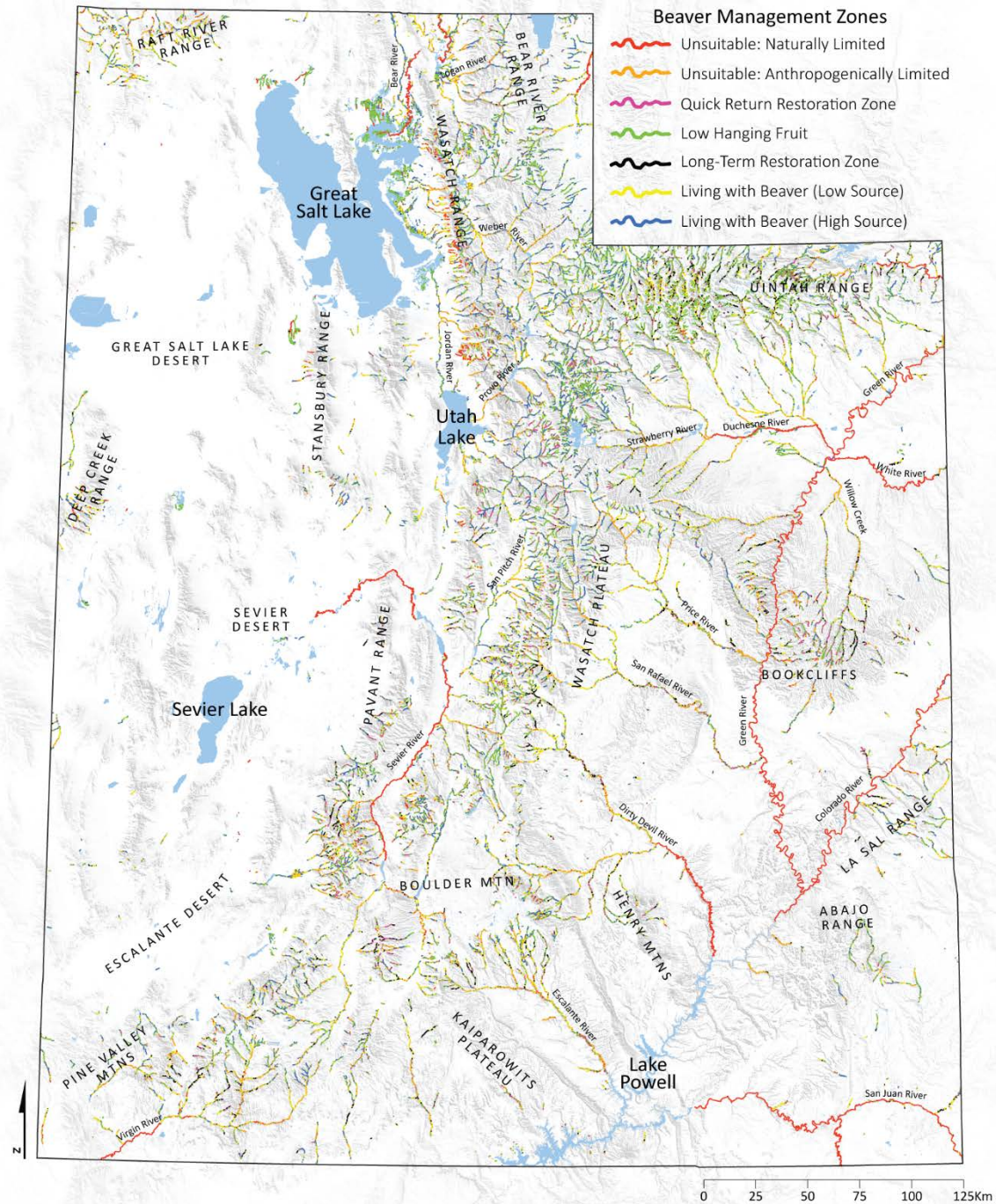
III. Call for Adaptations to Recipes

IV. Take Aways



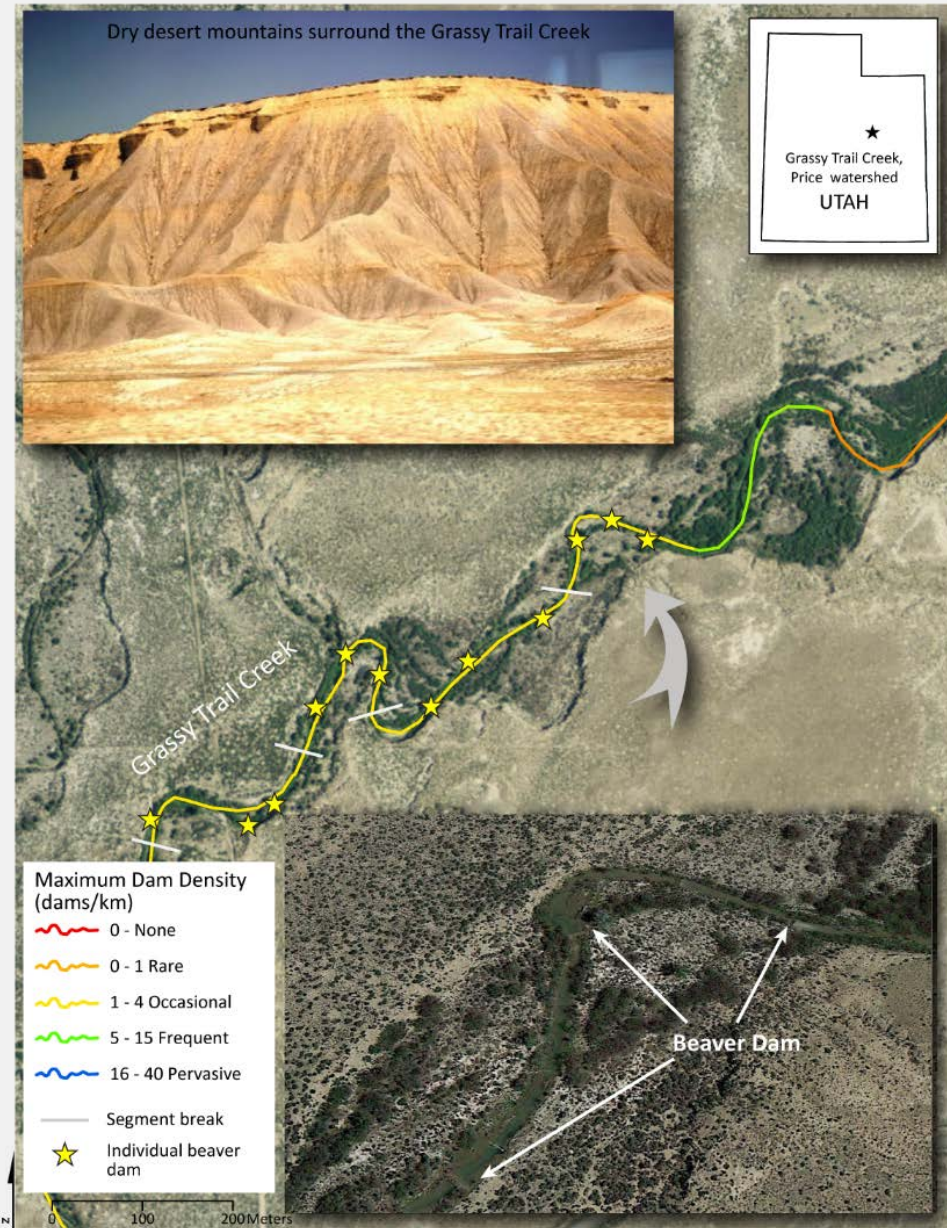
A FIRST CUT

- Focus on areas deemed 'suitable' for restoration
- How much effort?



WHERE TO PLACE?

- Tailor short term expectations to existing capacity
- Consider long term potential capacity with historic capacity and riparian recovery potential
- Don't overseed beaver relative to capacity...



TRANSLOCATION

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



Kent Sorenson
(UDWR)

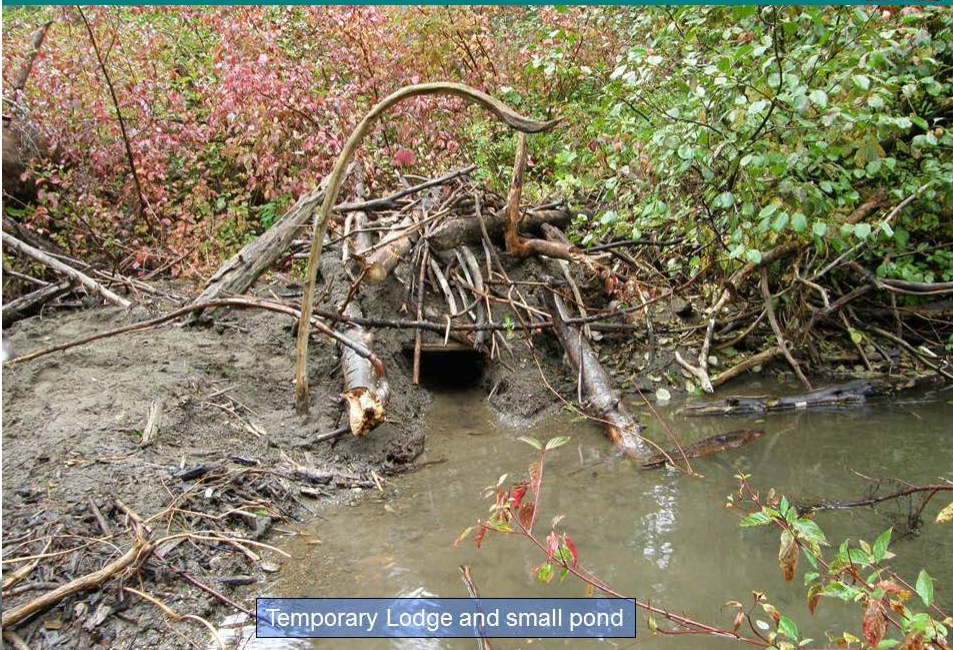


Nuisance beavers being translocated from Henry's Fork to High Uintah's (Courtesy of Sorenson)

SOME EVEN BUILD LODGES FOR BEAVER

- Building a starter lodge for translocated beaver to settle into their new surroundings can increase the chances they do work where you want them to

The new homestead – Temporary lodge 🐾



<http://wdfw.wa.gov/living/beavers.html#preventingconflicts>



Photo courtesy of William Meyer (WDFW)

RESTORATION & CONSERVATION WITH BEAVER

I. Underlying Principles

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III. Call for Adaptations to Recipes

IV. Take Aways



IS THIS GOOD BEAVER HABITAT?



BDAs MAY BE USED PRIOR TO BEAVER TO PROMOTE RIPARIAN RECOVERY



RESOURCES AVAILABLE NOW



RESTORATION & CONSERVATION WITH BEAVER

I. Underlying Principles

II. Various Alternatives

I. Conservation / Promotion

II. Accidental Restoration

III. Transplant to area that with suitable capacity

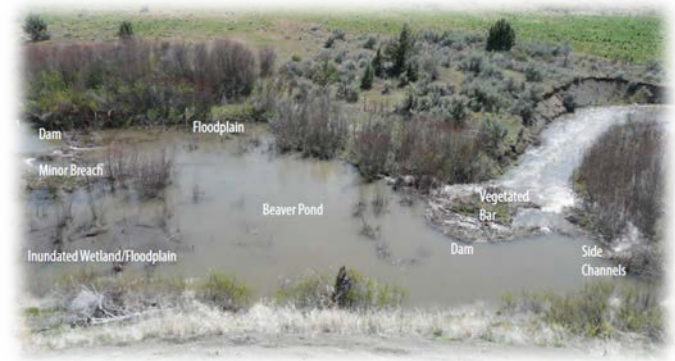
IV. Restore riparian -> Followed by Transplant

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(5) e.g. **INCISED STREAMS ARE UBIQUITOUS**



USING BEAVER TO RESTORE INCISED STREAMS

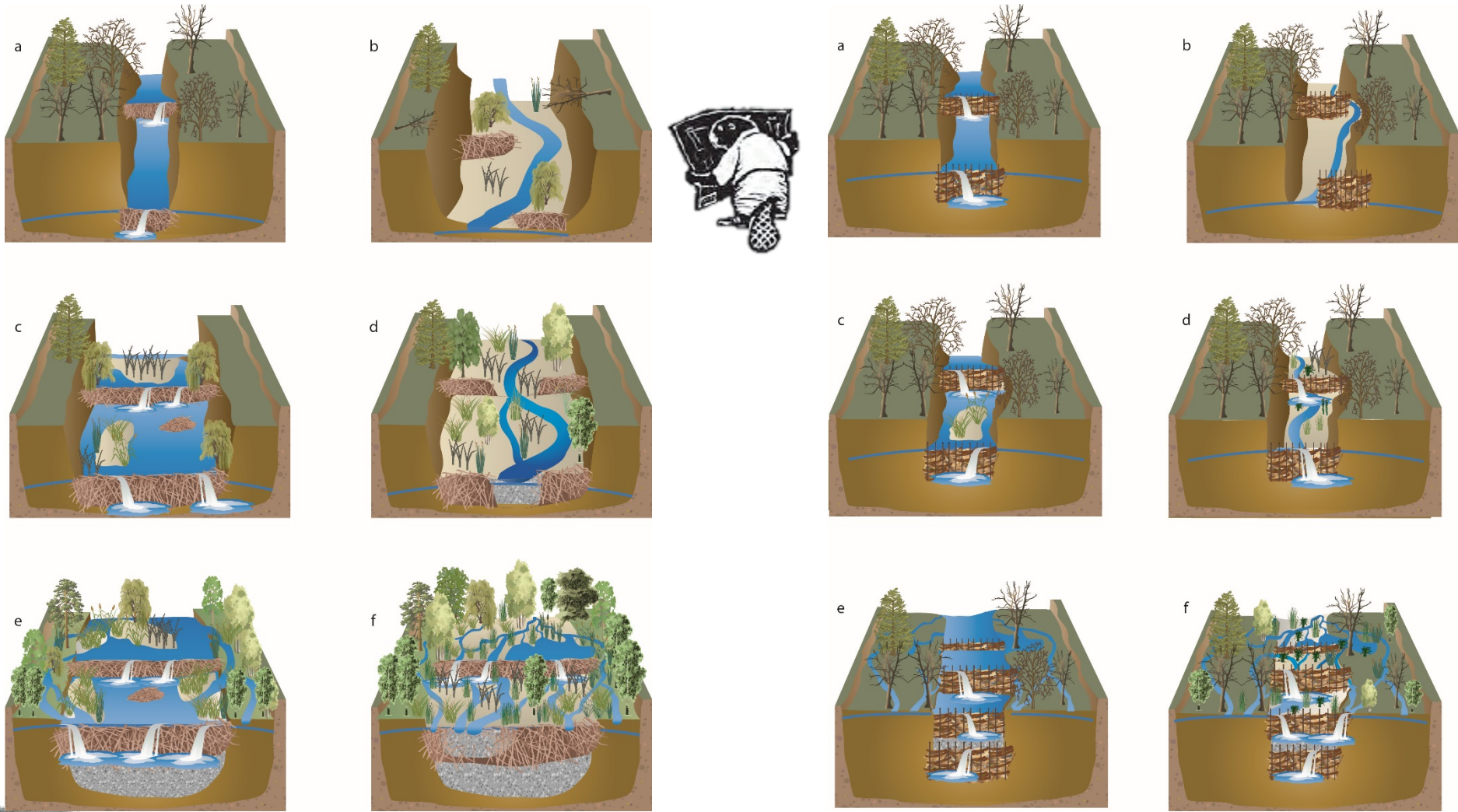


Figure from Pollock et al.
(Accepted) Bioscience

Using Beaver Dams to Restore Incised Stream Ecosystems

Overview Articles

MICHAEL M. POLLOCK, TIMOTHY J. BEECHIE, JOSEPH M. WHEATON, CHRIS E. JORDAN, NICK BOWEN,
and MICHAEL WESER, AND CAROL VOLK

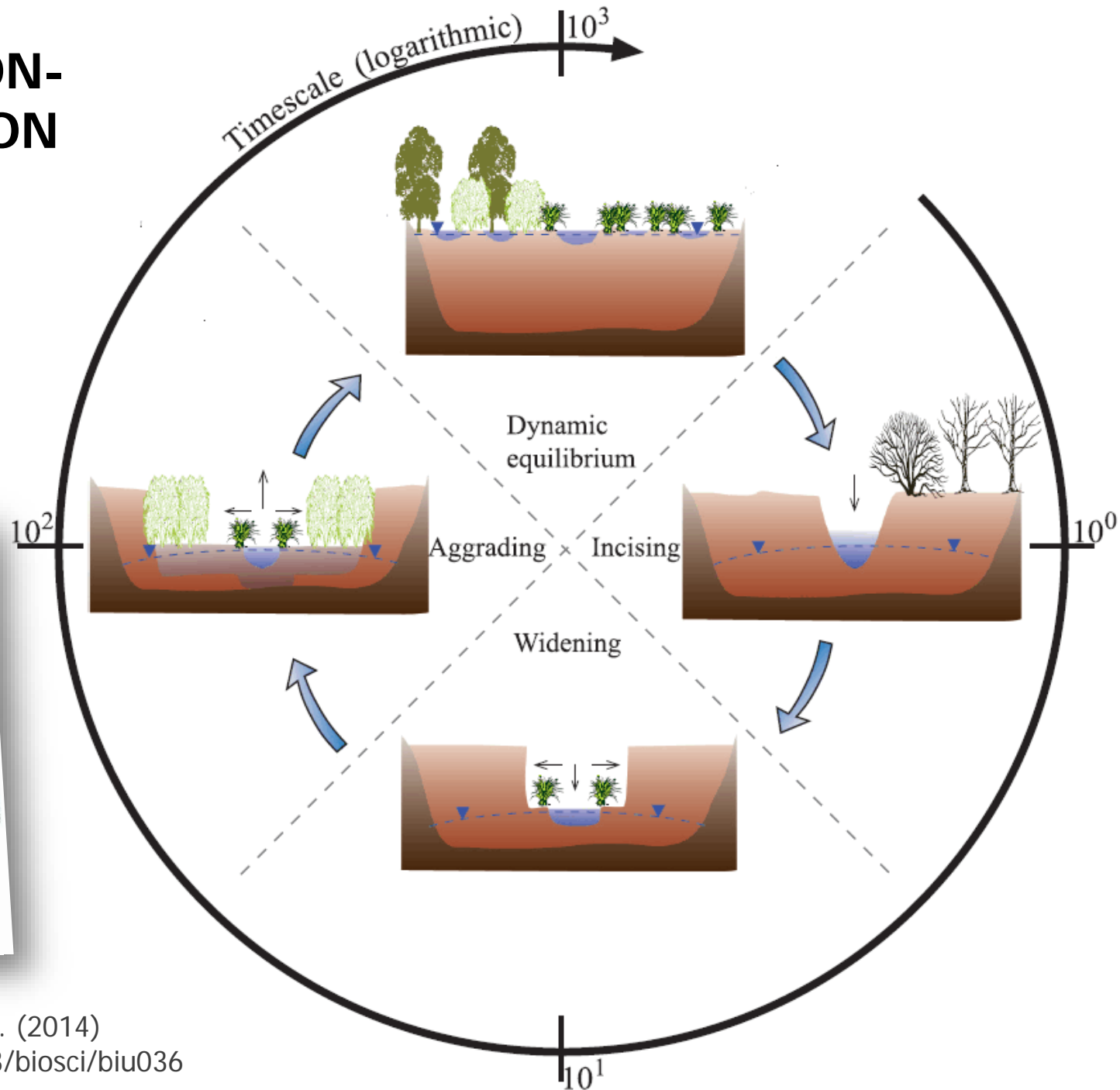
regions located just in front of, large, and less vegetation in the same stream have instead been changed to a forest largely from dead snags or from streams that were once forested. The vegetation in the riparian zone is largely composed from snags or dead trees that have been left in place. These dead trees are a common sight of restoration efforts, and are discussed in more detail in the next section. The vegetation in the riparian zone is largely composed from snags or dead trees that have been left in place. These dead trees are a common sight of restoration efforts, and are discussed in more detail in the next section. The vegetation in the riparian zone is largely composed from snags or dead trees that have been left in place. These dead trees are a common sight of restoration efforts, and are discussed in more detail in the next section.

[illegible]

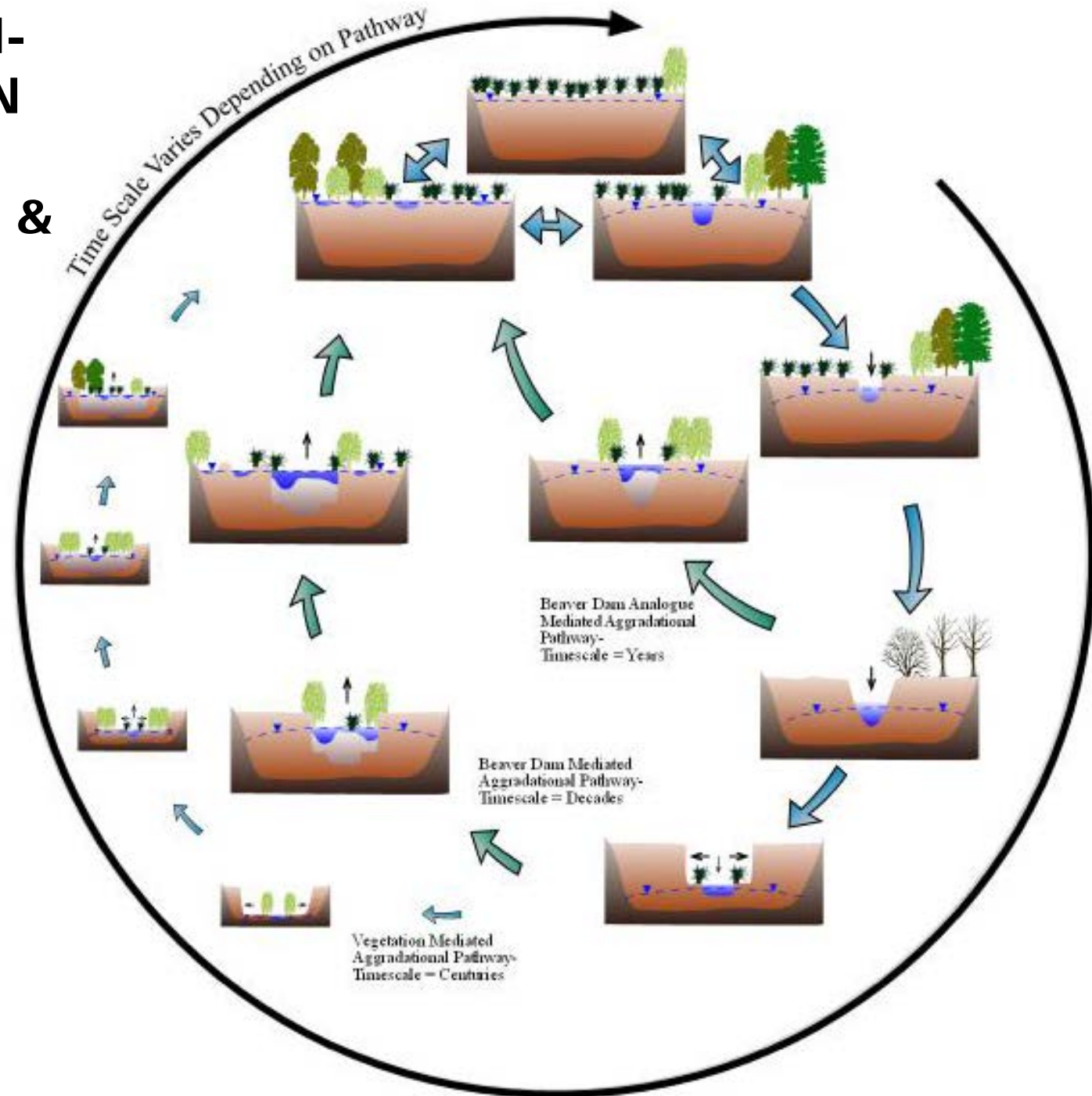
bioRxiv preprint doi: <https://doi.org/10.1101/2019.05.20.256811>; this version posted May 20, 2019. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted bioRxiv a license to display the preprint in perpetuity. It is made available under aCC-BY-NC-ND 4.0 International license.

XXXX XXXX / Vol. XX, No. X - September 2015

<http://www.elsevier.com/locate/jmb>



THE INCISION-AGGRADATION CYCLE WITH BEAVER DAMS & BEAVER DAM ANALOGUES



RESTORATION & CONSERVATION WITH BEAVER

I. Review

II. Underlying Principles

III. Various Alternatives

I. Conservation / Promotion

II. Accidental Restoration

III. Transplant to area that with suitable capacity

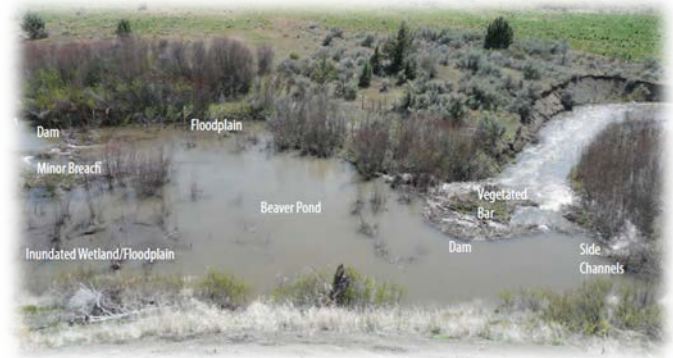
IV. Restore riparian -> Followed by Transplant

V. Help beaver out – Beaver Dam Analogues

VI. Mimic Beaver....

IV. Call for Adaptations to Recipes

V. Take Aways



SAME AS BDAs, BUT W/O BEAVER

- Key difference is who does maintenance
- Resist tendency to over engineer
- Porosity is everything....
Think about what you want



TAKE AWAYS

- Variety of approaches to 'use', 'partner with', or 'mimic' beaver as restoration and conservation tool
- DON'T apply blanket, uniform approach across landscape
- Tailor solutions and adapt to local constraints/ opportunities
- Results are promising... but not full proof



For more information, visit:
<http://beaver.joewheaton.org>



UTAH'S BEAVER MANAGEMENT PLAN



© Cadel Wheaton

© ET-AL USU - <http://etal.joewheaton.org>

Joe Wheaton



UDWR – BEAVER MANAGEMENT PLAN

- One of most progressive plans in US
- Specifically relies on beaver as a restoration tool

UTAH BEAVER MANAGEMENT PLAN 2010 - 2020

Plan Goal

Maintain healthy, functional beaver populations in ecological balance with available habitat, human needs, and associated species.

INTRODUCTION

The purpose of the Utah Beaver Management Plan is to provide direction for management of American beaver (*Castor canadensis*) in Utah and where appropriate expand the current distribution to historic range. This purpose is in accordance with the mission statement of the Utah Division of Wildlife Resources (UDWR). The mission of UDWR is:

To serve the people of Utah as trustee and guardian of the state's wildlife

UTAH BEAVER MANAGEMENT PLAN 2010 – 2020



Developed in consultation
with
BEAVER ADVISORY COMMITTEE

DWR Publication 09-29

Utah Division of Wildlife Resources
1594 West North Temple
Salt Lake City, Utah 84114

Approved by the Wildlife Board January 6, 2010



UDWR BEAVER MANAGEMENT PLAN

Damage Management

Objective 1:

Increase consistency in the response options (lethal and non-lethal) currently in use and increase the frequency of use of non-traditional options (e.g. beaver deceivers, live-trapping) used by UDWR, governmental and non-governmental agencies and landowners for managing beaver causing property damage through 2020.

- Awareness of non-traditional options is already increasing...
- Non-lethal options are being used throughout state



TRANSLOCATION

- In Utah, translocation is already allowed under UDWR's Beaver Management Plan



Kent Sorenson
(UDWR)



Nuisance beavers being translocated from Henry's Fork to High Uintah's (Courtesy of Sorenson)

UDWR BEAVER MANAGEMENT PLAN

Outreach and Education

Objective 1:

Increase awareness of and appreciation for the role of beaver in Utah's ecosystems in 10% of stakeholders (landowners, educators, recreationalists, sportsmen, water rights holders) by 2020.

- Citizen Science can be used to help with Outreach & Education

Population Management

Objective 1:

Maintain reproducing beaver populations within their current distribution in appropriate habitat through 2020. (See Watershed Restoration Objective for population expansion)

- Plus, data can help with Population Management

Strategies:

1. Develop a statewide baseline beaver distribution map to document current status within two years after plan approval by working with UDWR regions, universities, governmental and non-governmental organizations.

BEAVER MONITORING APP!

- Simple enough 2nd graders can use it
- Sophisticated enough that researchers get useful data streams
- Going to launch statewide monitoring campaign with USU Extension & DWR



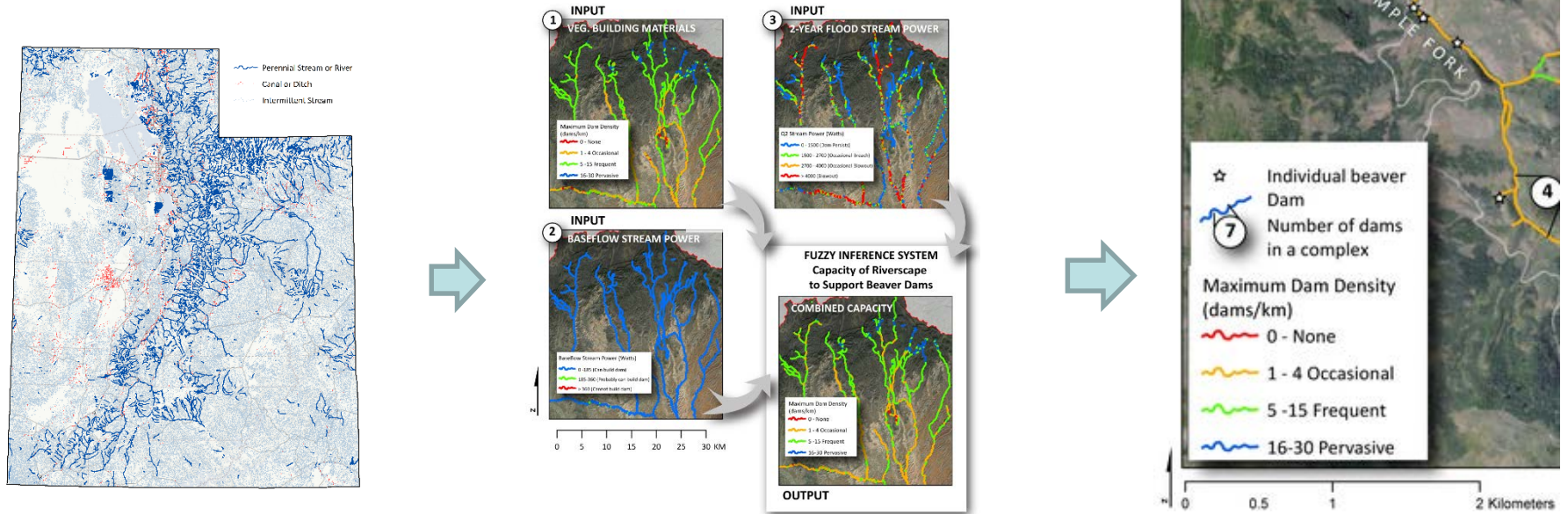
EVEN SECOND GRADERS GET IT

- They use the App
- They build their own dams in beaver side channels
- They learn how beaver modify the landscape



WHAT WE DID & WHAT WE WANT TO DO

- Ran BRAT for whole state
- Refine decision support elements in a bespoke manner for UDWR



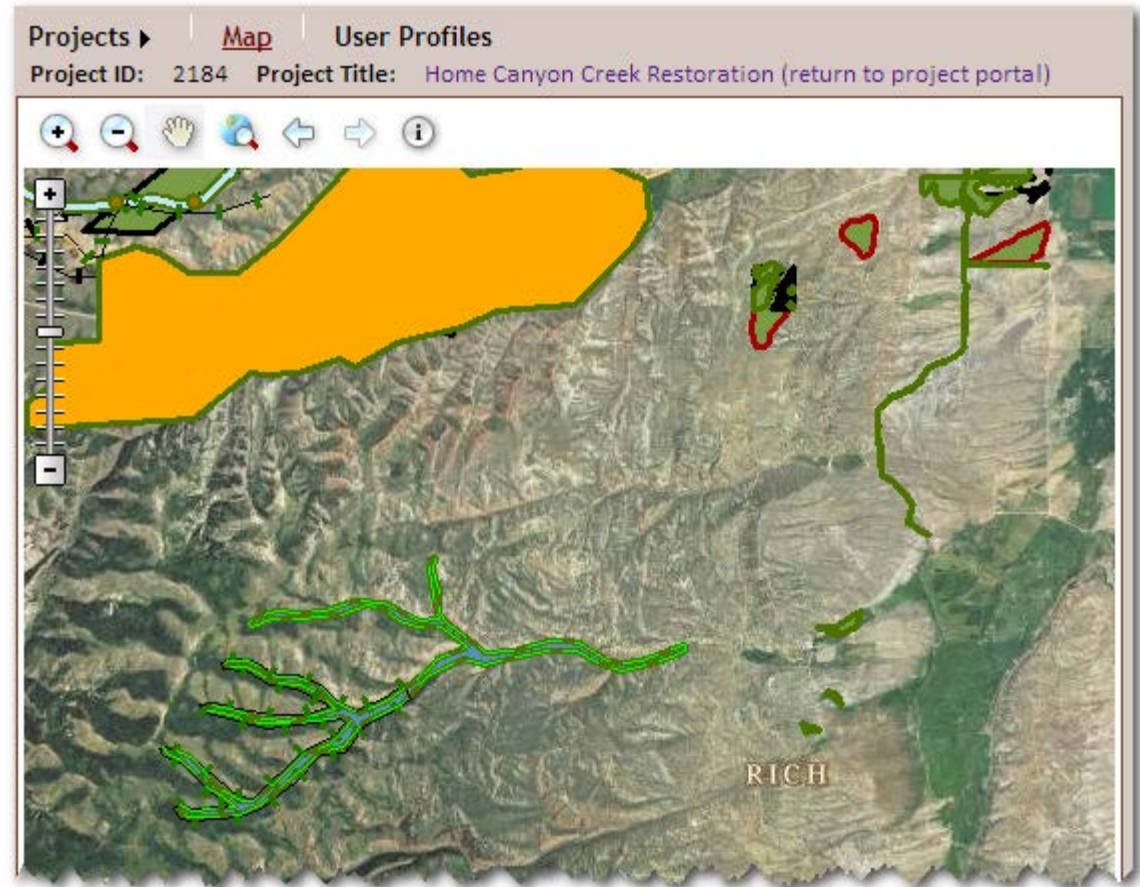
2. Identify zones on the map to illustrate appropriate beaver management strategies for given geographic areas, i.e. existing populations (including source populations), unoccupied historical range and areas where the potential for conflict is high.

WHAT SORNO & US ARE DOING...



Utah's Watershed
RESTORATION INITIATIVE

- Two WRI proposed projects in Box Elder County:
 - One is in year 2 – Basin Creek
 - The other is a new one in Grouse Creek
- Monitoring responses & setting up as showcase



4. Establish at least one showcase beaver management area in each UDWR Region.

TWO REPORTS UDWR PAID FOR...

RECOMMENDATIONS FOR THE UTAH BEAVER MANAGEMENT PLAN

The UDWR has one of the most progressive statewide beaver management plans (UDWR, 2010) in the country. This plan paves the way for a more holistic and sustainable approach to beaver management. However, to date, too few examples exist of the plan being implemented on the ground by UDWR personnel and partners as intended, despite large interest amongst a diverse group of organizations and individuals. We believe this is the case in part because although the plan lays out clear policies, goals and strategies; the specifics of how to implement specific strategies on the on the ground are lacking. Actively relocating nuisance beaver to parts of watersheds and the state in which they could be restoration agents is relatively new territory for UDWR staff. Demonstration projects are underway to help provide such guidance (e.g. Watershed Restoration Initiative & Sage Grouse Initiative Funding in Raft River Basin; translocation in Uintah Basin). However, we have tailored the BRAT to specifically help UDWR implement the plan. In the Macfarlane et al. (2014) report we provide detailed suggestions on how BRAT can specifically help UDWR staff implement the strategies. In other instances, we made specific recommendations to update the plan. A brief summary of bullet recommendations is provided below by topic:

- **Population Management**
 - Extend the Google Earth-based beaver dam census statewide used in Macfarlane et al. (2014) report to verify model performance.
 - Update the Beaver Management Plan with new maps from the outputs of BRAT.
 - Use 'Beaver Monitoring App' to track dams and infer population numbers. In partnership with Utah State University's Water Quality Extension's 'Utah Water Watch' program, we developed an app for citizen science monitoring of beaver activity. <http://extension.usu.edu/utahwaterwatch/html/beaver-monitoring-app>. The program could coordinate volunteer efforts to target 'missing' parts of the state where we need to know more. The app could also be deployed with UDWR personnel so they could track their observations. We could extend the app to meet UDWR's specific needs and share the database with UDWR.
 - Leverage data collection on beaver from other agencies.
 - Replace the 'baseline map' with BRAT outputs.
- **Harvest Management**
 - Using BRAT to encourage the growth of beaver populations in areas with low conflict potential and high capacity to support beaver could potentially increase this important recreational fur-trapping resource.

THE UTAH BEAVER RESTORATION ASSESSMENT TOOL: A DECISION SUPPORT & PLANNING TOOL

FINAL REPORT TO UTAH DIVISION OF WILDLIFE RESOURCES



Prepared by:

WILLIAM W. MACFARLANE, *Research Associate*

JOSEPH M. WHEATON, *Assistant Professor*

MARTHA L. JENSEN, *Research Technician*



OCTOBER, 2014

• Both available at: <http://brat.joewheaton.org>



OUR RECOMMENDATIONS

- Population Management
 - Extend Google Earth dam census statewide
 - Use beaver monitoring app to track populations
 - Replace the 'baseline map with BRAT output
- Harvest Management
 - Use BRAT to encourage growth of beaver populations in areas with low conflict potential and high capacity
 - Balance needs of beaver as fur-bearer and recreational resource vs. restoration agent
 - More research needed to ascertain what defines a 'sustainable harvest'



OUR RECOMMENDATIONS

- Damage Management
 - Adopt a standard response by developing an 'Adaptive Beaver Management Plan'
- Statewide Beaver Transplant List
 - Update the transplant list and decision support elements of BRAT to use 'Low Hanging Fruit Restoration Zone' and 'Quick Return Restoration Zone' as candidate streams for transplanting
 - Make regional prioritization/ranking more transparent or remove



OUR RECOMMENDATIONS

- Watershed Restoration
 - Use BRAT to help scope and initially identify 'suitable habitat' for watershed restoration by beaver
- Live Trapping Protocol
 - Implement the COR program to certify trappers
 - Develop a simple App & web-reporting system for tracking translocation activities
 - Replace habitat assessment section with BRAT and its logic
 - Language surrounding 'source population considerations' is unnecessarily restrictive



TAKE AWAYS

- Utah is far better positioned than many western states with its Beaver Management Plan to take advantage of beaver as a restoration tool
- Some major progress towards plan goals has been made
- Some practical hurdles to implementing policy exist
- Straight-forward solutions to overcome hurdles being considered



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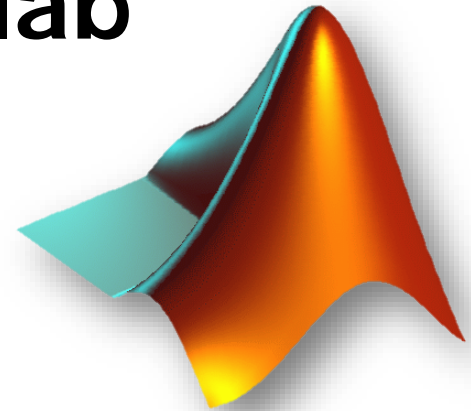


HOMEOWRK QUESTIONS:

BRAT – BEAVER RESTORATION ASSESSMENT TOOL

HOMEWORK

Running BRAT in Matlab

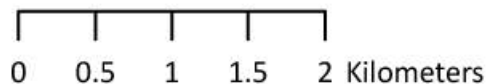
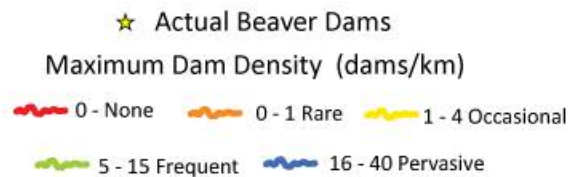
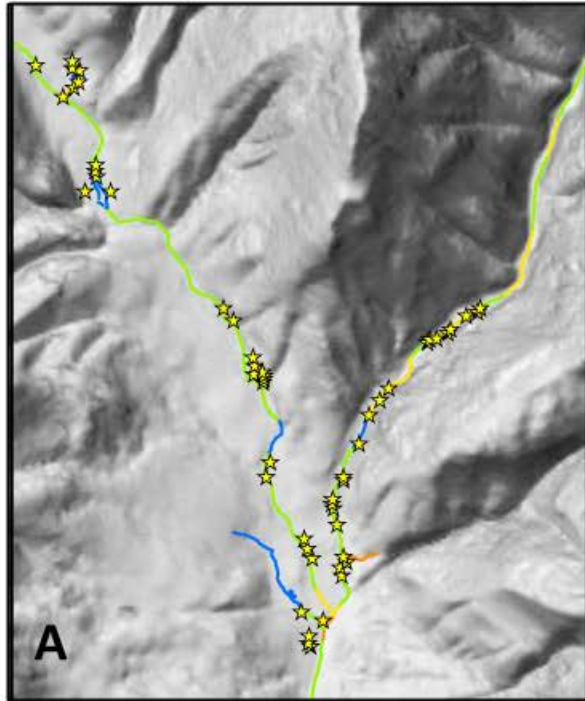


BRAT OUTPUTS IN A NUTSHELL

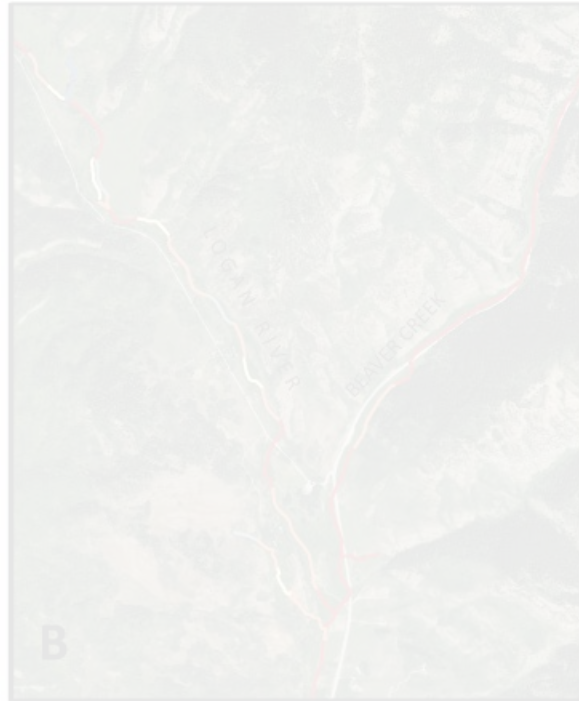


- Existing & Historic Capacities → Potential Conflict → Management

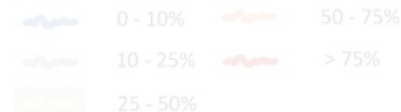
Existing Beaver Dam Capacity



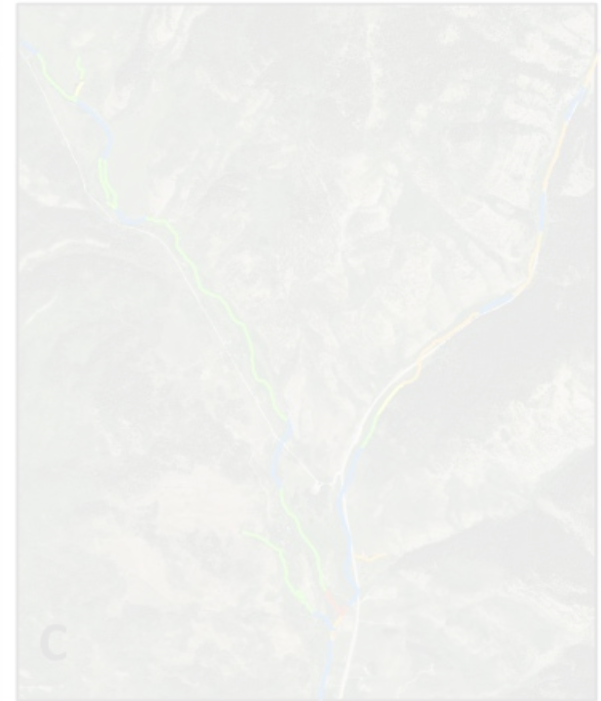
Potential for Human Beaver Conflict



Probability of Conflict



Ecosystem Management

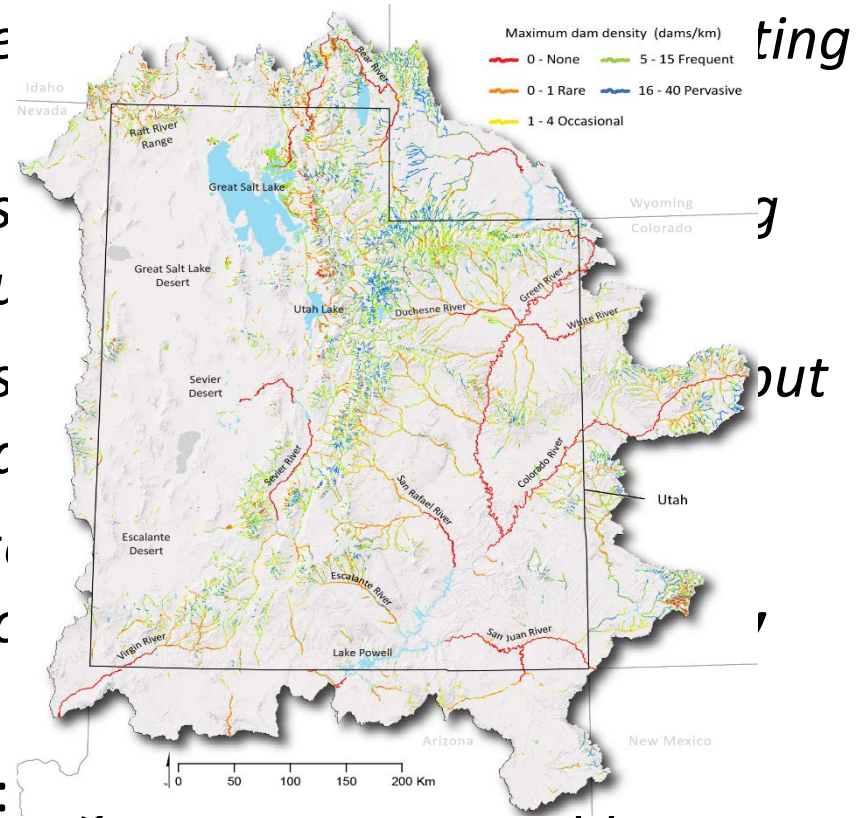


Beaver Management Zones



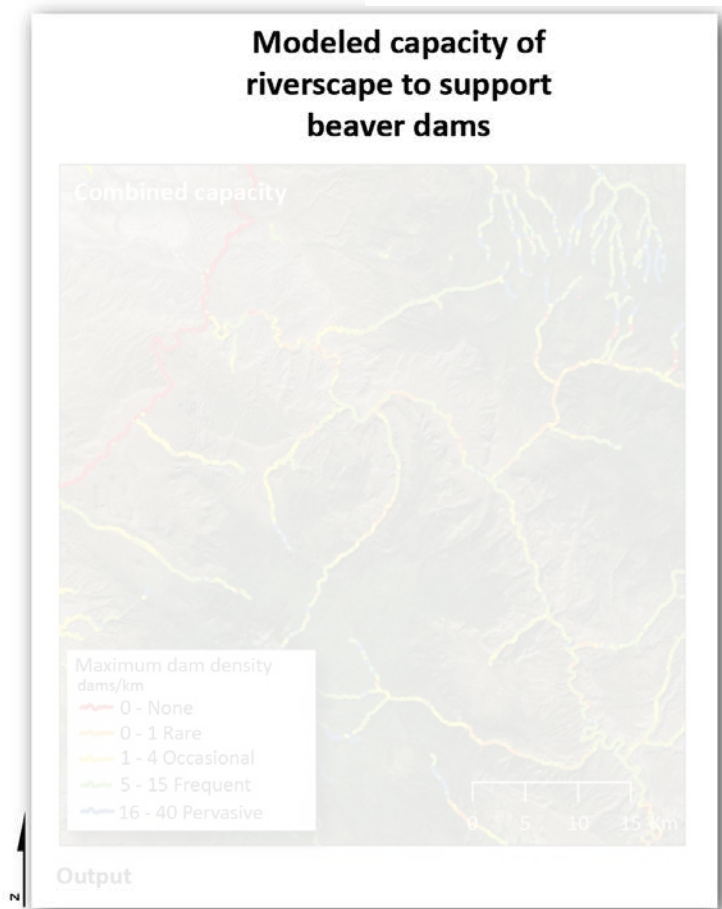
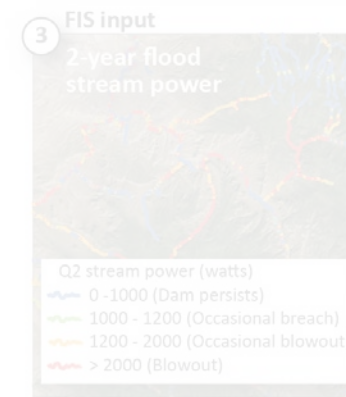
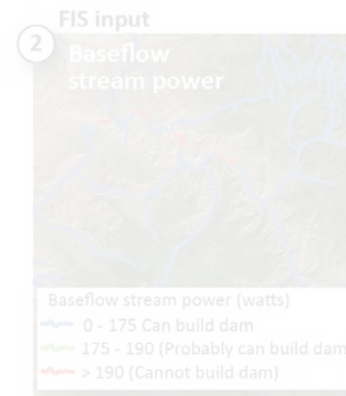
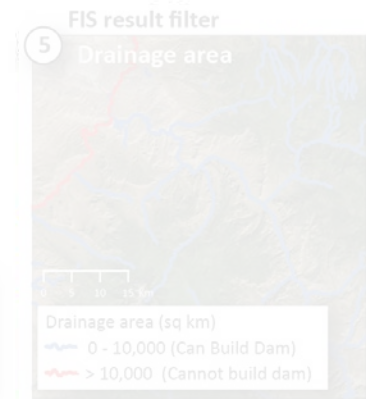
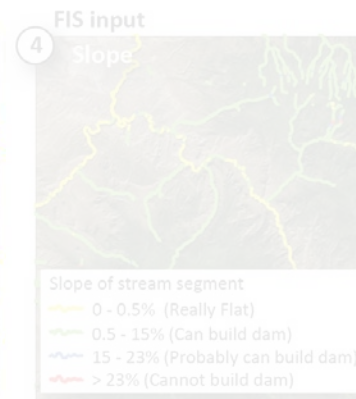
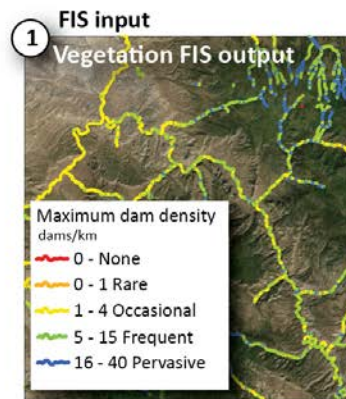
DAM DENSITY OUTPUT CATEGORIES:

- **None** – 0 dams: *segments de dam building activity*
- **Rare** – 1 dam/km: *segments dam building activity; likely u*
- **Occasional** – 2-4 dams/km: *s can support an occasional d*
- **Frequent** – 5-15 dams/km: *s multiple colonies and dam c*
resource limited
- **Pervasive** – 16-40 dams/km: *extensive dam complexes and many colonies*

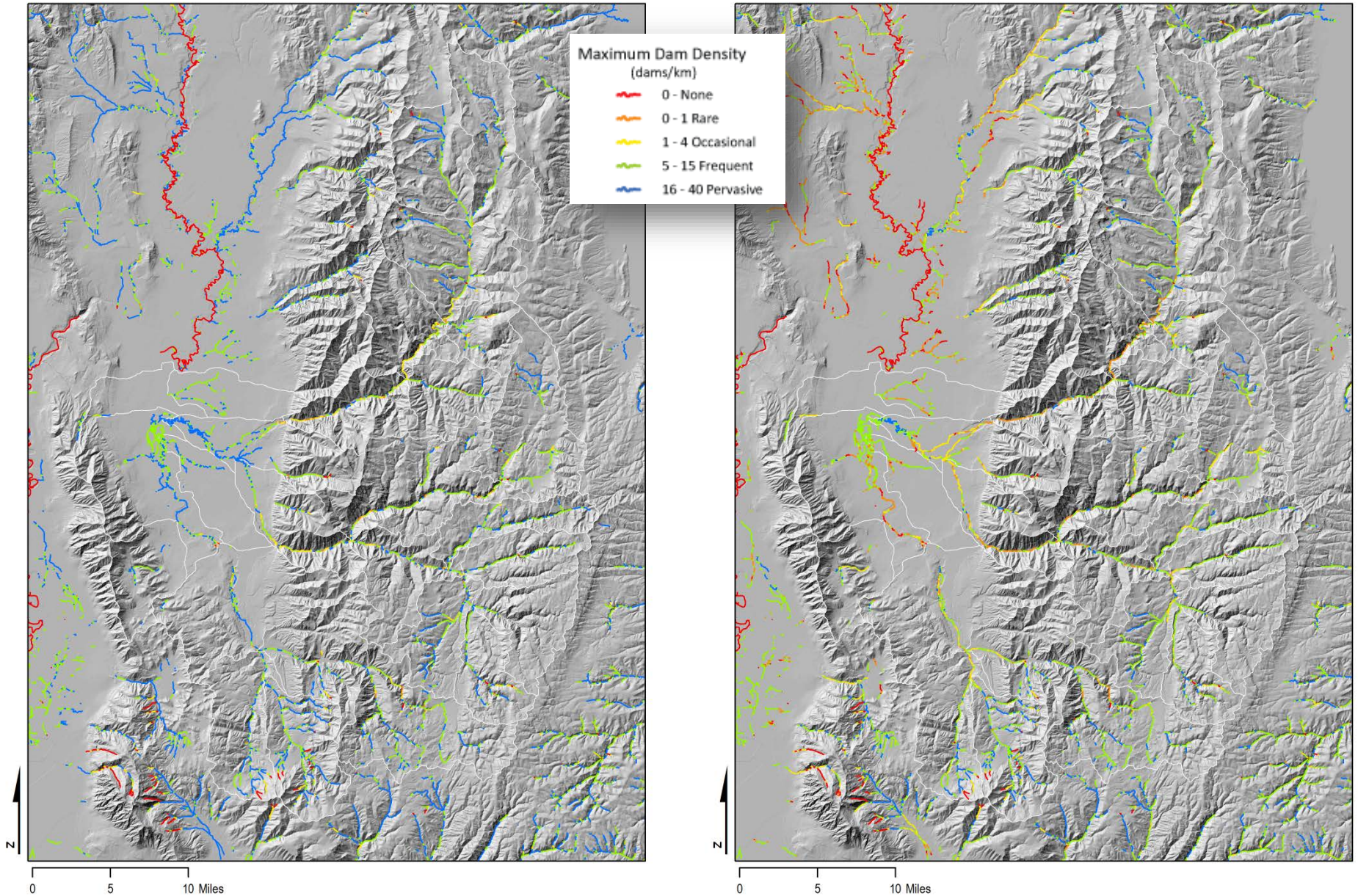


BRAT – THE INPUTS...

- Can all be run from freely available, nationally available datasets
- Could be run for entire US or logic applied locally
- Makes a prediction at 250 m long reaches



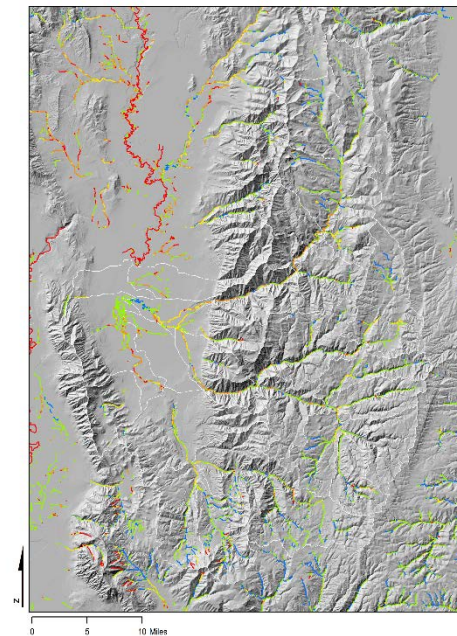
CACHE VALLEY – HISTORIC VS. EXISTING



- 11,038 historic capacity vs. 7,402 existing capacity

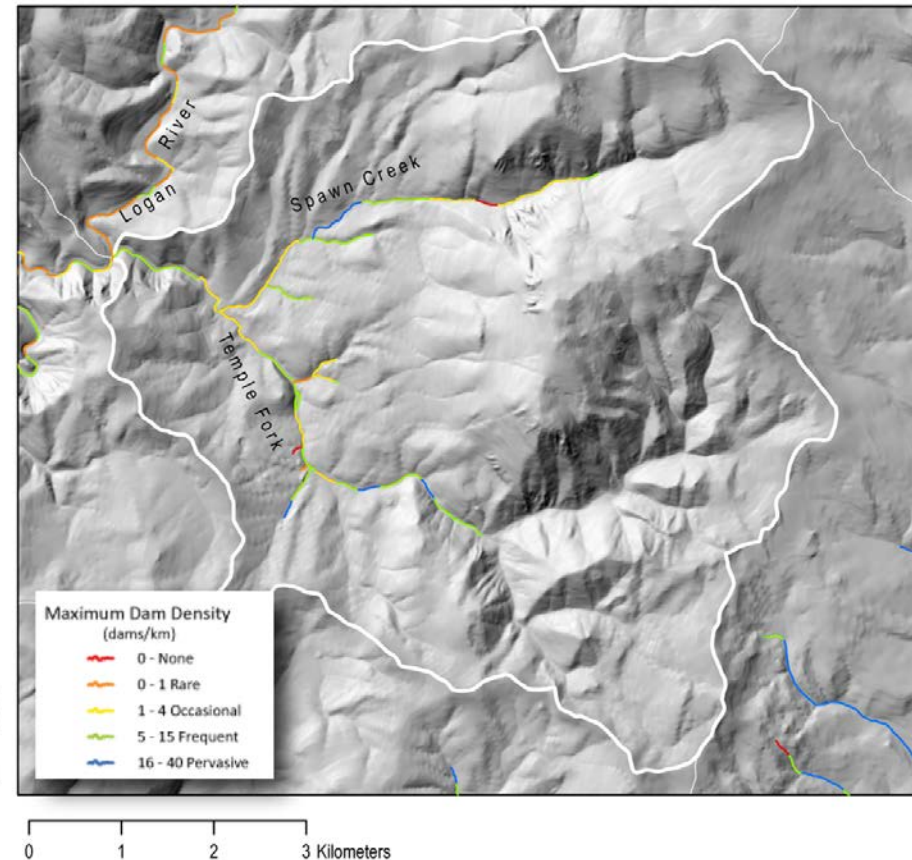
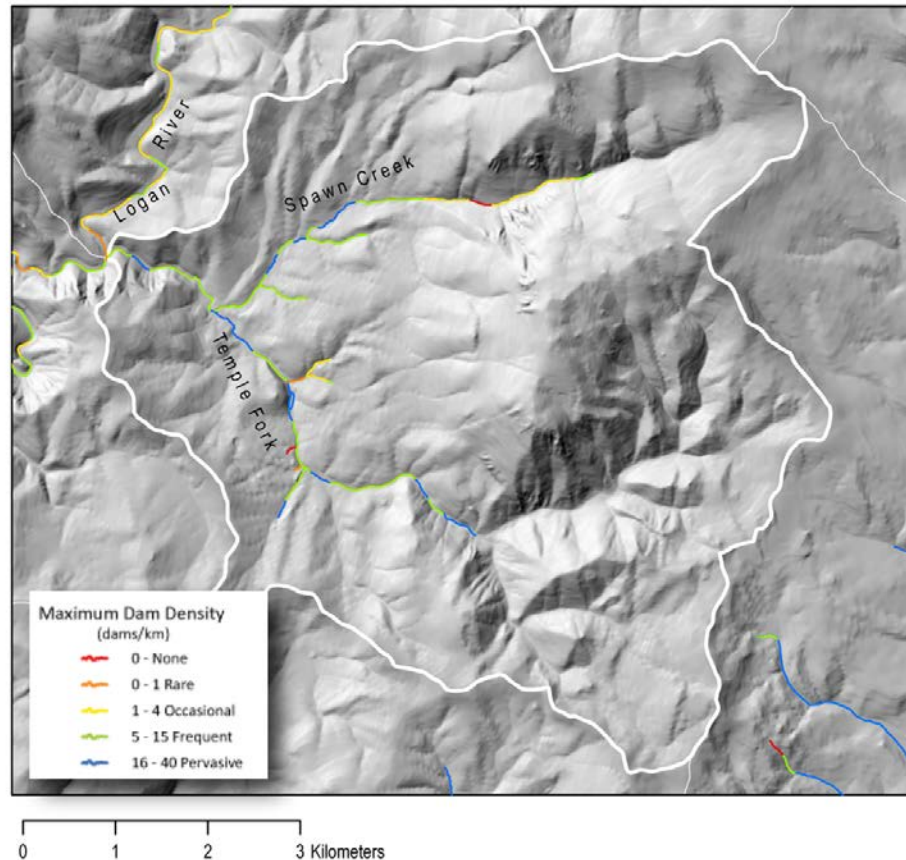
LOOKING CLOSER AT OUTPUT

- Logan & Blacksmith Fork River
 - Max Capacity: 7402 dams
 - Currently 1313 dams
 - Current average of 1.8 dams/km
 - Current capacity of 10.1 dams/km
 - Only 18% of Existing Capacity & 12% of Historic



	Length of Stream	Existing Capacity (Density)	Historic Capacity (density)	Existing Capacity	Historic Capacity	Existing Count	Existing Dam Density	% of Existing Capacity	% of Historic Capacity
	<i>iGeoLength</i>	<i>oCC_EX</i>	<i>oCC_PT</i>	<i>mCC_EX_Ct</i>	<i>m_CC_PT_CT</i>	<i>e_DamCT</i>			
	km	Average Dam Density (Dams/Km)		Total Dams	Total Dams	Total Dams	Actual Dam Density	%	%
Logan River HUC8	731	10.1	15.1	7,402	11,038	1,313	1.8	18%	12%
L Logan River HUC10	211	10.2	15.4	2,146	3,255	449	2.1	21%	14%
L Temple Fork HUC12	14	7.7	11.3	108	158	42	3.0	39%	27%
L Beaver Creek HUC12	25	11.2	16.2	281	405	142	5.7	51%	35%
L Right Hand Fork HUC12	14	7.7	11.3	108	158	42	3.0	39%	27%
L Franklin Basin HUC12	32.7	15.5	17.7	506	578	138	4.2	27%	24%
L Red Banks Logan HUC12	43.2	11.3	13.8	488	596	58	1.3	12%	10%
L Blacksmith Fork HUC 10	205	9.6	13.8	1,968	2,827	437	2.1	22%	15%
L Curtis Creek HUC12	13.5	8.2	13.8	111	186	16	1.2	14%	9%
L Rook Creek HUC12	26.4	10.3	14.7	272	388	58	2.2	21%	15%
City Logan	59	9.0	20.2	533	1,192	4	0.07	1%	1%

HOW ABOUT A LITTLE WATERSHED?

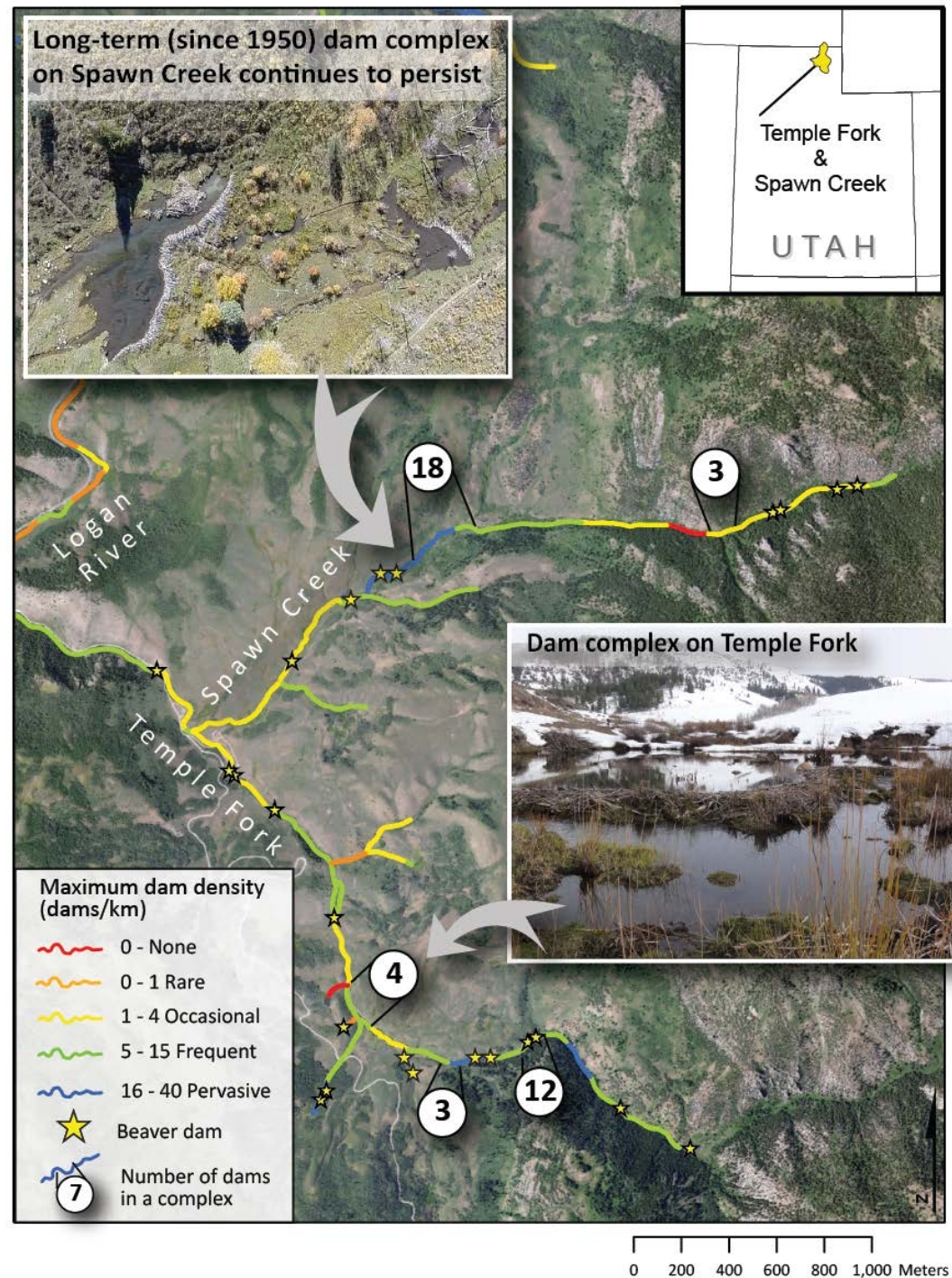


- 186 historic capacity vs. 111 existing capacity
- 11.3 dams/km historic vs. 7.7 dams/km currently

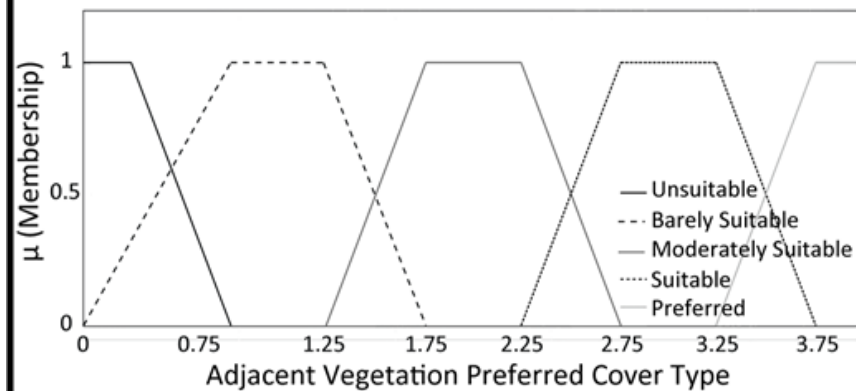
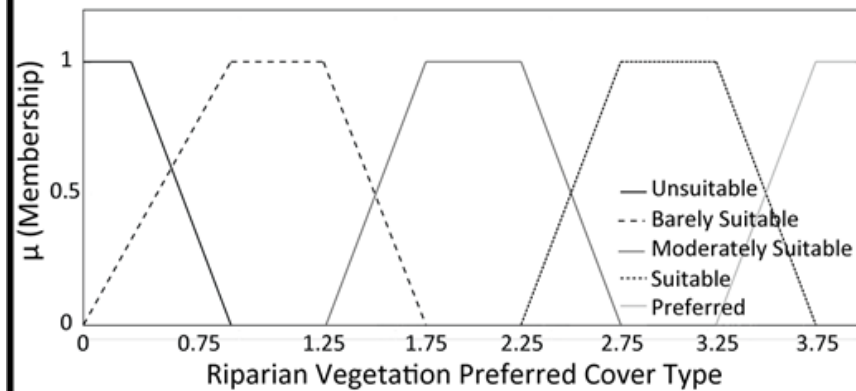


MORE FOCUSED VALIDATION...

- Encouraging...
- No dams where there shouldn't be
- Higher densities in places that are
- Even some events that make sense



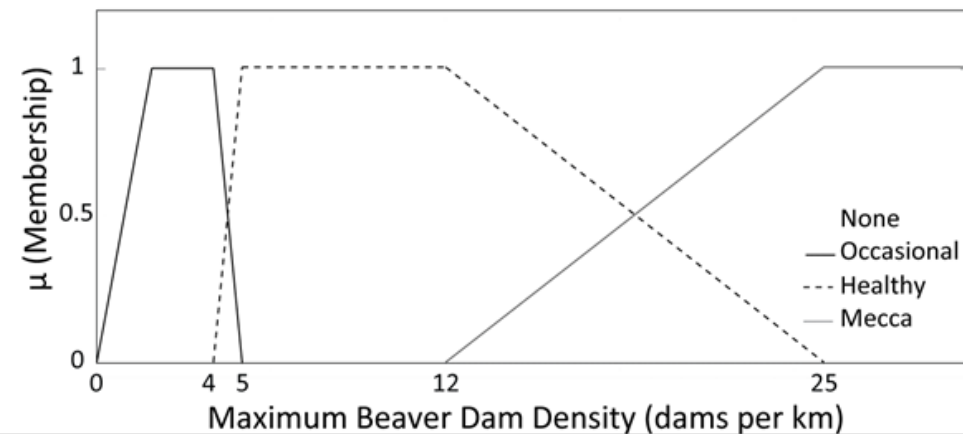
INPUTS



FUZZY INFERENCE SYSTEM

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

OUTPUT



PERENNIAL STREAM & VEGETATION FIS



MEMBERSHIP FUNCTIONS (*.FIS)

- Simple ascii text file
- Computing w/ words

```
input_veg.asc | GrazingProb_3input.fis | VegCapacityBeaver_2input.fis
1 [System]
2 Name='VegCapacityBeaver'
3 Type='mamdani'
4 Version=2.0
5 NumInputs=2
6 NumOutputs=1
7 NumRules=25
8 AndMethod='min'
9 OrMethod='max'
10 ImpMethod='min'
11 AggMethod='max'
12 DefuzzMethod='centroid'
13
14 [Input1]
15 Name='RiparianVegPrefCover'
```

```
14 [Input1]
15 Name='RiparianVegPrefCover'
16 Range=[0 4]
17 NumMFs=5
18 MF1='UnsuitableMaterial':'trimf',[0 0 1]
19 MF2='BarelySuitableMaterial':'trimf',[0 1 2]
20 MF3='ModeratelySuitableMaterial':'trimf',[1 2 3]
21 MF4='SuitableMaterial' : 'trimf' , [2 3 4]
22 MF5='PreferredMaterial' : 'trimf' , [3 4 4]
23
24 [Input2]
25 Name='AdjacentVegPrefCover'
26 Range=[0 4]
27 NumMFs=5
28 MF1='UnsuitableMaterial':'trimf',[0 0 1]
29 MF2='BarelySuitableMaterial':'trimf',[0 1 2]
30 MF3='ModeratelySuitableMaterial':'trimf',[1 2 3]
31 MF4='SuitableMaterial' : 'trimf' , [2 3 4]
32 MF5='PreferredMaterial' : 'trimf' , [3 4 4]
33
34 [Output1]
35 Name='BeaverDamsVegCanSupport'
36 Range=[0 45]
37 NumMFs=4
38 MF1='None':'trimf',[0 0 1]
39 MF2='Occasional':'trapmf',[0 1 4 5]
40 MF3='Moderate':'trapmf',[4 5 12 20]
41 MF4='Mecca':'trapmf',[12 20 45 45]
42
```



THE RULE TABLE...

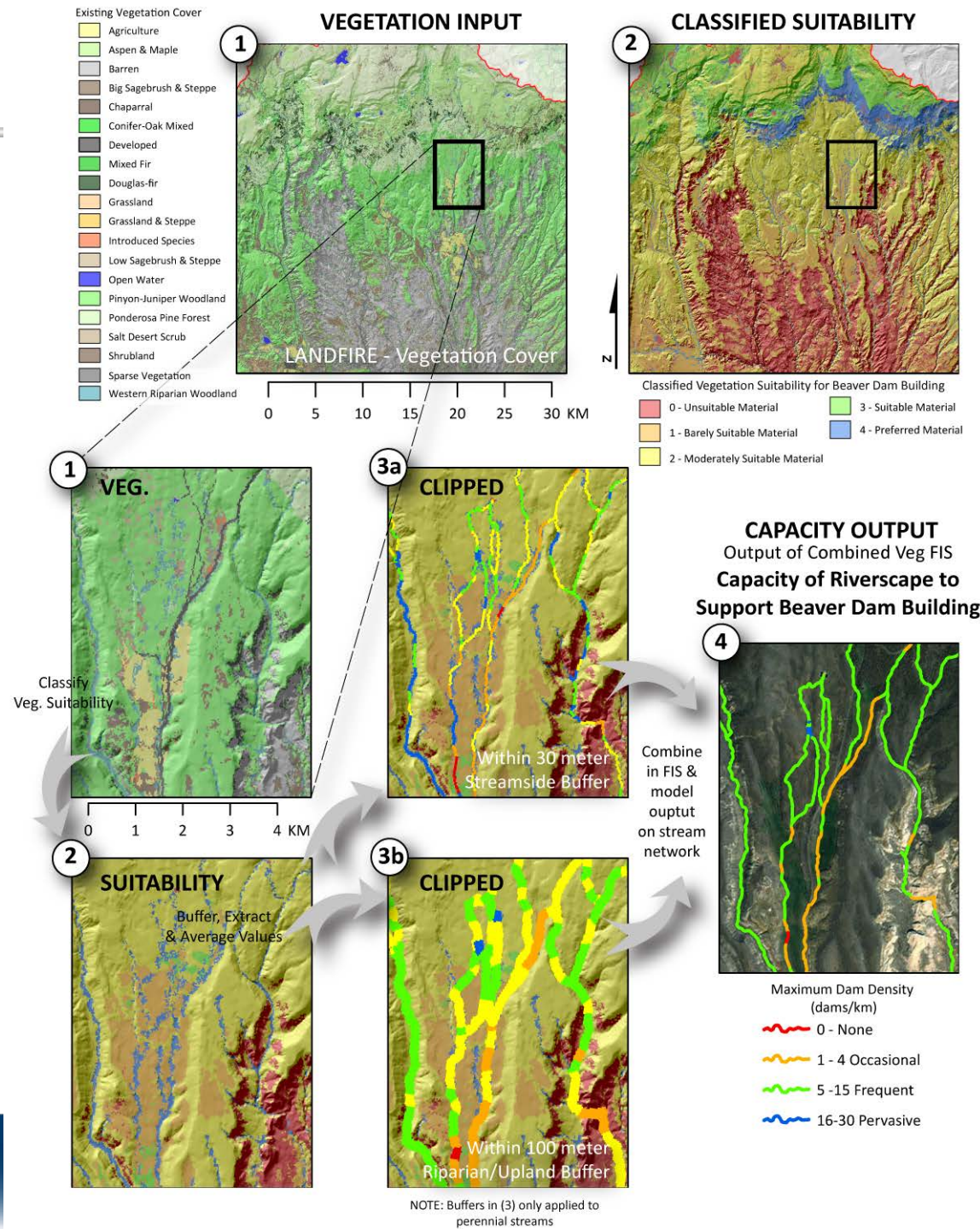
43	[rules]
44	1 1, 1 (1) : 1
45	2 1, 2 (1) : 1
46	3 1, 2 (1) : 1
47	4 1, 2 (1) : 1
48	5 1, 3 (1) : 1
49	1 2, 2 (1) : 1
50	2 2, 2 (1) : 1
51	3 2, 2 (1) : 1
52	4 2, 3 (1) : 1
53	5 2, 3 (1) : 1
54	1 3, 2 (1) : 1
55	2 3, 2 (1) : 1
56	3 3, 3 (1) : 1
57	4 3, 3 (1) : 1
58	5 3, 3 (1) : 1
59	1 4, 2 (1) : 1
60	2 4, 2 (1) : 1
61	3 4, 3 (1) : 1
62	4 4, 3 (1) : 1
63	5 4, 3 (1) : 1
64	1 5, 2 (1) : 1
65	2 5, 3 (1) : 1
66	3 5, 3 (1) : 1
67	4 5, 4 (1) : 1
68	5 5, 4 (1) : 1

INPUTS					OUTPUT
IF	Suitability of Streamside Vegetation		Suitability of Riparian/Upland Vegetation		Dam Density Capacity
RULES	1 Unsuitable	&	Unsuitable	, then	None
	2 Barely Suitable	&	Unsuitable	, then	Occasional
	3 Moderately Suitable	&	Unsuitable	, then	Occasional
	4 Suitable	&	Unsuitable	, then	Occasional
	5 Preferred	&	Unsuitable	, then	Frequent
	6 Unsuitable	&	Barely Suitable	, then	Occasional
	7 Barely Suitable	&	Barely Suitable	, then	Occasional
	8 Moderately Suitable	&	Barely Suitable	, then	Occasional
	9 Suitable	&	Barely Suitable	, then	Frequent
	10 Preferred	&	Barely Suitable	, then	Frequent
	11 Unsuitable	&	Moderately Suitable	, then	Occasional
	12 Barely Suitable	&	Moderately Suitable	, then	Occasional
	13 Moderately Suitable	&	Moderately Suitable	, then	Frequent
	14 Suitable	&	Moderately Suitable	, then	Frequent
	15 Preferred	&	Moderately Suitable	, then	Frequent
	16 Unsuitable	&	Suitable	, then	Occasional
	17 Barely Suitable	&	Suitable	, then	Occasional
	18 Moderately Suitable	&	Suitable	, then	Frequent
	19 Suitable	&	Suitable	, then	Frequent
	20 Preferred	&	Suitable	, then	Frequent
	21 Unsuitable	&	Preferred	, then	Occasional
	22 Barely Suitable	&	Preferred	, then	Frequent
	23 Moderately Suitable	&	Preferred	, then	Frequent
	24 Suitable	&	Preferred	, then	Pervasive
	25 Preferred	&	Preferred	, then	Pervasive



VEG MODEL...

1. LANDFIRE Vegetation
2. Classify in terms of suitability for dam building
3. Clip down to 30 m and 100 m stream buffers
4. Run FIS Model to transfer raster to vector...



RUNNING BRAT IN MATLAB PLAN

I. Understanding both FIS

I. Vegetation Model

II. Combined FIS

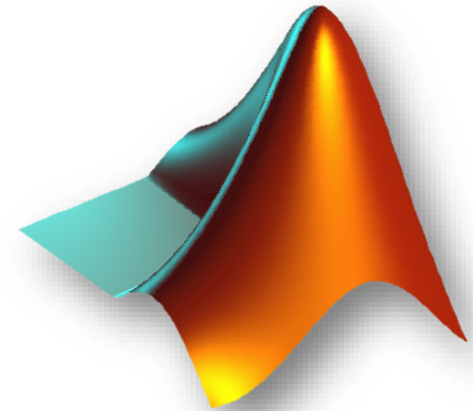
II. Running FIS one row at a time

I. Vegetation Model

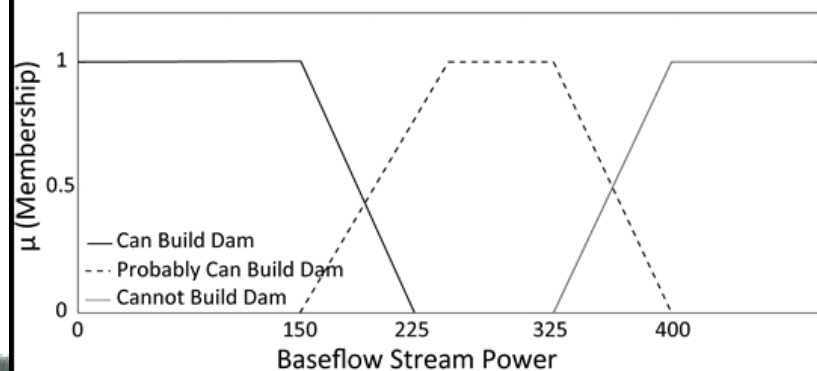
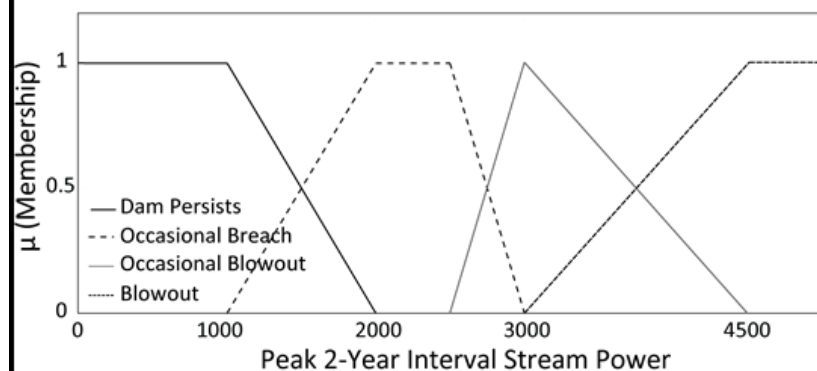
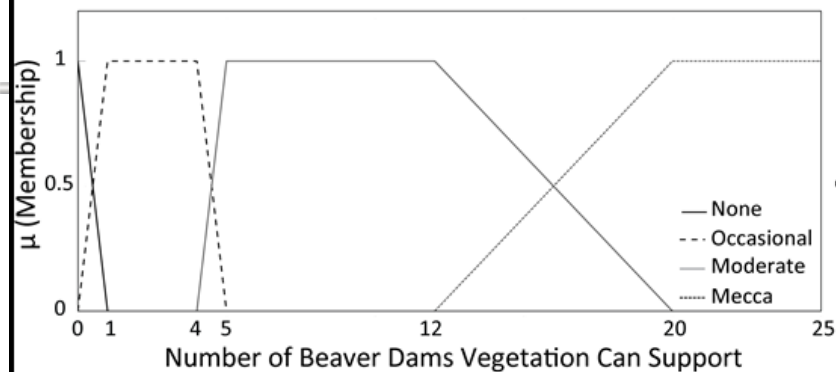
II. Combined FIS

III. Running whole thing...

IV. Getting it back in GIS



INPUTS

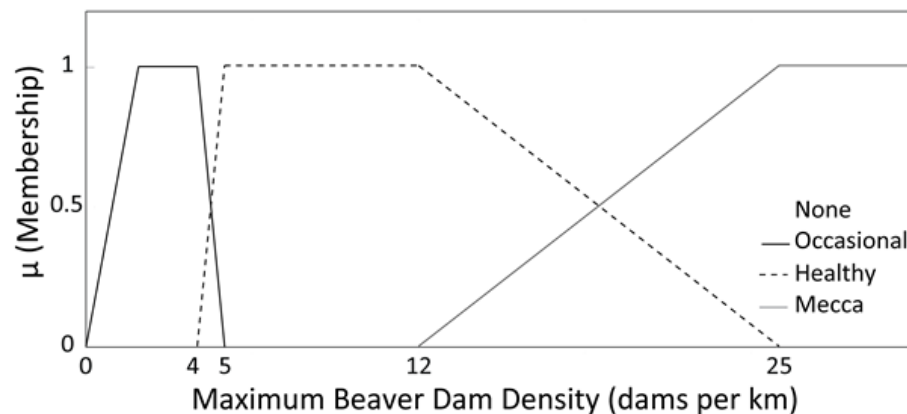


PERENNIAL STREAM VEGETATION & STREAM POWER FIS

FUZZY INFERENCE SYSTEM

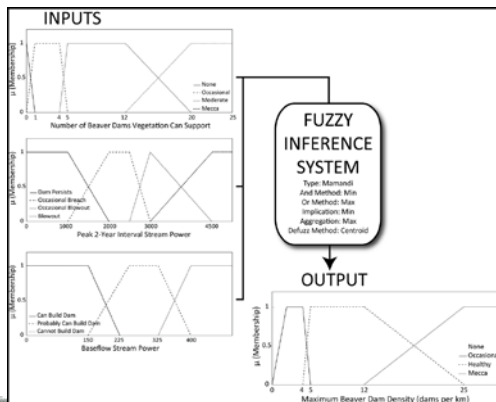
Type: Mamandi
 And Method: Min
 Or Method: Max
 Implication: Min
 Aggregation: Max
 Defuzz Method: Centroid

OUTPUT



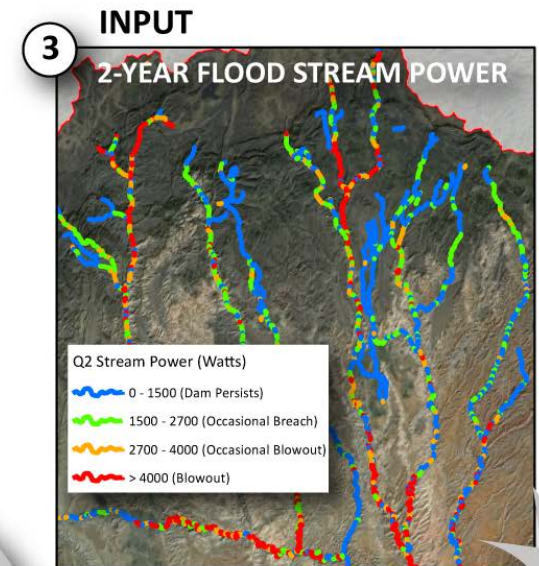
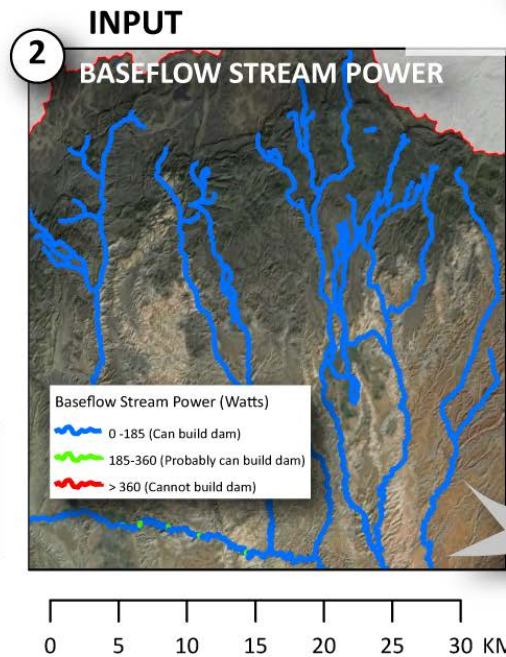
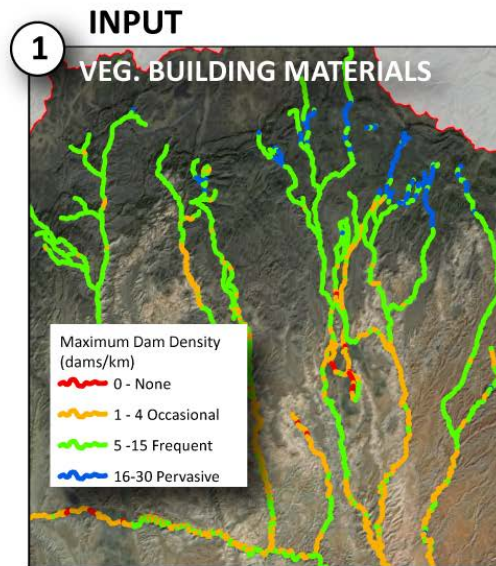
RULE TABLE...

	INPUTS				OUTPUT	
	IF	Vegetative Dam Density Capacity (FIS)	Baseflow Stream Power	2 Year Flood Stream Power		Dam Density Capacity
RULES	1	None	& -	& -	, then	None
	2	-	& Cannot Build Dam	& -	, then	None
	3	Occasional	& Can Build Dam	& Dam Persists	, then	Occasional
	4	Frequent	& Can Build Dam	& Dam Persists	, then	Frequent
	5	Pervasive	& Can Build Dam	& Dam Persists	, then	Pervasive
	6	Occasional	& Can Build Dam	& Occasional Breach	, then	Occasional
	7	Frequent	& Can Build Dam	& Occasional Breach	, then	Frequent
	8	Pervasive	& Can Build Dam	& Occasional Breach	, then	Frequent
	9	Occasional	& Can Build Dam	& Occasional Blowout	, then	Occasional
	10	Frequent	& Can Build Dam	& Occasional Blowout	, then	Occasional
	11	Pervasive	& Can Build Dam	& Occasional Blowout	, then	Frequent
	12	Occasional	& Can Build Dam	& Blowout	, then	Occasional
	13	Frequent	& Can Build Dam	& Blowout	, then	Occasional
	14	Pervasive	& Can Build Dam	& Blowout	, then	Occasional
	15	Occasional	& Can Probably Build Dam	& Occasional Breach	, then	Occasional
	16	Frequent	& Can Probably Build Dam	& Occasional Breach	, then	Frequent
	17	Pervasive	& Can Probably Build Dam	& Occasional Breach	, then	Frequent
	18	Occasional	& Can Probably Build Dam	& Occasional Blowout	, then	Occasional
	19	Frequent	& Can Probably Build Dam	& Occasional Blowout	, then	Occasional
	20	Pervasive	& Can Probably Build Dam	& Occasional Blowout	, then	Frequent
	21	Occasional	& Can Probably Build Dam	& Blowout	, then	Occasional
	22	Frequent	& Can Probably Build Dam	& Blowout	, then	Occasional
	23	Pervasive	& Can Probably Build Dam	& Blowout	, then	Occasional



COMBINED

1. Veg FIS
 2. Baseflow (can they build a dam?)
 3. 2 Year Flood (does dam blow out)
- = Resulting Capacity



FUZZY INFERENCE SYSTEM
Capacity of Riverscape to Support Beaver Dams

