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PARTNERING WITH BEAVER IN RESTORATION

WATS 6860

TODAY'S PLAN

I. **Wrap up Ecological Feedbacks**

II. Review Homework – Dam Mapping

III. Intro to Beaver Dam Capacity Modelling

IV. Lab – How to run BRAT capacity model

Bridge Creek © Wheaton

From: http://www.howstuffworks.com/beaver-dam.htm

THE HABITAT THEY MAKE IS GOOD FOR OTHERS TOO!

NATIONAL GEOGRAPHIC

Before & After Wolves

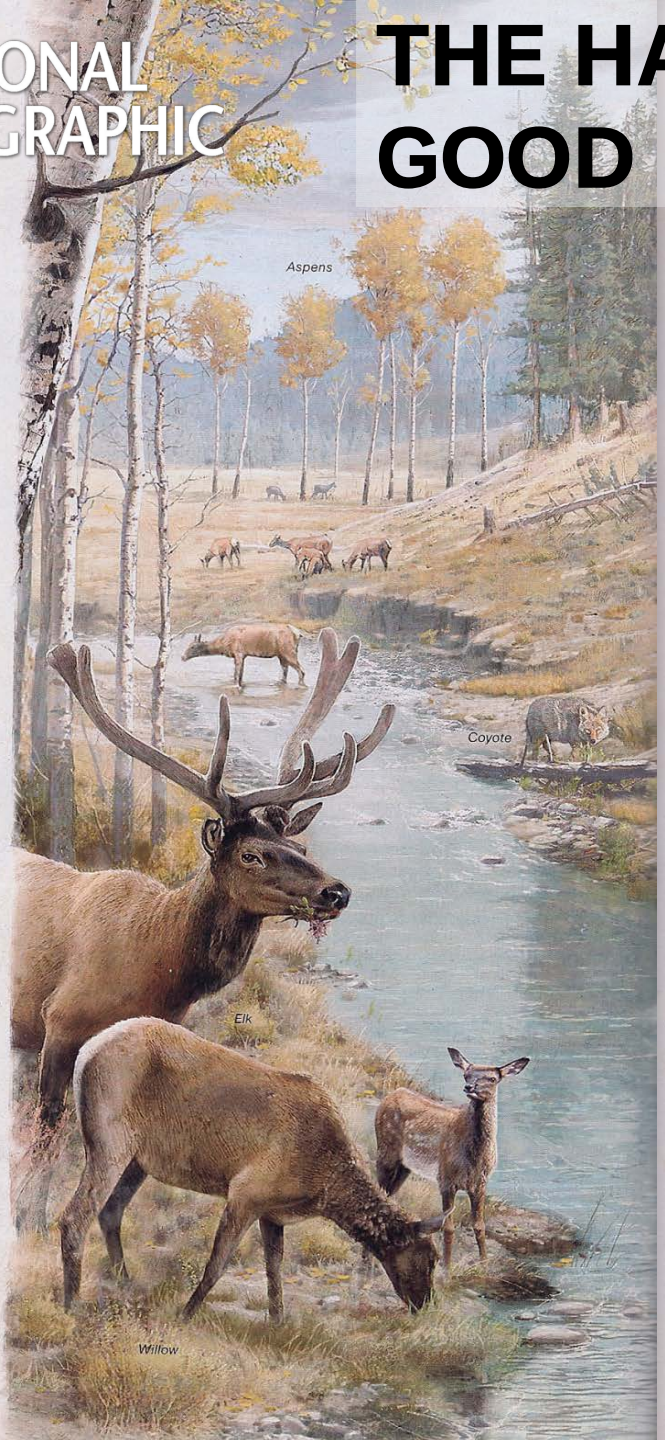
Restoring wolves to Yellowstone after a 70-year absence as a top predator—especially of elk—set off a cascade of changes that is restoring the park's habitat as well.

YELLOWSTONE WITHOUT WOLVES 1926-1995

ELK overbrowsed the streamside willows, cottonwoods, and shrubs that prevent erosion. Birds lost nesting space. Habitat for fish and other aquatic species declined as waters became broader and shallower and, without shade from streamside vegetation, warmer.

ASPEN trees in Yellowstone's northern valleys, where elk winter, were seldom able to reach full height. Elk ate nearly all the new sprouts.

COYOTE numbers climbed. Though they often kill elk calves, they prey mainly on small mammals like ground squirrels and voles, reducing the food available for foxes, badgers, and raptors.



YELLOWSTONE WITH WOLVES 1995-PRESENT

ELK population has been halved. Severe winters early in the reintroduction and drought contributed to the decline. A healthy fear of wolves also keeps elk from lingering at streamsides, where it can be harder to escape attack.

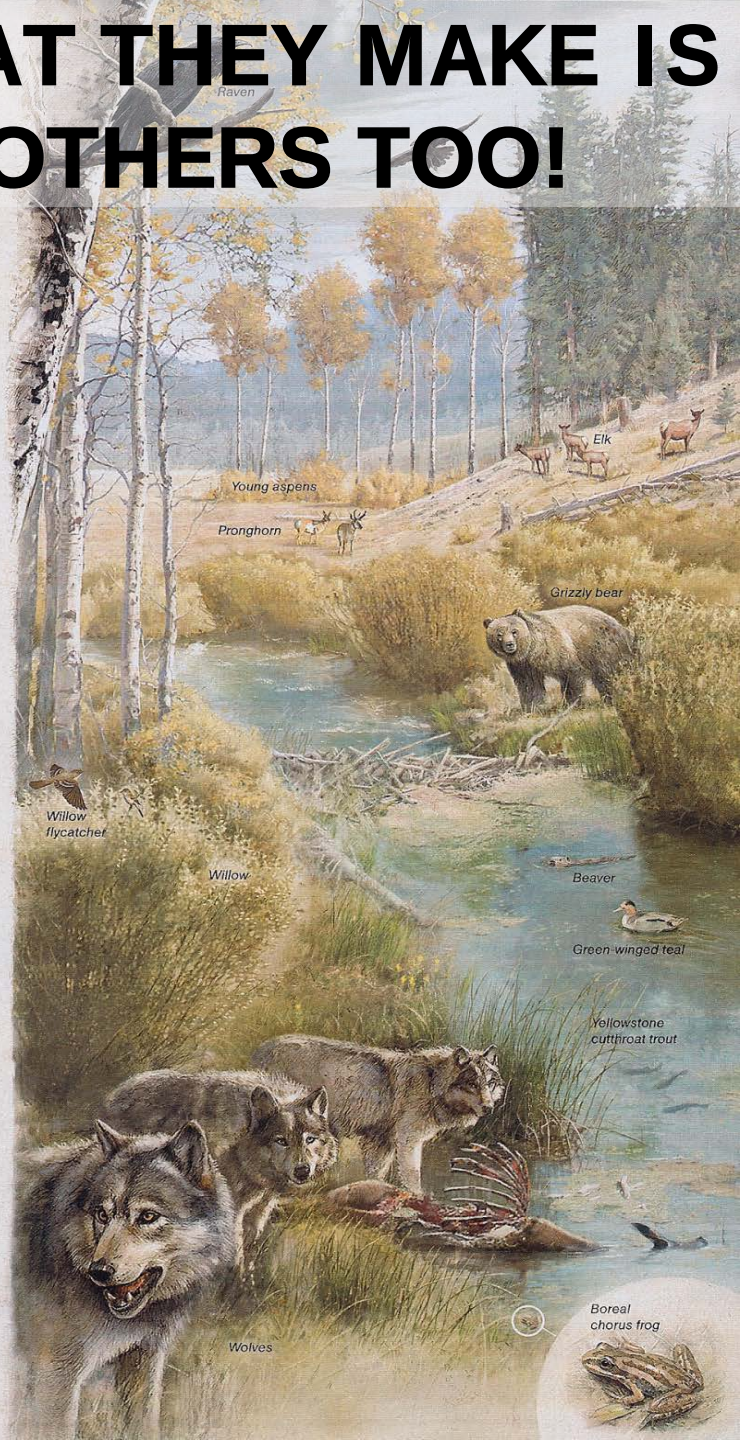
ASPENS The number of new sprouts eaten by elk has dropped dramatically. New groves in some areas now reach 10 to 15 feet tall.

COYOTES Wolf predation has reduced their numbers. Fewer coyote attacks may be a factor in the resurgence of the park's pronghorn.

WILLOWS, cottonwoods, and other riparian vegetation have begun to stabilize stream banks, helping restore natural water flow. Overhanging branches again shade the water and welcome birds.

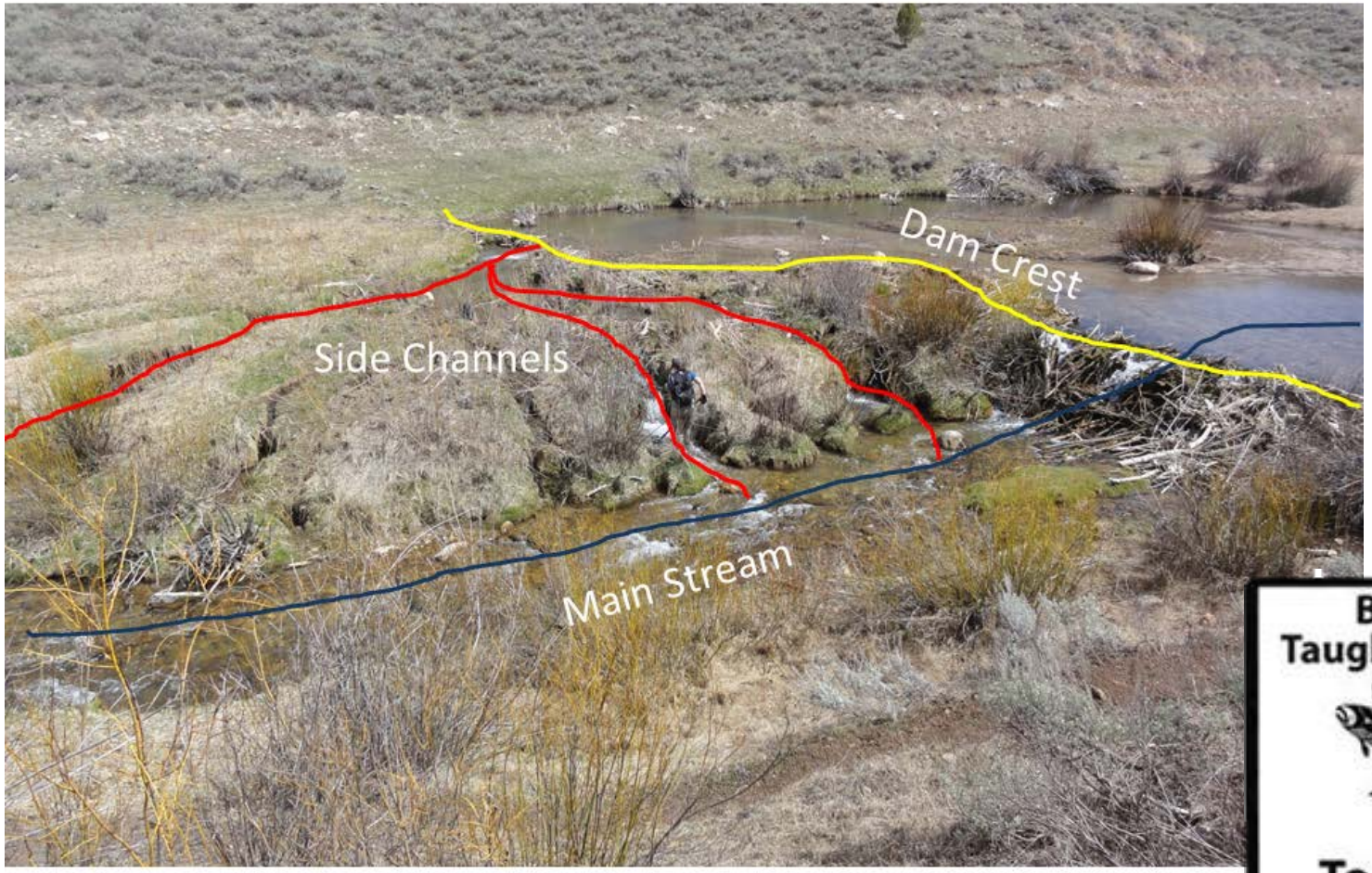
BEAVER colonies in north Yellowstone have risen from one to 12, now that some stream banks are lush with vegetation, especially willows (a key beaver food). Beaver dams create ponds and marshes, supporting fish, amphibians, birds, small mammals, and a rich insect population to feed them.

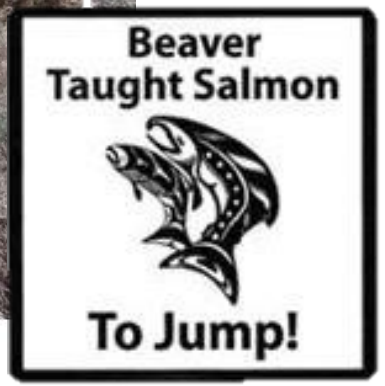
CARRION Wolves don't cover their kill, so they've boosted the food supply for scavengers, notably bald and golden eagles, coyotes, ravens, magpies, and bears.



ART BY FERNANDO G. BAPTISTA, NG STAFF; AMANDA HOBBS, NG STAFF
SOURCES: ROBERT L. BESCHTA AND WILLIAM J. RIPPLE, OREGON STATE UNIVERSITY; DOUGLAS W. SMITH, YELLOWSTONE NATIONAL PARK

DO BEAVER DAMS PREVENT FISH FROM GETTING UPSTREAM?





Lokteff RL*, Roper B and Wheaton JM. 2013. Do beaver dams impede the movement of trout? Transactions of American Fisheries Society. DOI: 10.1080/00028487.2013.797497

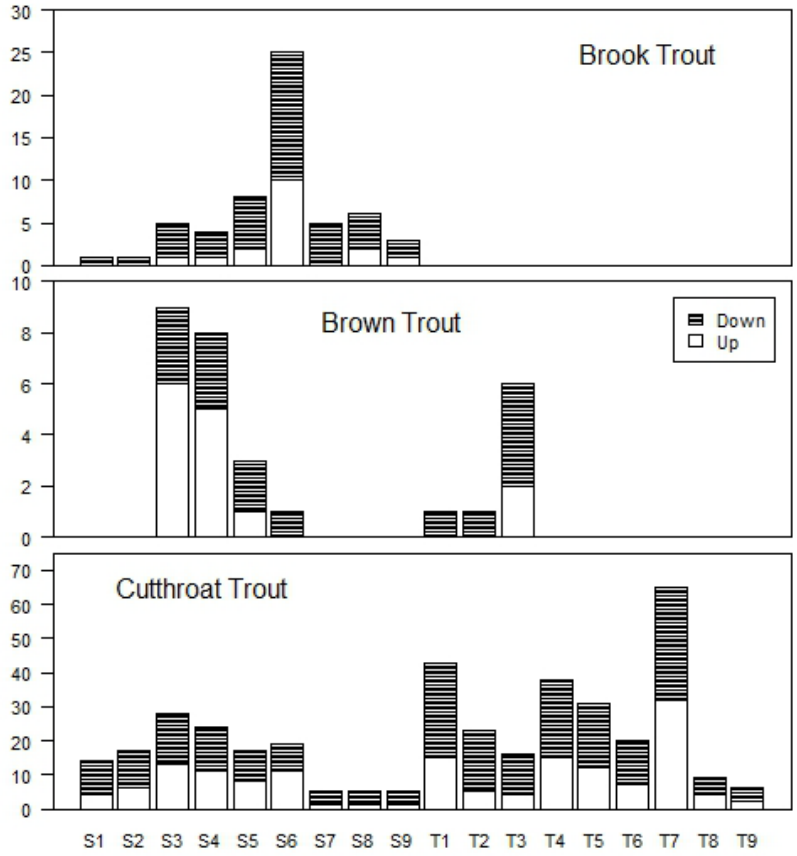
BEAVER IMPACTS ON FISH?

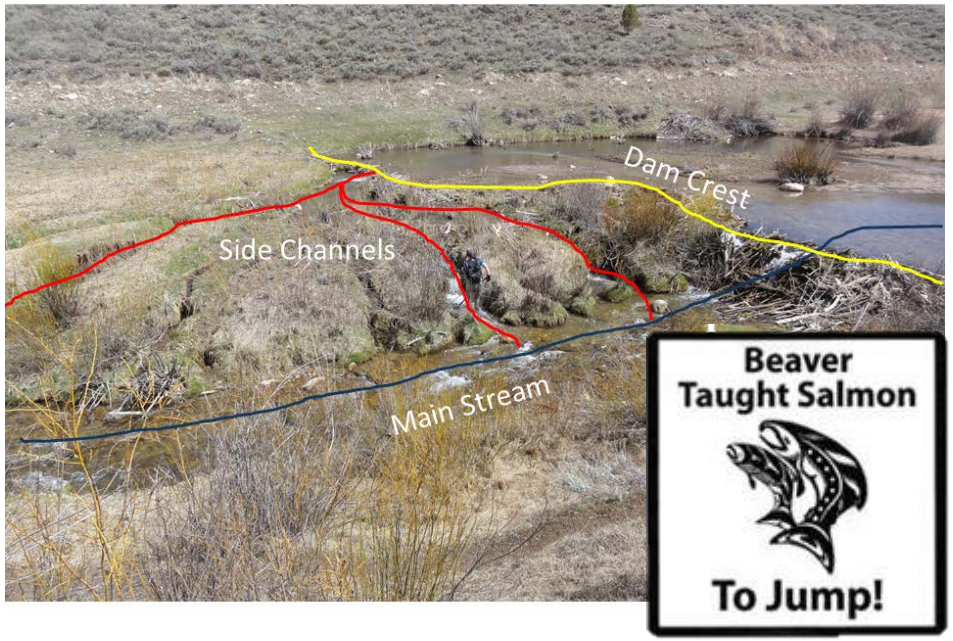
Table 3 Citation of negative impacts of beaver activity on fish populations and the percentage of citations based on quantitative analysis or speculation. Different impacts are expressed as the number of times they are cited in 108 literature sources and as a percentage of the total number of citations.

Negative impacts	Number	% of total citations	Data driven (%)	Speculative (%)
Barriers to fish movement	51	42.9	21.6	78.4
Reduced spawning habitat	20	16.8	40.0	60.0
Altered temperature regime	11	9.2	9.1	90.9
Reduced oxygen levels	12	10.1	50.0	50.0
Reduced habitat quality	2	1.7	0	100
Altered flow regimes	4	3.4	75.0	25.0
Loss of cover	5	4.2	0	100
Reduced productivity	9	7.6	33.3	66.7
Retarded growth	2	1.7	50.0	50.0
Abandonment of beaver settlements	1	0.8	100	0
Reduced water quality	2	1.7	50.0	50.0
Total	119	100	28.6	71.4

Kemp et al., 2012

DO BEAVER DAMS PREVENT FISH FROM GETTING UPSTREAM?





- Native cutthroats can pass easier then invasive Browns!

Lokteff RL*, Roper B and Wheaton JM. 2013. Do beaver dams impede the movement of trout? Transactions of American Fisheries Society. DOI: 10.1080/00028487.2013.797497

SOMETIMES…

Transactions of the American Fisheries Society 142:1114–1125, 2013
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ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2013.797497

ARTICLE

Do Beaver Dams Impede the Movement of Trout?

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Joseph M. Wheaton
Department of Watershed Sciences, Utah State University, 5210 Old Main Hill, Logan, Utah 84322, USA

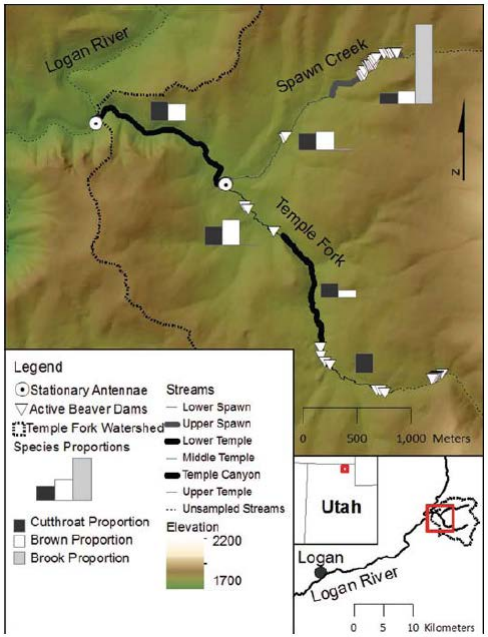
Abstract

Dams created by North American beavers *Castor canadensis* (hereafter, "beavers") have numerous effects on stream habitat use by trout. Many of these changes to the stream are seen as positive, and many stream restoration projects seek either to reintroduce beavers or to mimic the habitat that they create. The extent to which beaver dams act as movement barriers to salmonids and whether successful dam passage differs among species are topics of frequent speculation and warrant further research. We investigated beaver dam passage by three trout species in two northern Utah streams. We captured 1,375 trout above and below 21 beaver dams and fitted them with PIT tags to establish whether fish passed the dams and to identify downstream and upstream passage; 187 individual trout were observed to make 481 passes of the 21 beaver dams. Native Bonneville Cutthroat Trout *Oncorhynchus clarkii utah* passed dams more frequently than nonnative Brown Trout *Salmo trutta* and nonnative Brook Trout *Salvelinus fontinalis*. We determined that spawn timing affected seasonal changes in dam passage for each species. Physical characteristics of dams, such as height and upstream location, affected the passage of each species. Movement behaviors of each trout species were also evaluated to help explain the observed patterns of dam passage. Our results suggest that beaver dams are not acting as movement barriers for Bonneville Cutthroat Trout or Brook Trout but may be impeding the movements of invasive Brown Trout.

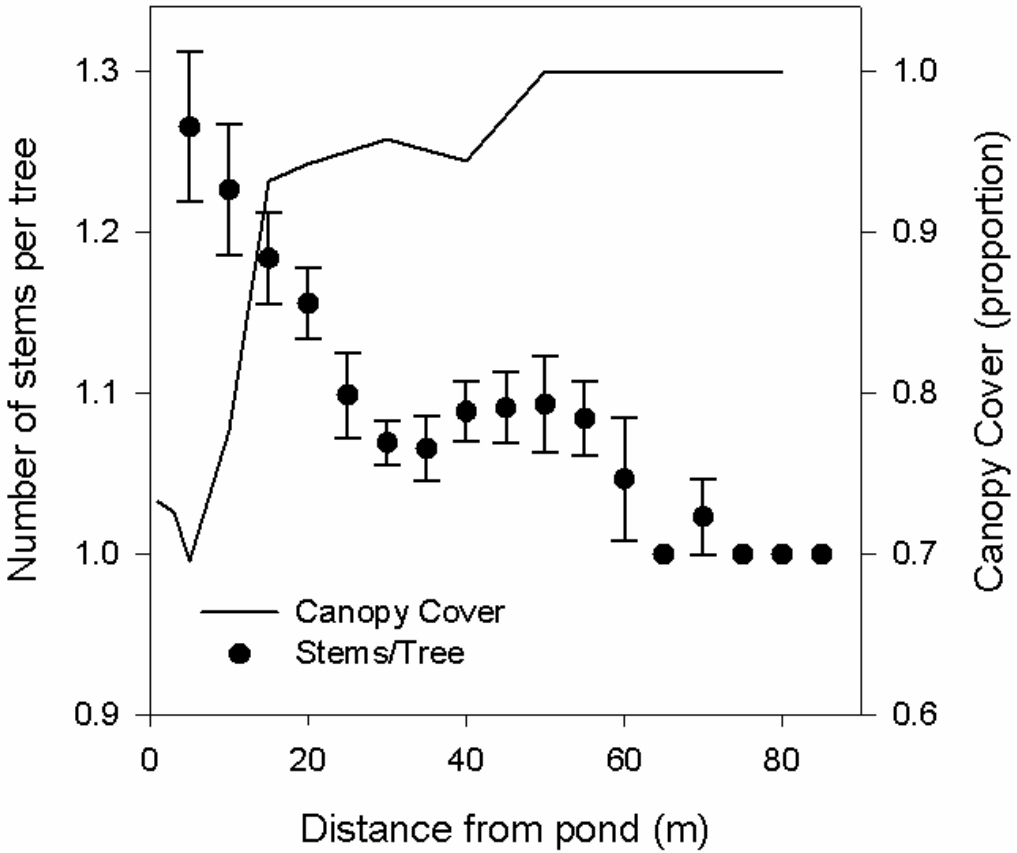
Before settlement by Europeans, North American beavers *Castor canadensis* (hereafter, "beavers") played a significant role in shaping the habitats of North American fishes (Naiman et al. 1988). The extensive removal of beavers beginning in the 17th century affected native fish, such as Brook Trout *Salvelinus fontinalis* in the east and Cutthroat Trout *Oncorhynchus clarkii* in the west. With the recent recovery of beavers in some western streams (Naiman et al. 1988), the reintroduction of beavers into other streams, and restoration projects that seek to mimic the effects of beavers on stream processes (DeVries et al. 2012; Pollock et al. 2011), a better understanding of the interactions between beavers and native fish is needed. This understanding would permit improved choices and prioritization in how and where these types of restoration activities are used, especially in the presence of declining native populations of Cutthroat Trout (Budy et al. 2012) and Brook Trout (Marschall and Crowder 1996; Fausch 2008).

It has been suggested that the increased habitat complexity found in reaches (especially lower-stream-order reaches) with beaver dams benefits salmonid species in western North America (Neff 1957; Gard 1961; Collen and Gibson 2001; Kemp et al. 2012) and provides vital habitats for threatened or imperiled fish species. Deeper water with low velocities and high wood abundances provides important rearing habitat for Endangered Species Act (ESA)-listed Coho Salmon *O. kisutch* (Pollock et al. 2004). White and Rahel (2008) showed that complementation of different habitat types, including beaver ponds, supported the needs of multiple life stages of imperiled Bonneville Cutthroat

*Corresponding author: rlokteff@gmail.com
Received November 26, 2012; accepted April 15, 2013



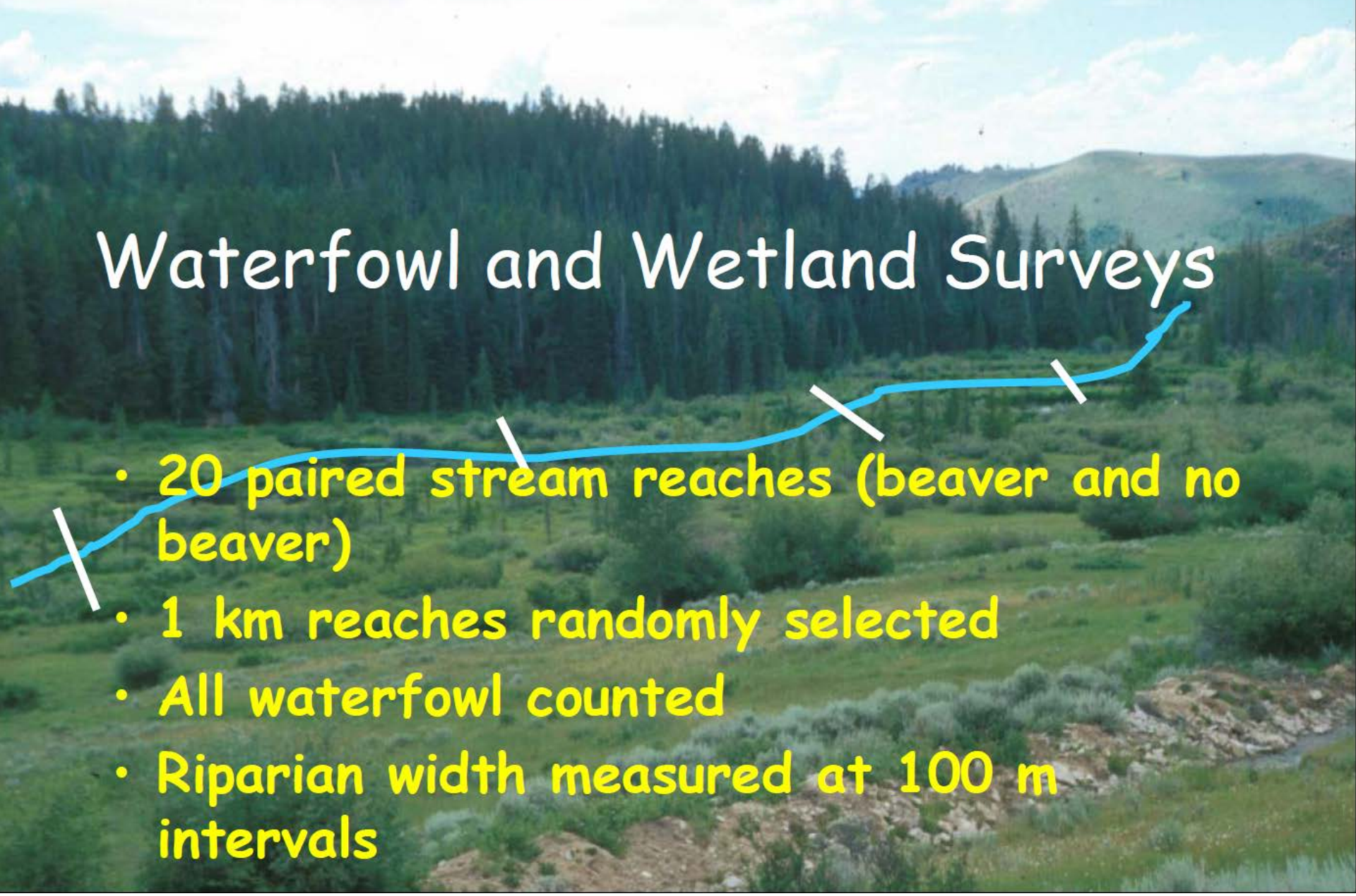
MORE MULTI-STEMMED TREES CLOSE TO THE POND EDGE…. ALSO MORE LIGHT



Harrison & Stella 2010
Slide courtesy of John Stella

BEAVER IN PATAGONIA

Waterfowl and Wetland Surveys



- 20 paired stream reaches (beaver and no beaver)
- 1 km reaches randomly selected
- All waterfowl counted
- Riparian width measured at 100 m intervals

Slide Courtesy of Mark McKinstry

Riparian Width and Wetland Area

	With Beaver	*Without Beaver*
Riparian Width	**33.9 m (CI=56.1)**	**10.5 m (CI = 19.7)**
Wetland Area	**3.3 ha/km (CI = 0.74 ha)**	**1.0 ha/km(CI = 0.25 ha)**
Past Research Munther 82, 83	**9.6 ha/km**	**0.8-1.6 ha/km**

Slide Courtesy of Mark McKinstry

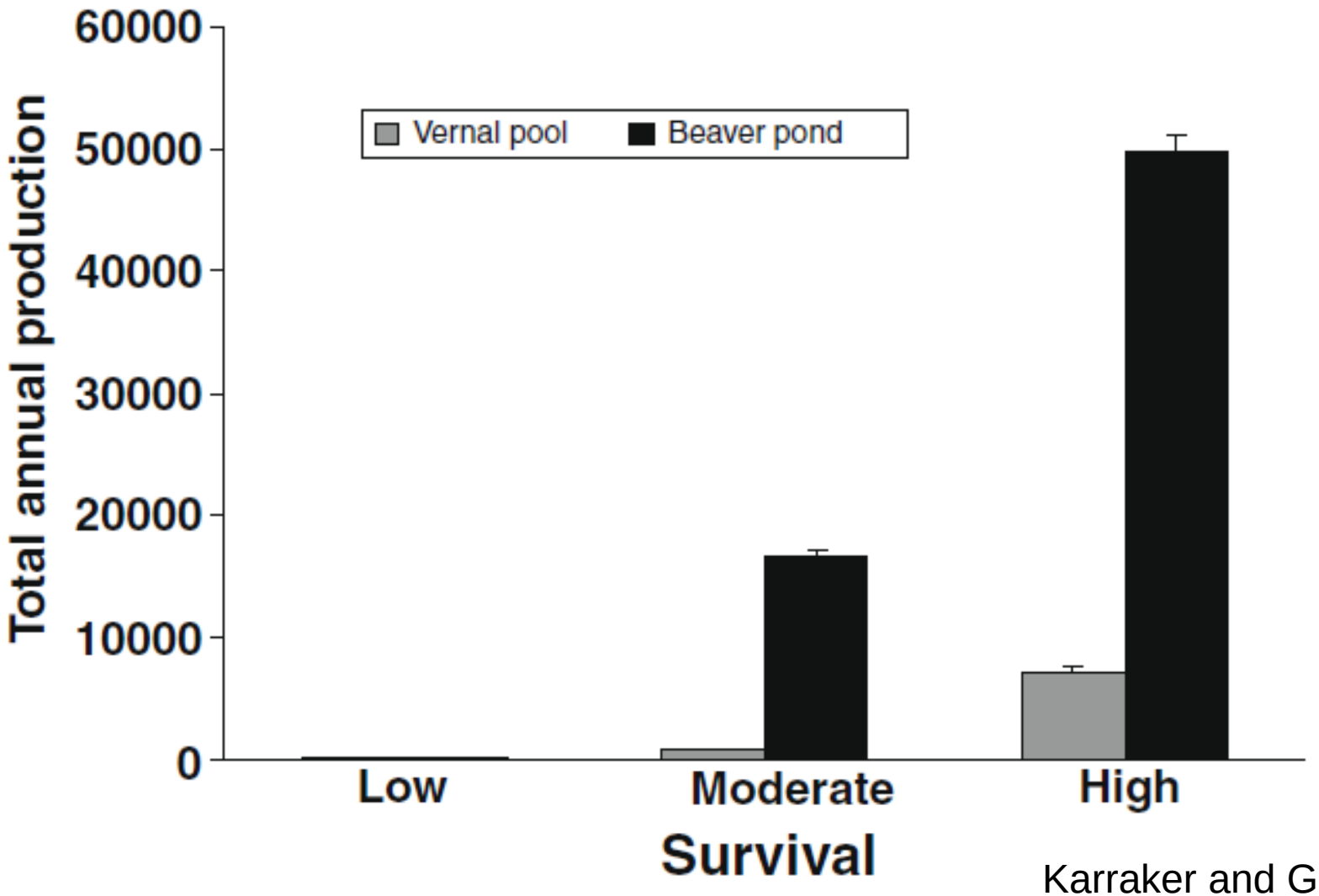
Waterfowl Densities
(Statewide 1st-3rd order)

	With Beaver	Without Beaver
Known Areas Where Beaver Have Been Extirpated	39,000 ducks (5,261 km; 17,300 ha wetlands)	5,200 ha wetlands
Total Areas in State (extrapolated 24% of total)	200,000 ducks (28,000 km; 93,000 ha wetlands)	28,000 ha wetlands

McKinstry, Caffrey, and Anderson. 2001. The importance of beaver to wetland habitats and waterfowl in Wyoming. Journal American Water Resources Association 37 (6):1571-1577.

Slide Courtesy of Mark McKinstry

WOOD FROG PRODUCTION



Karraker and Gibbs 2009

Table 1. Comparison of mean annual standing stocks and annual fluxes of carbon in a riffle and pond in Beaver Creek, Quebec. Data are from Naiman et al. 1986.

Component	Carbon		Ratio
	Riffle	Pond	Riffle:Pond
INPUT ($g \cdot m^{-2} \cdot yr^{-1}$)			
Precipitation and throughfall	16.9	6.9	2.45
Direct allochthonous	123.1	52.6	2.36
Lateral allochthono	55.8	4.3	12.98
Periphyton production	24.7	1.7	14.53
Total input	220.5	65.1	3.39
STANDING STOCK (g/m^2)			
Water column	2.0	18.0	0.11
Coarse wood	3926.9	3129.2	1.25
CPOM	419.4	5152.0	0.08
FPOM	33.7	3738.8	0.01
Primary producers	0.5	0.1	5.00
Invertebrates	0.4	2.7	0.15
Total standing stock	4382.9	12040.8	0.36
OUTPUTS ($g \cdot m^{-2} \cdot yr^{-1}$)			
Detritus respiration	22.0	111.5	0.20
Autotrophic respiration	28.0	1.6	17.50
Methane evasion	0.5	7.4	0.07
Insect emergence	0.3	0.4	0.75
Total outputs	50.8	120.9	0.42

Naiman et al. 1988

TEMPORAL DIVERSITY OF BUGS

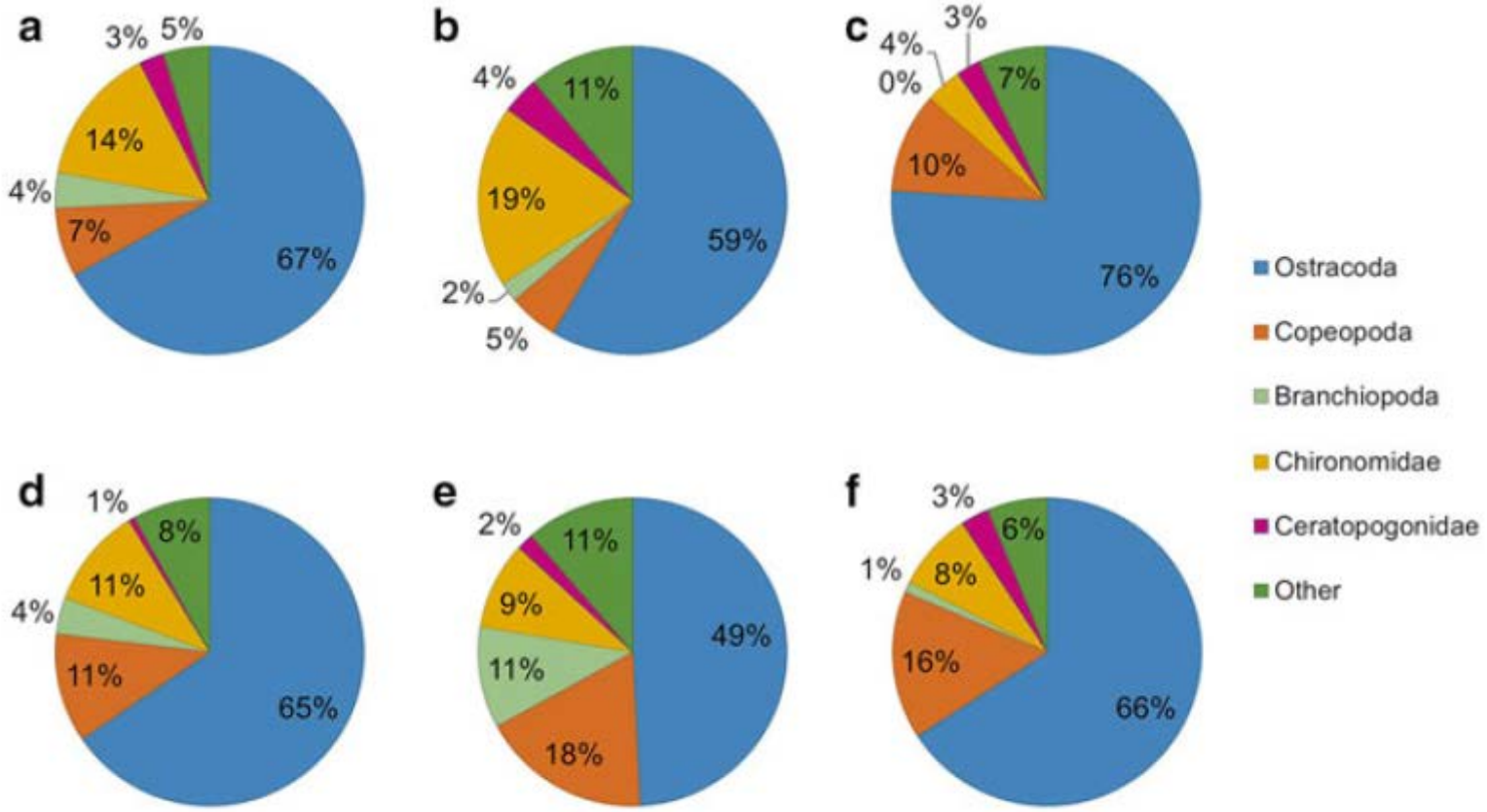


Fig. 12.8 Relative abundance of most dominant taxonomic groups in (**a**) October newly created, (**b**) October mature, (**c**) October abandoned, (**d**) May newly created, (**e**) May mature, and (**f**) May abandoned beaver wetlands of Georgia

Bush BM and Wissinger SA. 2016. Invertebrates in Beaver-Created Wetlands and Ponds. 411-449. DOI: 10.1007/978-3-319-24978-0_12

TAKE AWAYS…

- The impacts of their dam building are what have the biggest feedbacks on:
  - Hydrology (timing & magnitude)
  - Hydraulics (flow depth & velocity)
  - Water Quality (temp & chemistry)
  - Geomorphology (landforms left behind)
  - Habitat for a plethora of aquatic, riparian & upland biota (flora & fauna)

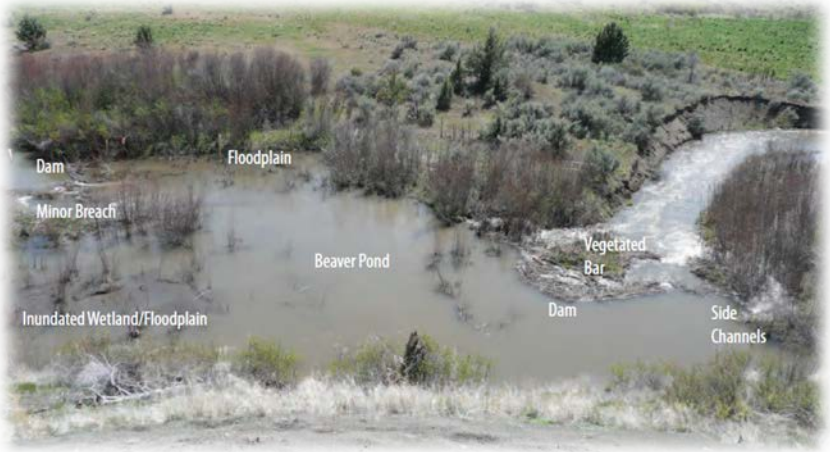
TODAY'S PLAN

I. Wrap up Ecological Feedbacks

II. Review Homework – Dam Mapping

III. Intro to Beaver Dam Capacity Modelling

IV. Lab – How to run BRAT capacity model



Bridge Creek © Wheaton

From: http://www.howstuffworks.com/beaver-dam.htm

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Bridge Creek © Wheaton

From: http://www.howstuffworks.com/beaver-dam.htm

WHERE BEAVER BUILD DAMS

Joe Wheaton
Wally Macfarlane
Jordan Gilbert
Josh Gilbert

THE RANGE MAP IS WRONG!

California Fish and Game 99(4):193-221; 2013

The historical range of beaver (*Castor canadensis*) in coastal California: an updated review of the evidence

CHRISTOPHER W. LANMAN, KATE LUNDQUIST, HEIDI PERRYMAN, J. ELI ASARIAN, BROCK DOLMAN, RICHARD B. LANMAN*, MICHAEL M. POLLOCK

Institute for Historical

Occidental Arts and Occidental, CA 9546

Worth a Dam, 3704 M

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National Oceanic and Montlake Boulevard E

**Correspondent: rickl*

The North An native to the Area. These policies regar of the 20th ce based on veri records. Nov largely inacc are native to groundwater of wetlands salmonids, as

Key words: range, San Fr

The currentl California, according t Department of Fish an

California Fish and Game 98(2):65-80; 2012

The historical range of beaver in the Sier of the evidence

RICHARD B. LANMAN*, HEIDI PERRYMAN, BROCK D JAMES

Institute for Historical Ecology, 556 Van Buren Street, Los A

Worth a Dam, 3704 Mt. Diablo Road, Lafayette, CA 94549,

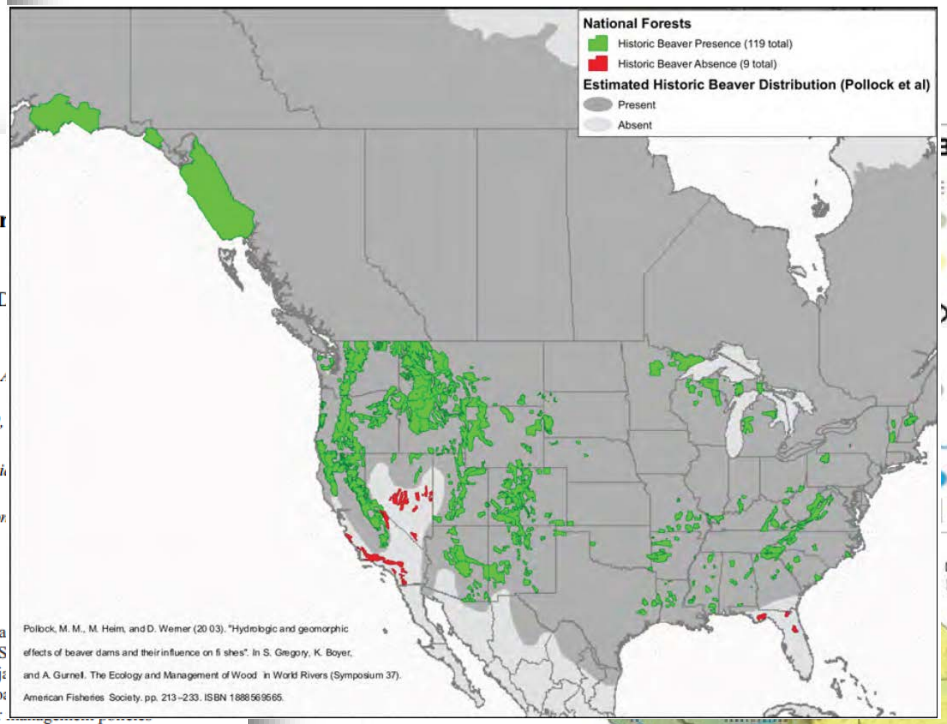
OAEC WATER Institute, 15290 Coleman Valley Road, Occi

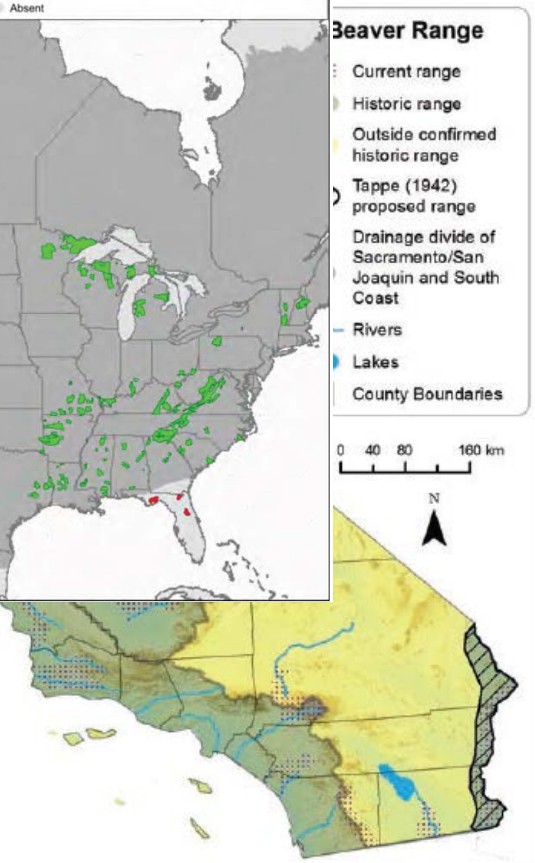
Bureau of Indian Affairs, Northwest Region, Branch of Environ Management, Portland, OR 97232, USA (CDJ)

**Correspondent: ricklanman@gmail.com*

The North American beaver (*Castor canadensis*) ha native to the mid- or high-elevations of the western S its eastern slope, although this mountain range is adja historical range in the Pit, Sacramento and San Joa tributaries. Current California and Nevada beaver appear to rest on assertions that date from the first half of the twentieth century. This review challenges those long-held assumptions. Novel physical evidence of ancient beaver dams in the north central Sierra (James and Lanman 2012) is here supported by a contemporary and expanded re-evaluation of historical records of occurrence by additional reliable observers, as well as new sources of indirect evidence including newspaper accounts, geographical place names, Native American ethnographic information, and assessments of habitat suitability. Understanding that beaver are native to the Sierra Nevada is important to contemporary management of rapidly expanding beaver populations. These populations were established by translocation, and have been shown to have beneficial effects on fish abundance and diversity in the Sierra Nevada, to stabilize stream incision in montane meadows, and to reduce discharge of nitrogen, phosphorus and sediment loads into fragile water bodies such as Lake Tahoe.

Key words: beaver, California, *Castor canadensis*, Cascade Range, Central Valley, historical distribution, Nevada, range, Sierra Nevada

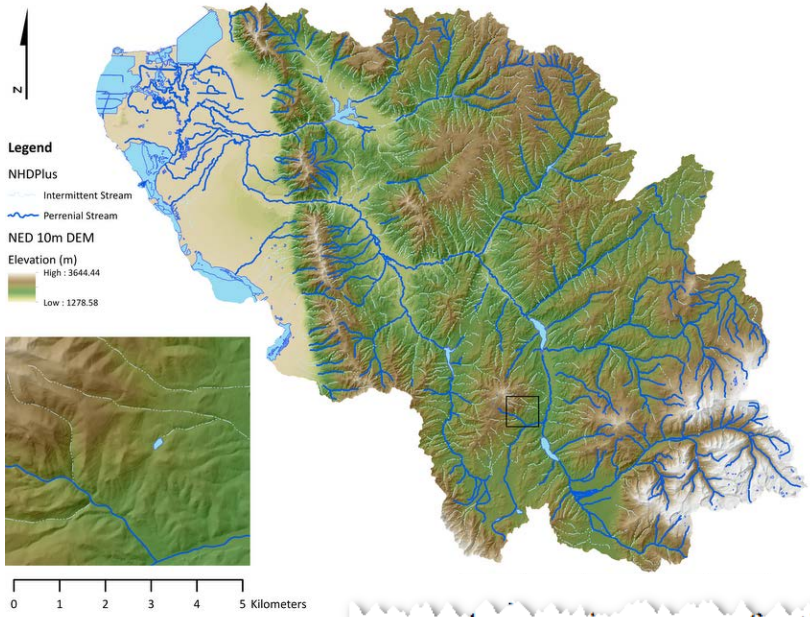


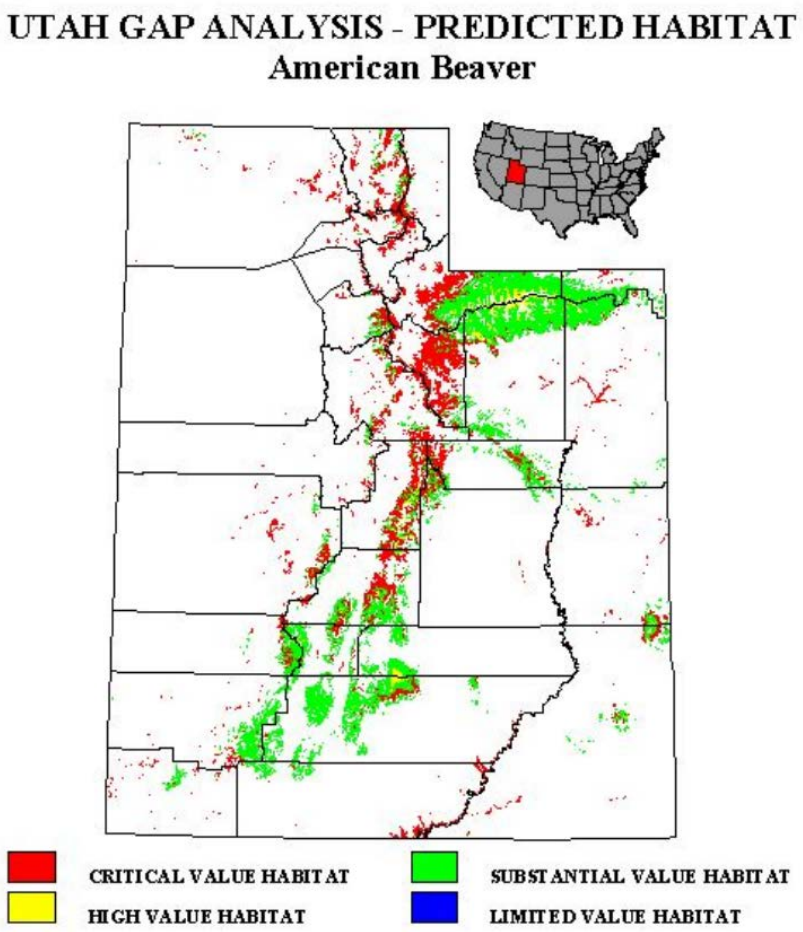


st. K., Perryman, H., Asarian, n, R.B., Pollock, M.M., 2013.

WHERE COULD WE USE BEAVER?

- This is not a very useful map... →
- What about in my district, on my stream?





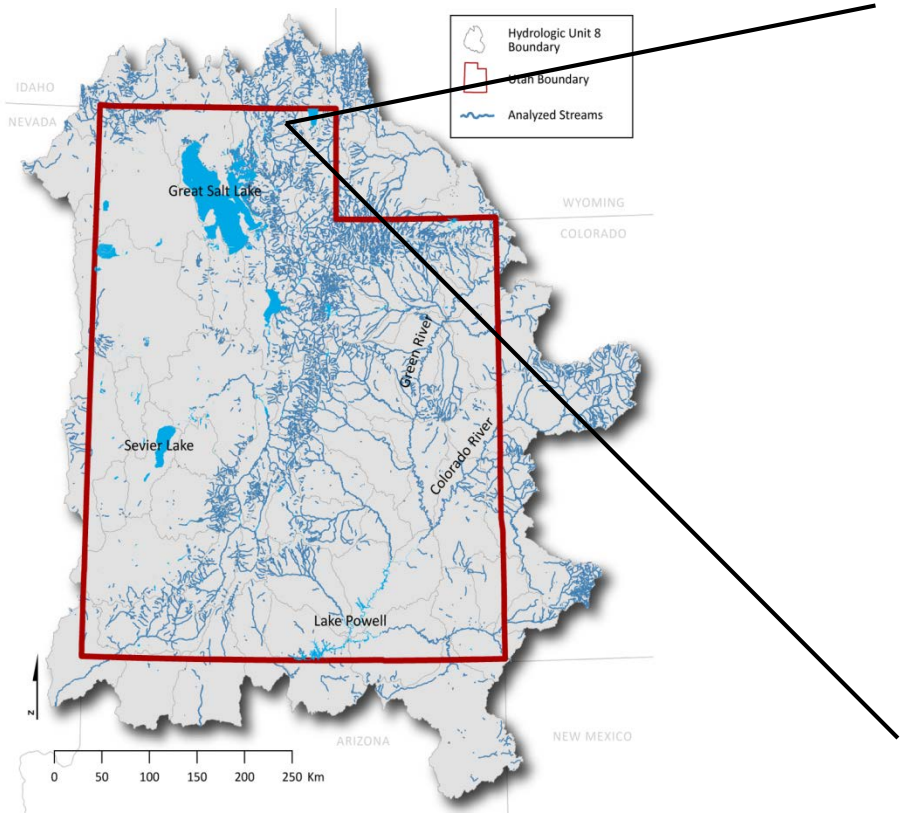
beavers in excess of estimated carrying capacity (Blackwell and Pederson 1993). The predicted beaver habitat in Utah was mapped as part of the 1995 Utah GAP Analysis (Figure 1). Current beaver distribution and abundance is not fully understood, however they are considered common and most of the suitable habitat believed to be occupied.

DAM-BUILDING CAPACITY MODELING

- **Beaver dams,** not beaver themselves, provide the positive feedbacks we seek
- While beaver can survive in 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: BEAVER DAM CAPACITY MODEL

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



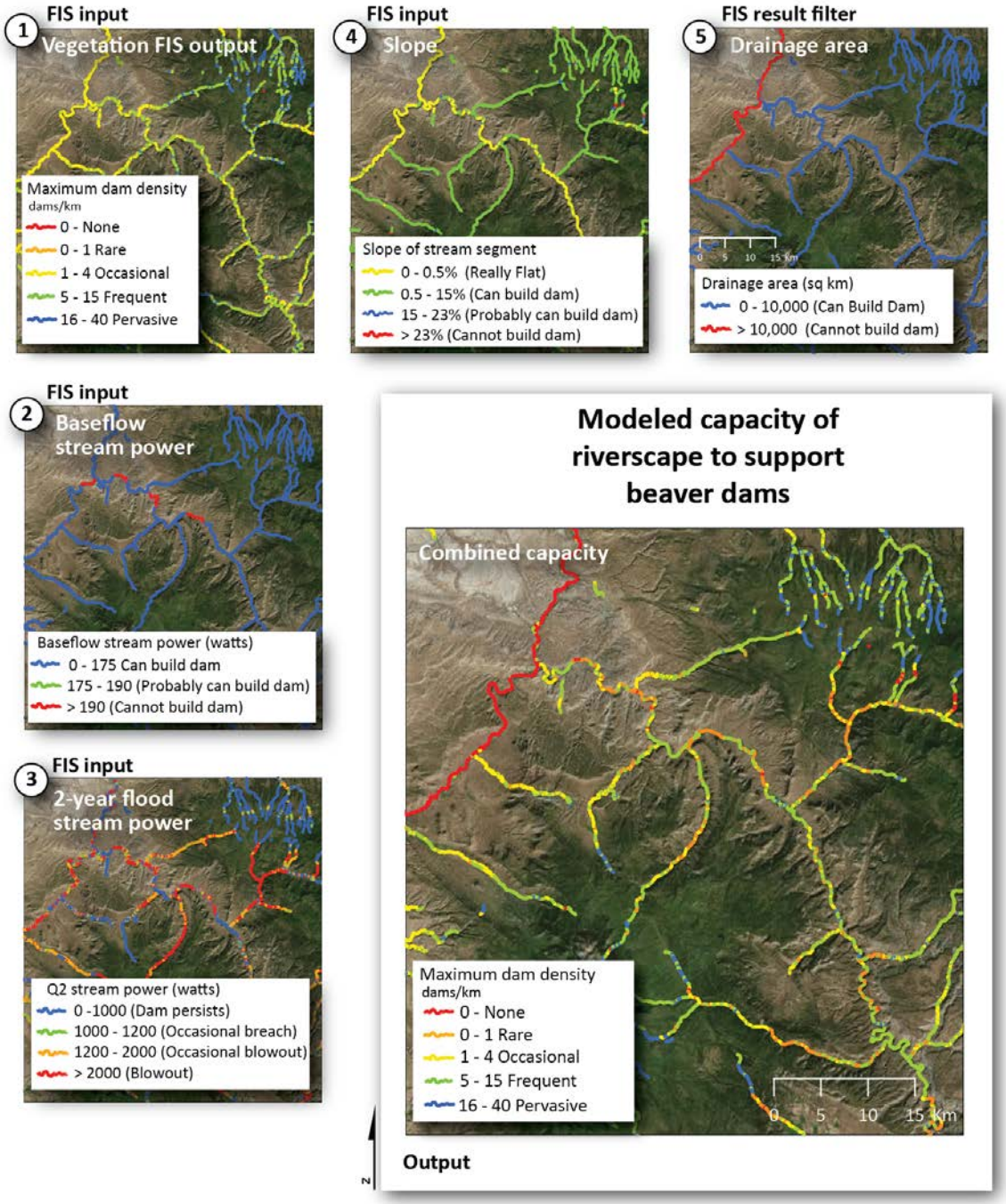
IN OTHER WORDS…

- BRAT is all about how many of these:

- Not how many of these:

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



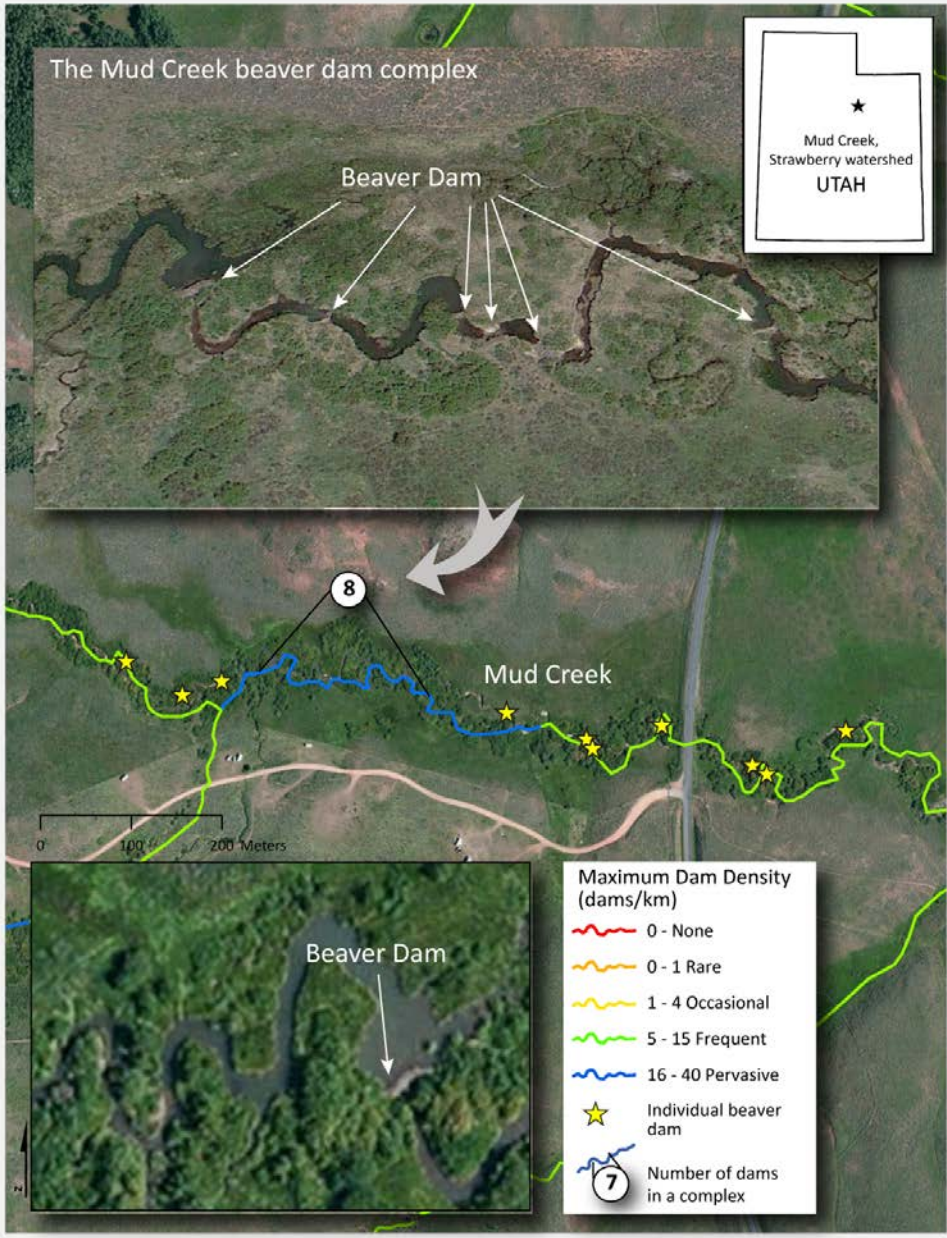
DAM DENSITY OUTPUT CATEGORIES:

- **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*

Moab: Beaver dam capacity estimates

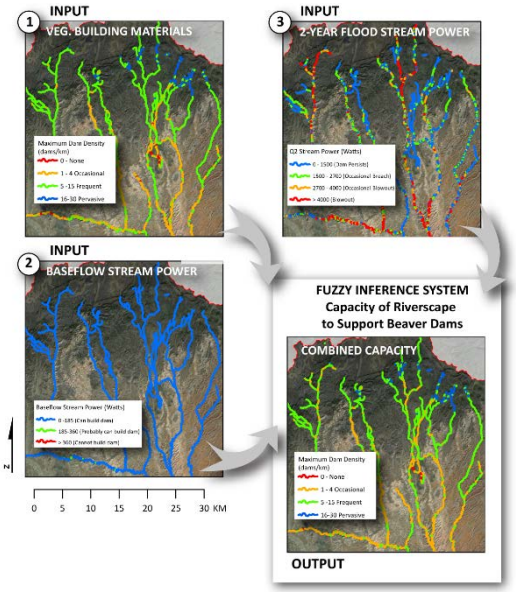
RESOLUTION OF BRAT

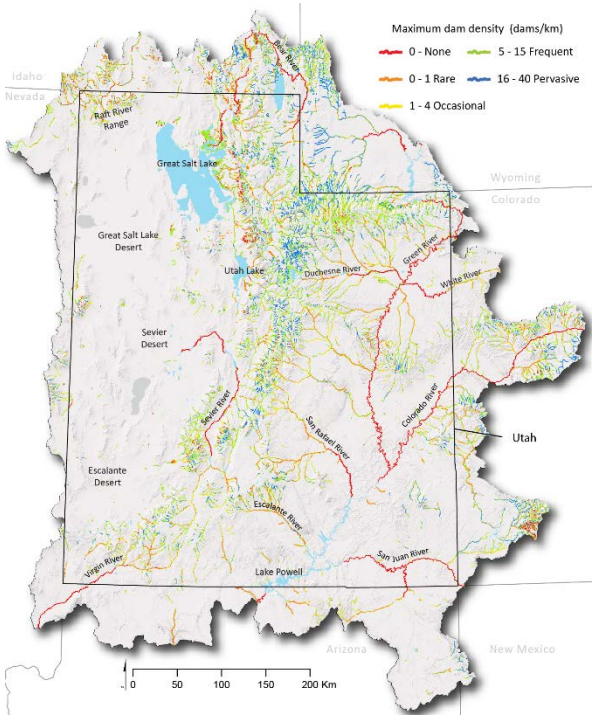
- At a scale that is still meaningful on the ground (250 m reaches)
- Just because BRAT predicts high capacity, does not mean it will be realized... but it does define a plausible upper limit
- In many places, at some point in time this upper limit is reached... just never all at once

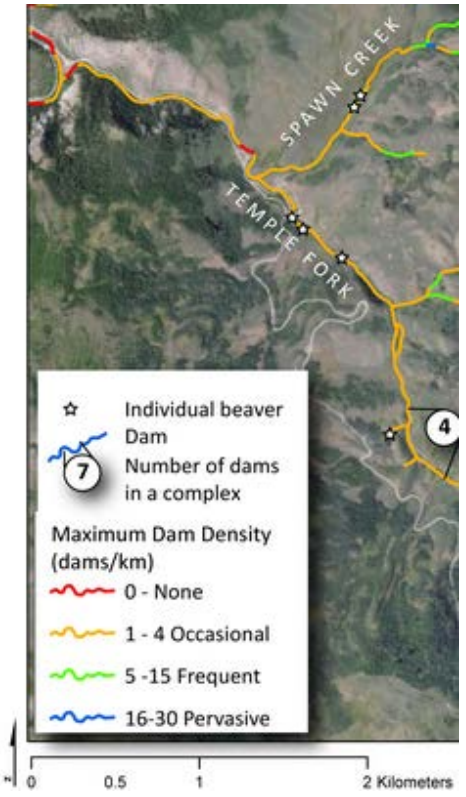


WHAT WE DID WITH BRAT…

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





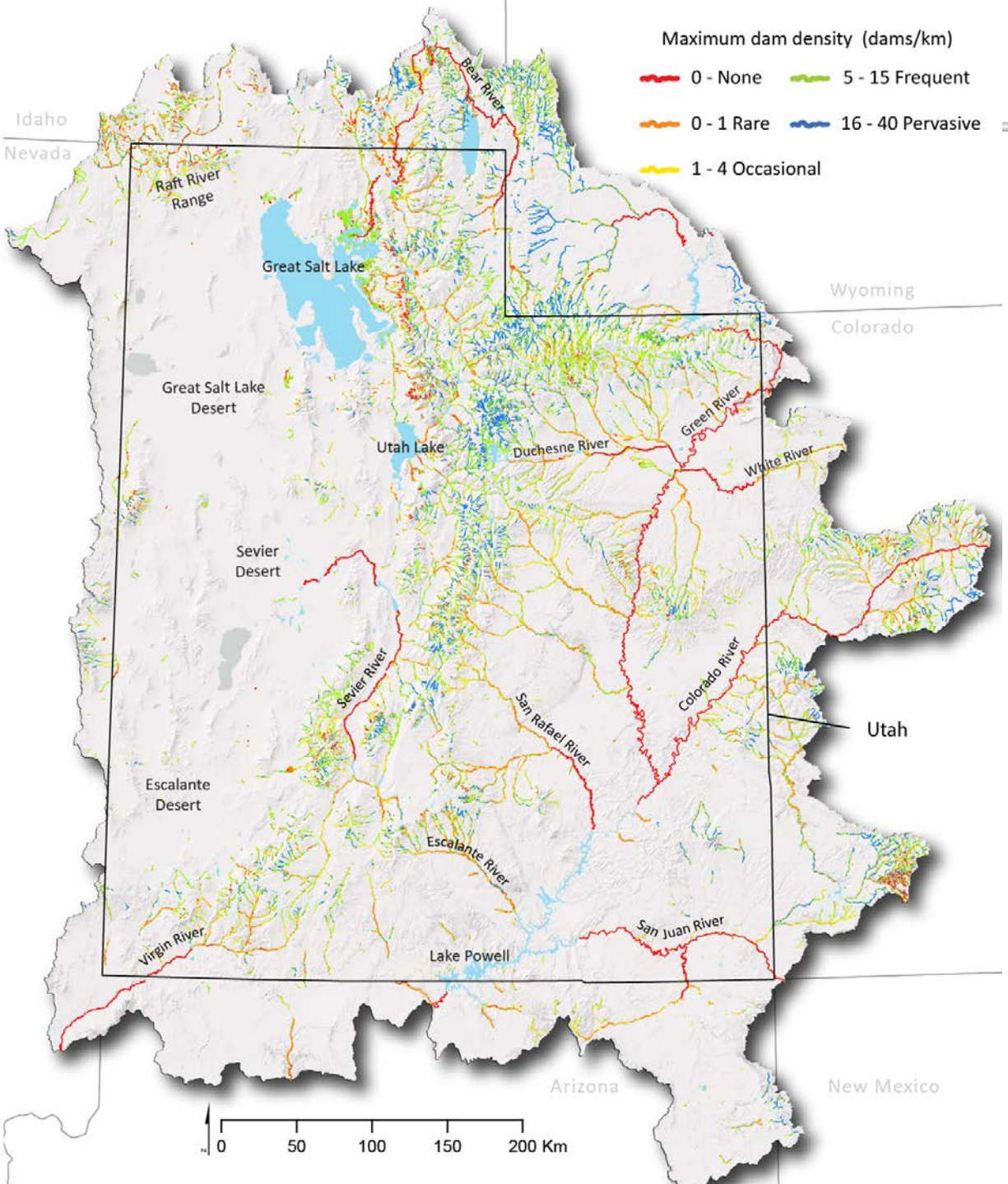


Run Model with Nationally Available Datasets

STATE OF UTAH (> 225,000 km^2)

Resolved at every 250 m long reach within State (27,000 km)

UTAH DNR
WILDLIFE RESOURCES

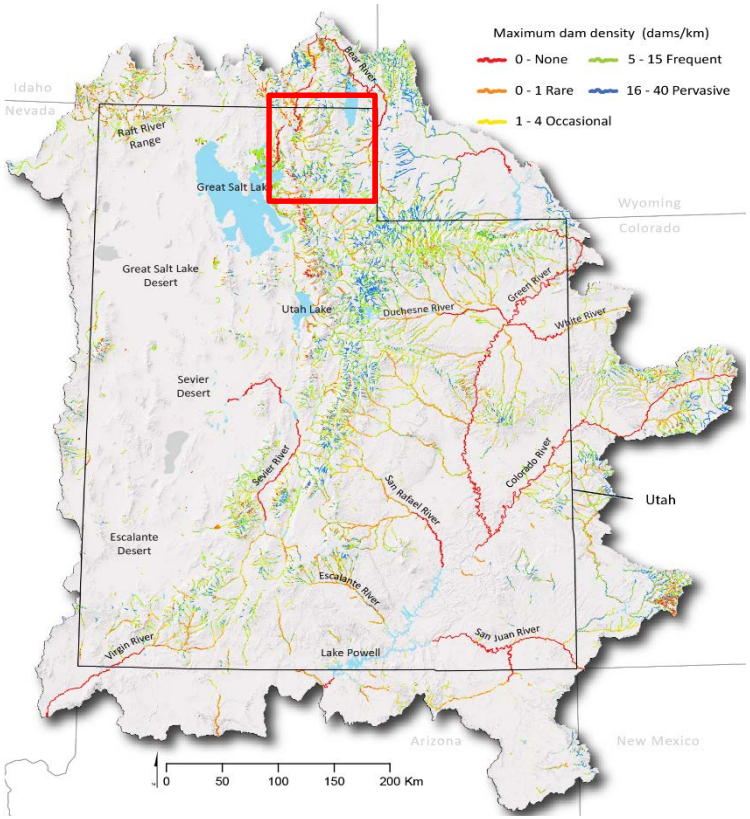


DAM DENSITY CAPACITY OUTPUT

Maximum Dam Density

(Beaver Dams / mile)

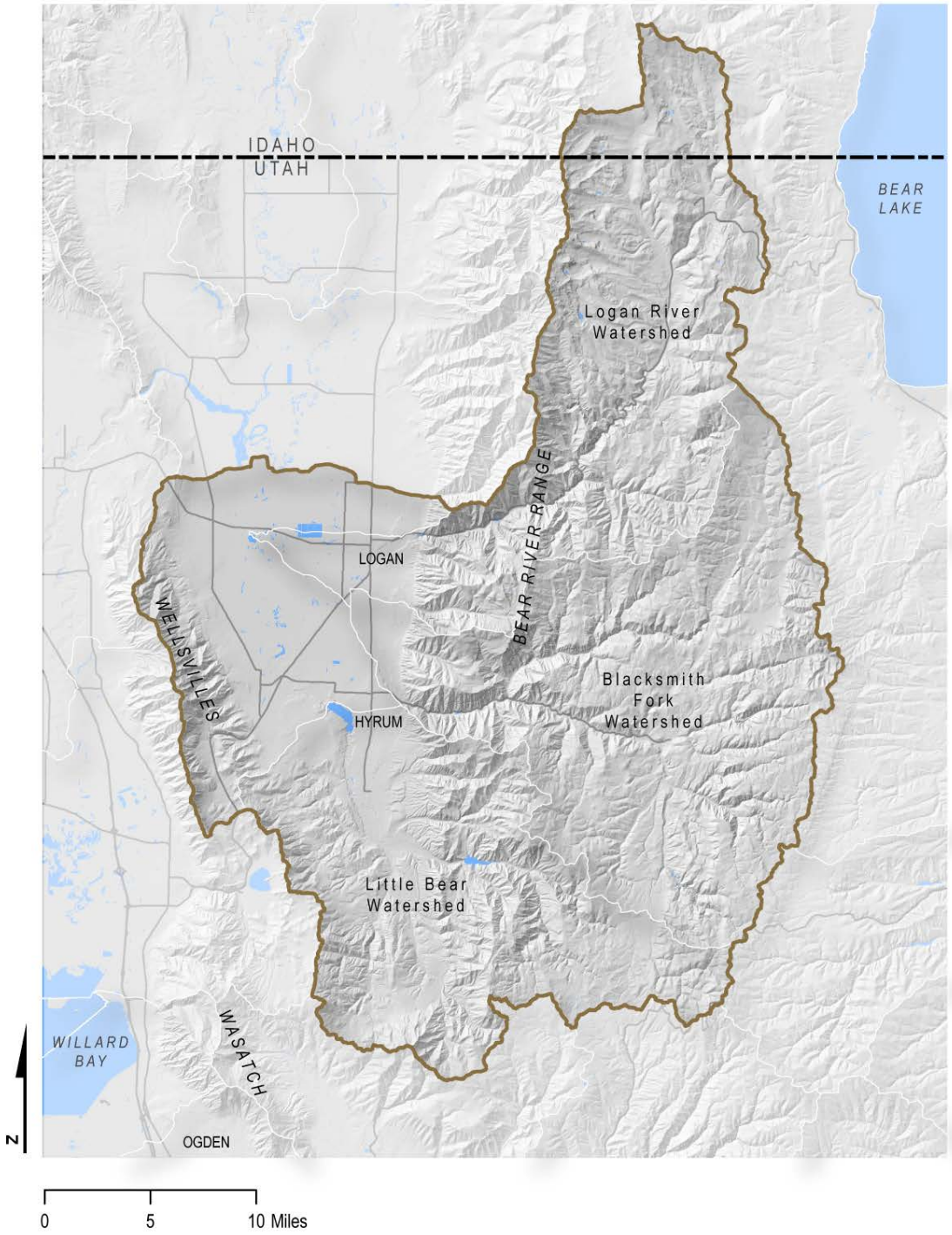
- 0 : None
- 0 - 3 : Rare
- 3 - 7: Occasional
- 8 - 25 : Frequent
- 26 - 65 : Pervasive



- Understand legend for maps you'll be looking at
- We'll zoom in to around here

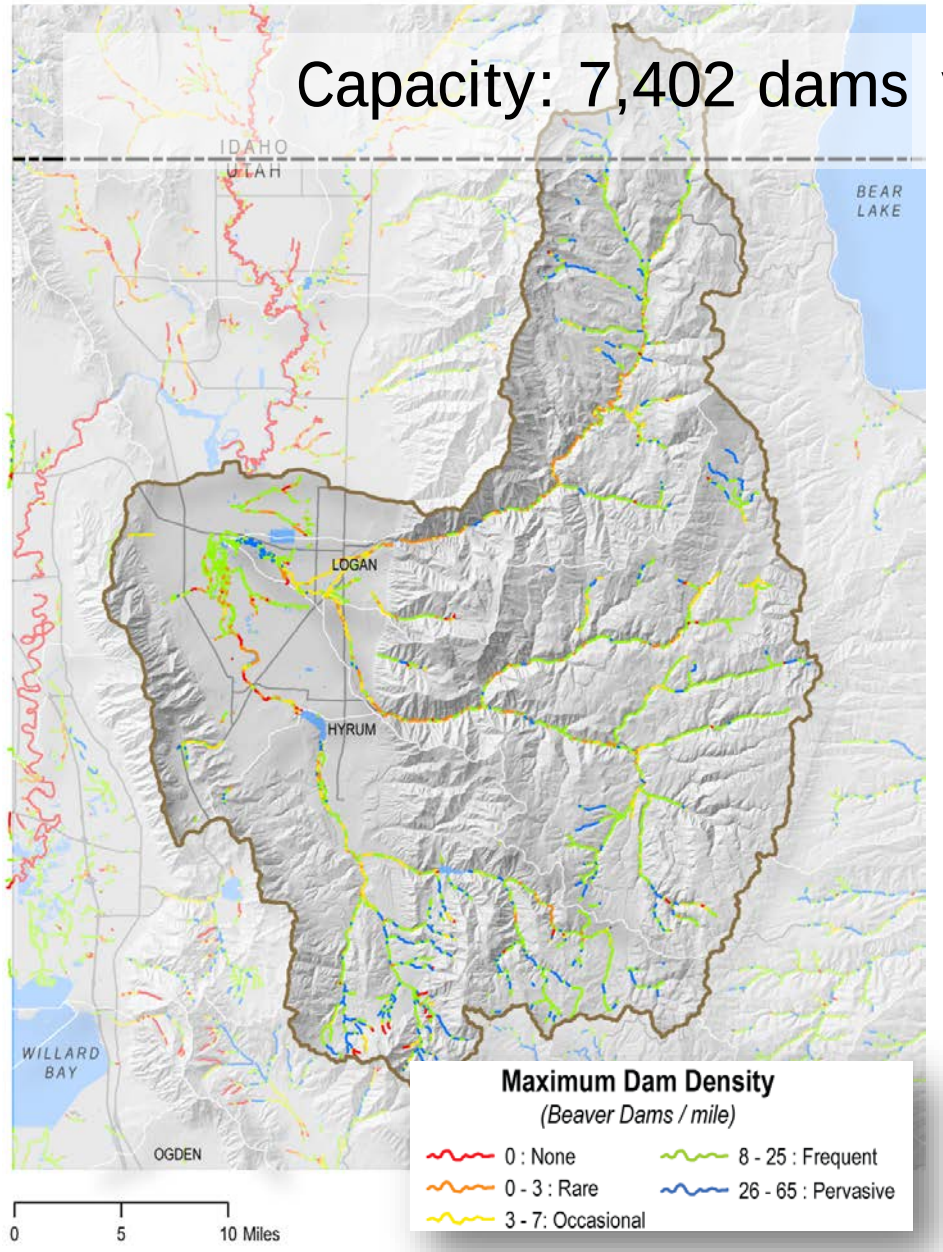
LOGAN RIVER WATERSHED

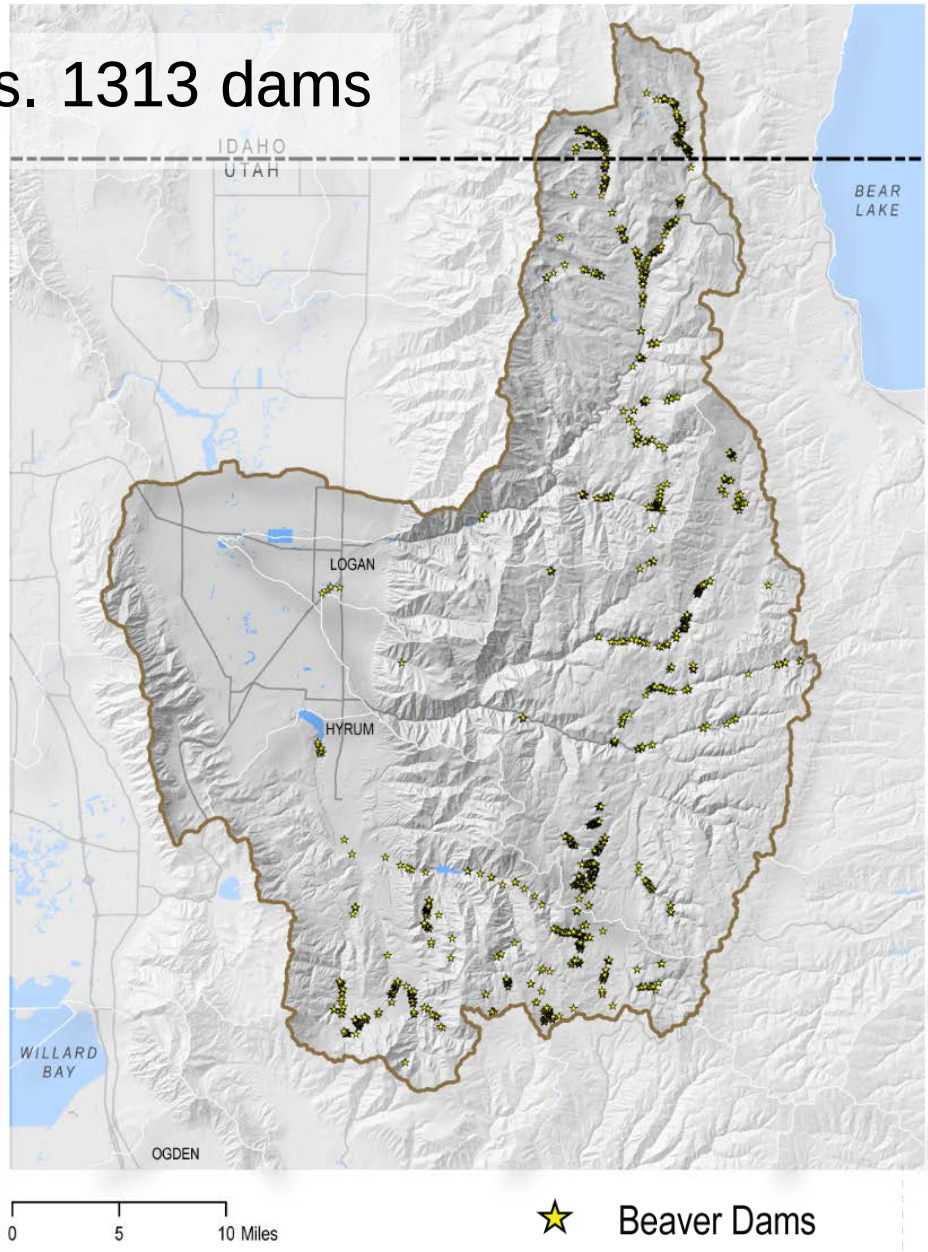
- Includes
  - Logan River
    Blacksmith Fork
  - Little Bear
- 436 miles of streams



BRAT OUTPUT VS. DAM CENSUS

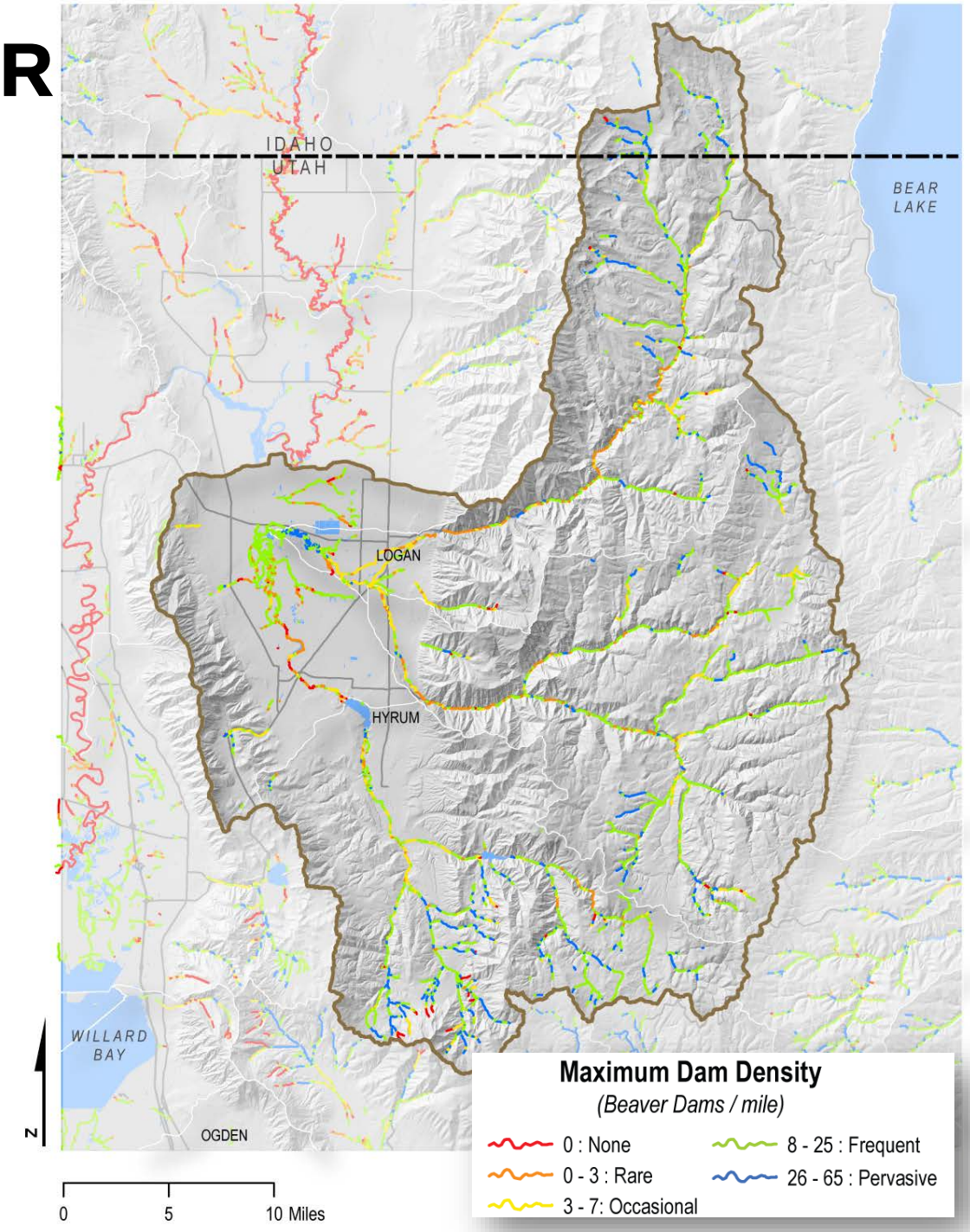
Capacity: 7,402 dams vs. 1313 dams





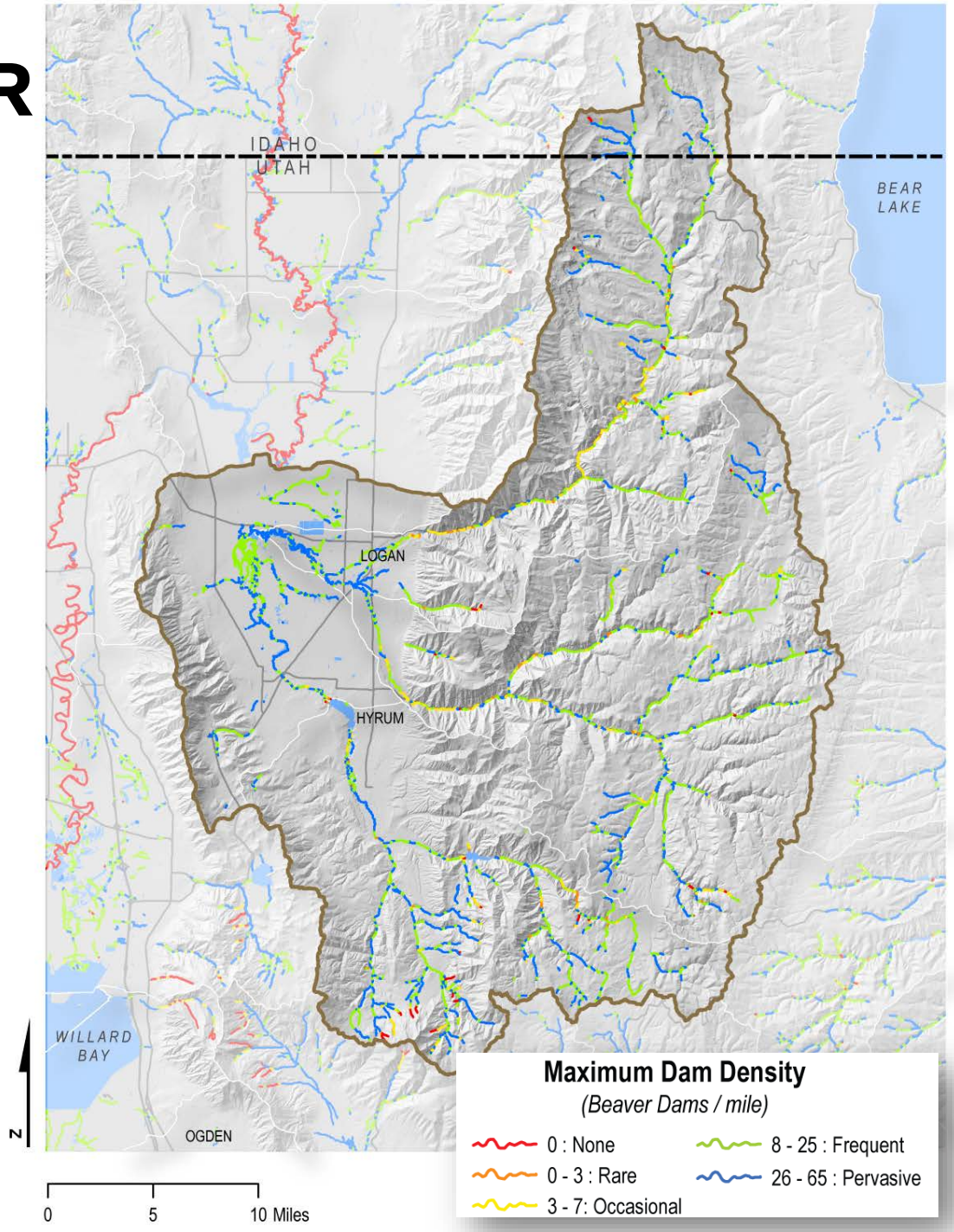
EXISTING BEAVER DAM CAPACITY

- Logan & Blacksmith Fork River
  - Max Capacity: 7402 dams
  - Current capacity of 16 dams/mile
  - Currently 1313 dams
  - Current average of 3 dams/mile
  - Only 18% of Existing Capacity



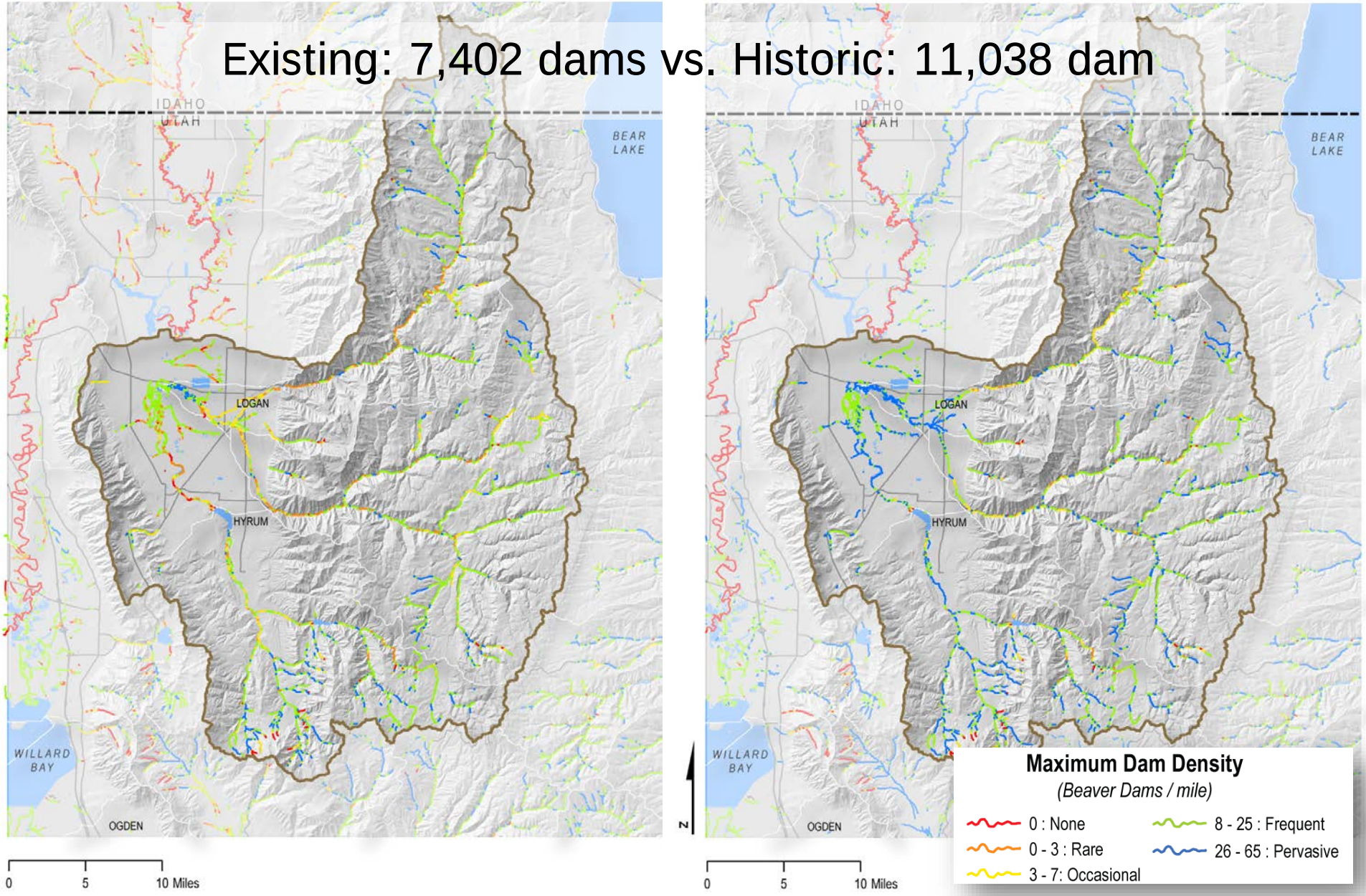
HISTORIC BEAVER DAM CAPACITY

- Logan & Blacksmith Fork River
  - Max Capacity: 11,038 dams
  - Historic capacity of 25 dams/mile
  - Currently, only 12% of Historic Capacity



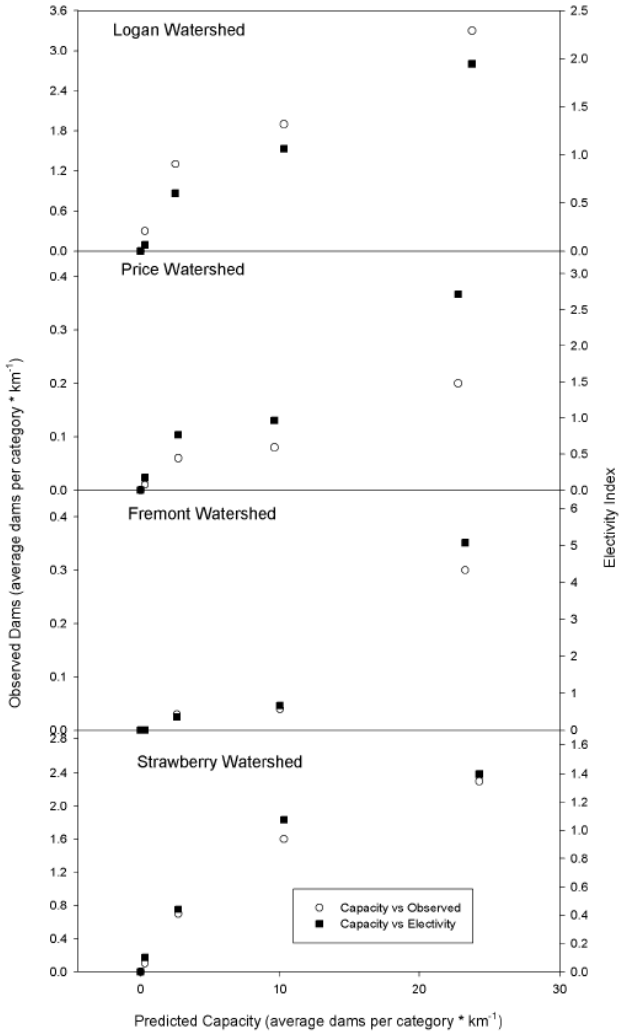
EXISTING VS. HISTORIC CAPACITY

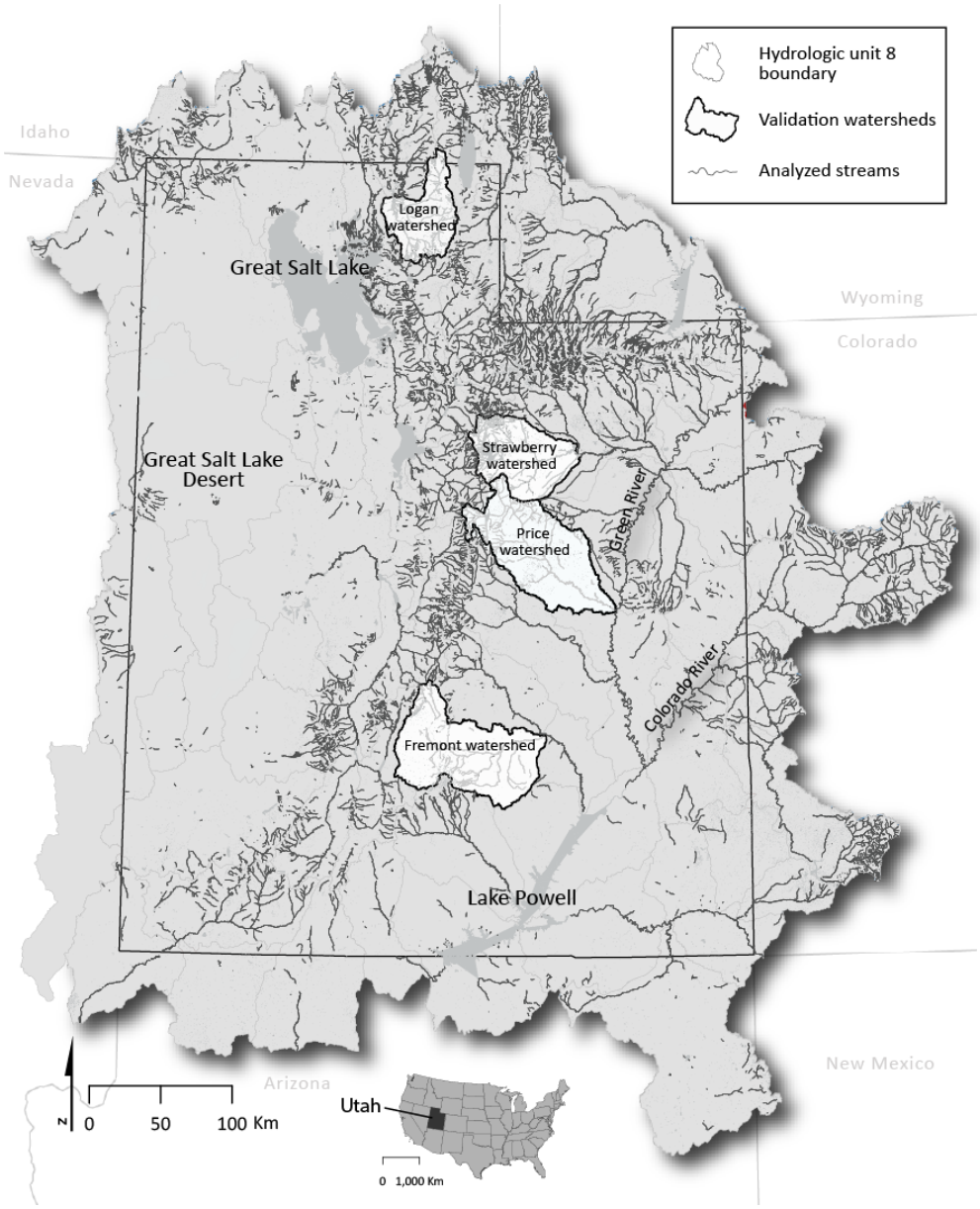
Existing: 7,402 dams vs. Historic: 11,038 dam



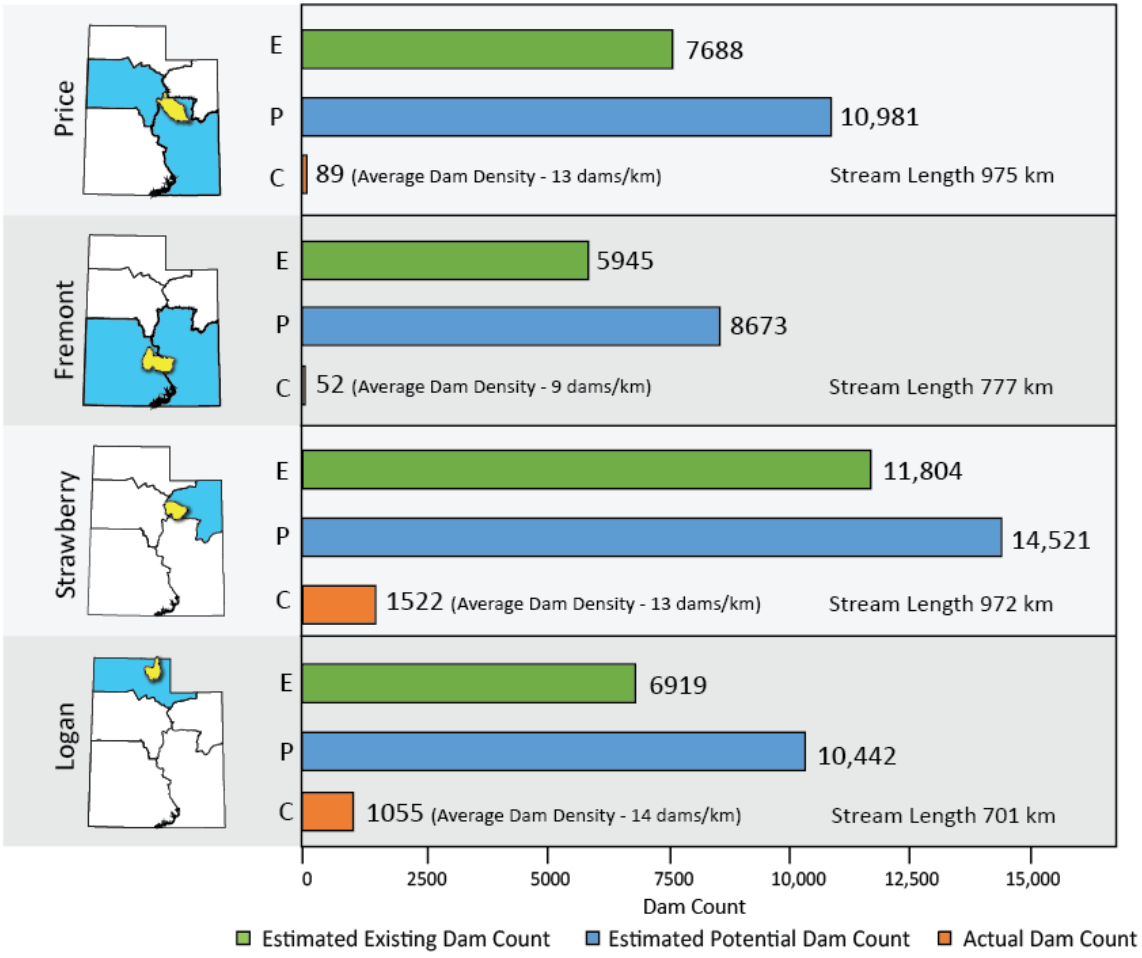
VALIDATION…

- Using 2852 dams in 4 diverse watersheds

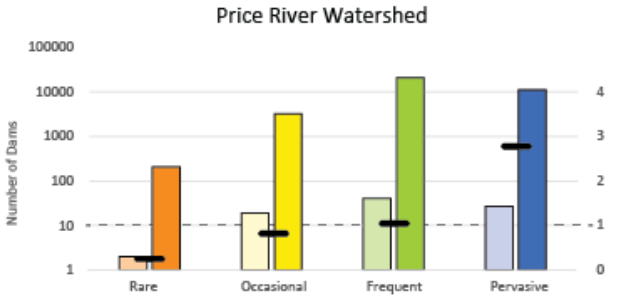


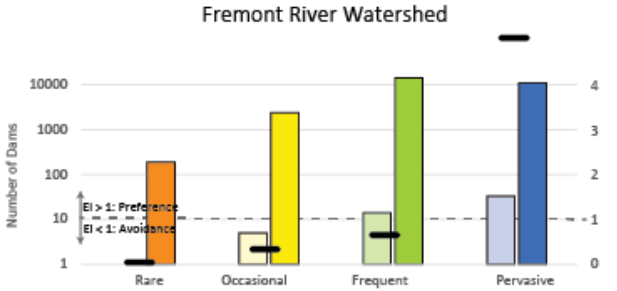


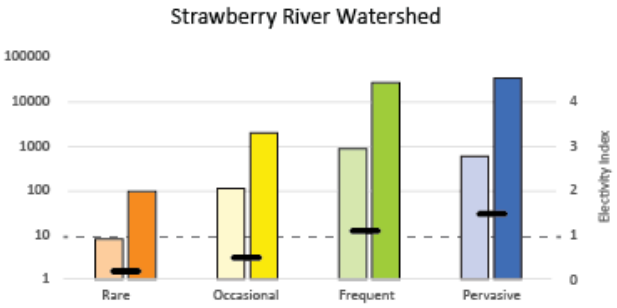
OTHER WATERSHEDS...

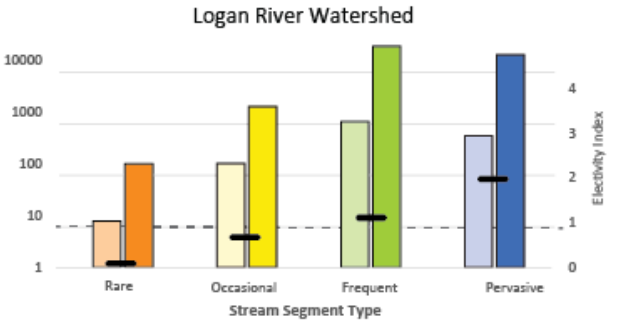


- Electivity Index suggests good agreement....





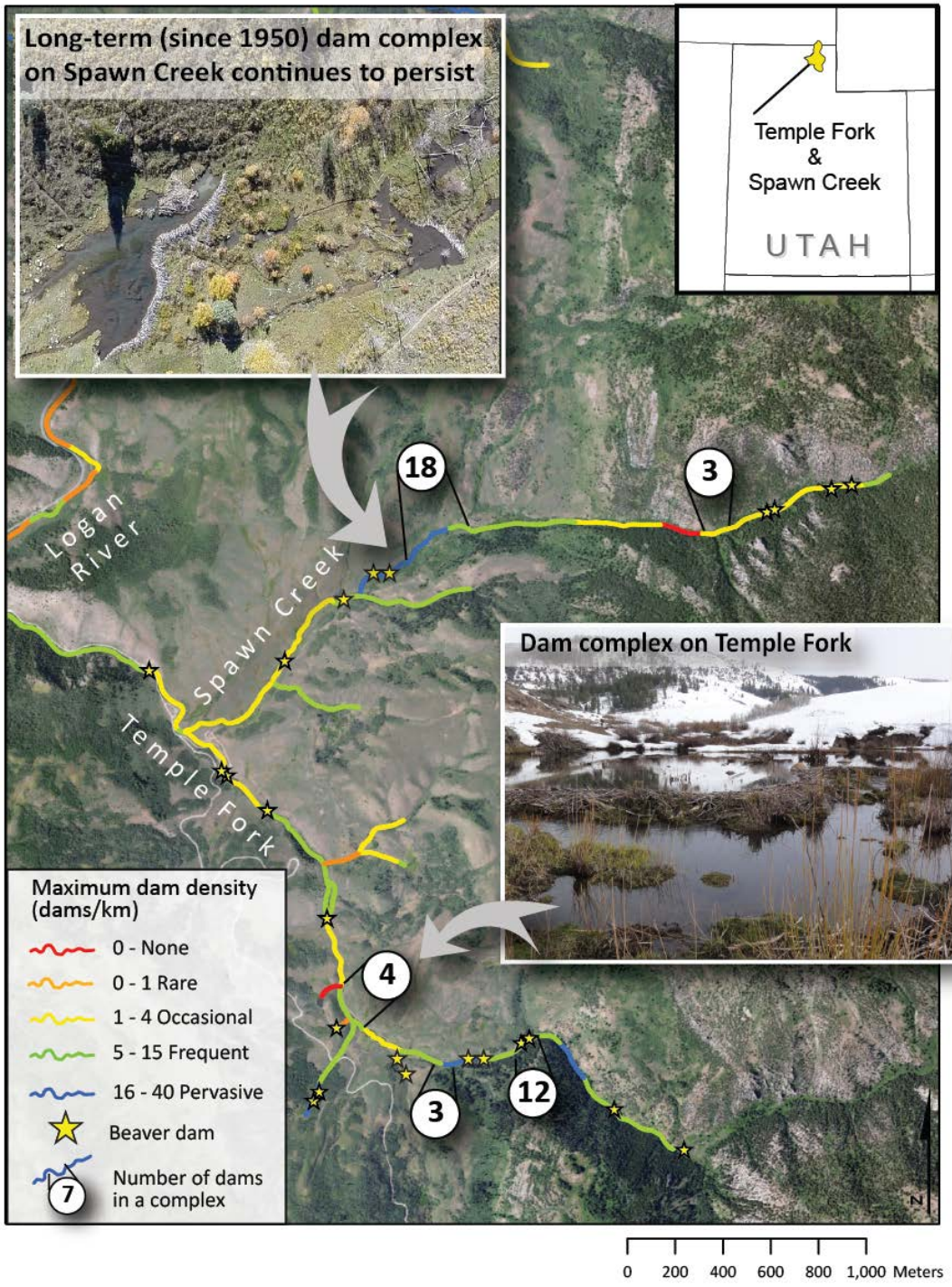




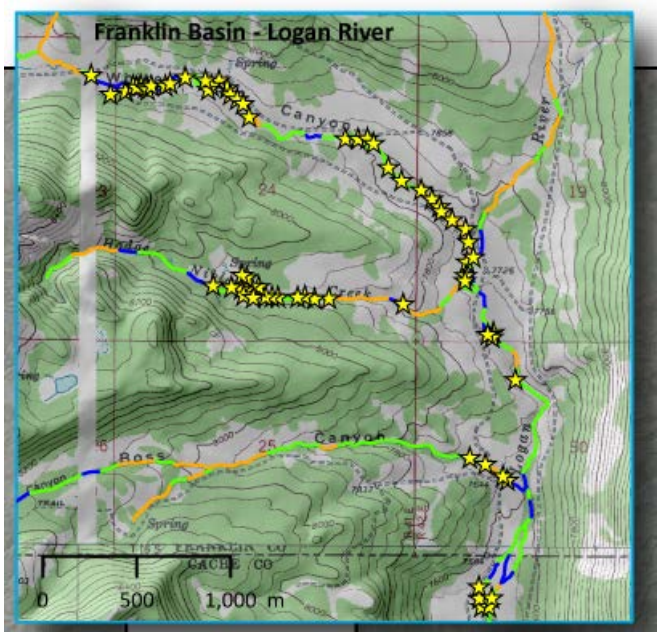
MORE FOCUSED VALIDATION…

What you look for…

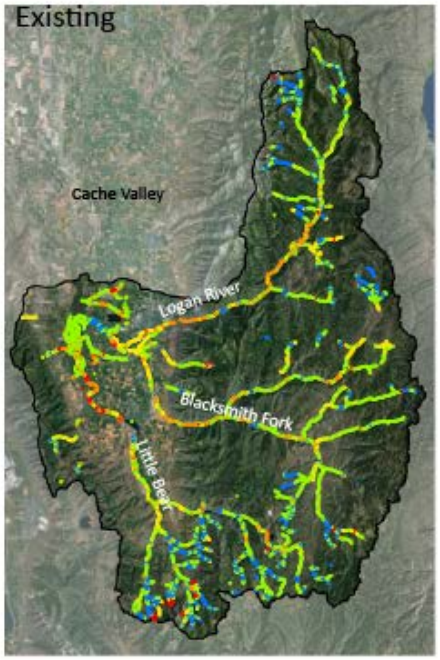
- No beaver dams where None predicted
- Low densities in ‘occasional’ zones
- Stable long-term dam complexes in ‘frequent’ or ‘pervasive’
- High quality (‘frequent’/’pervasive’) areas as likely locations of new colonies

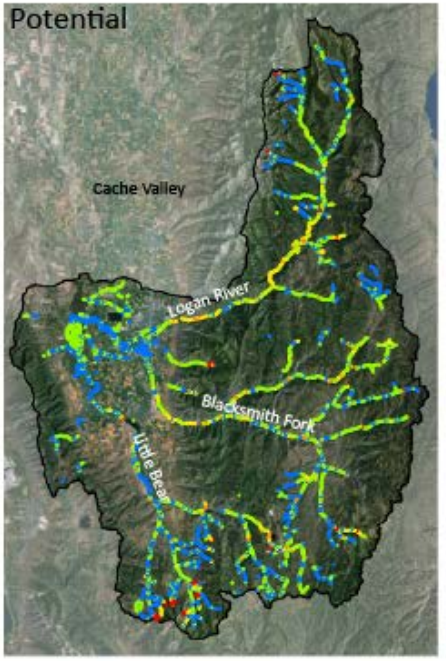


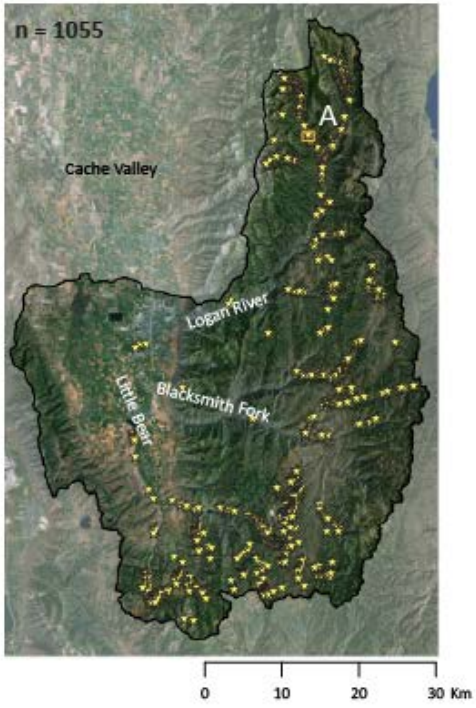
LOGAN-BLACKSMITH VALIDATION

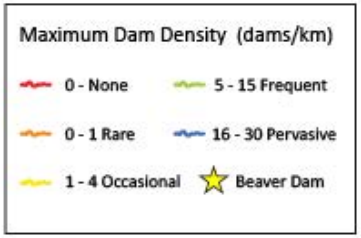


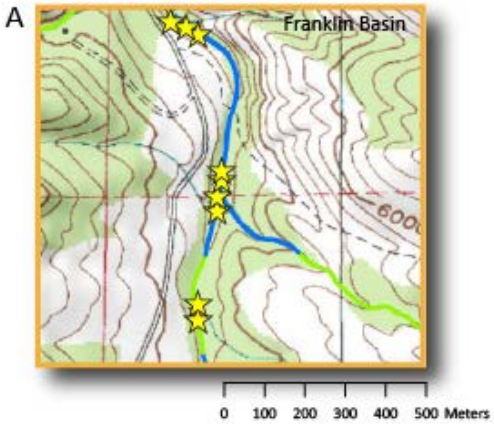
- Identify existing beaver dams (e.g. 1313 in Logan-Blacksmith)
- Compare with capacity estimates





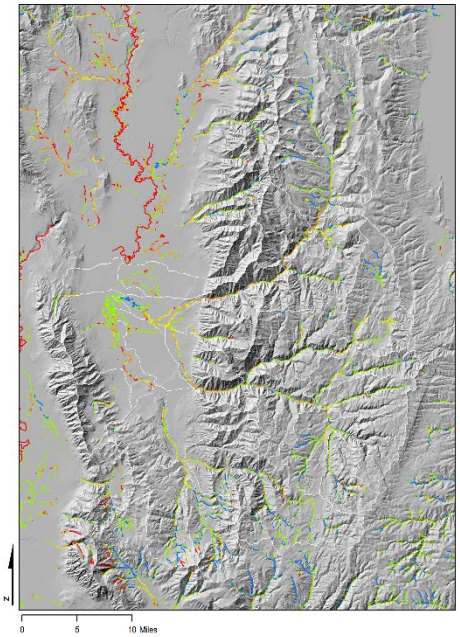






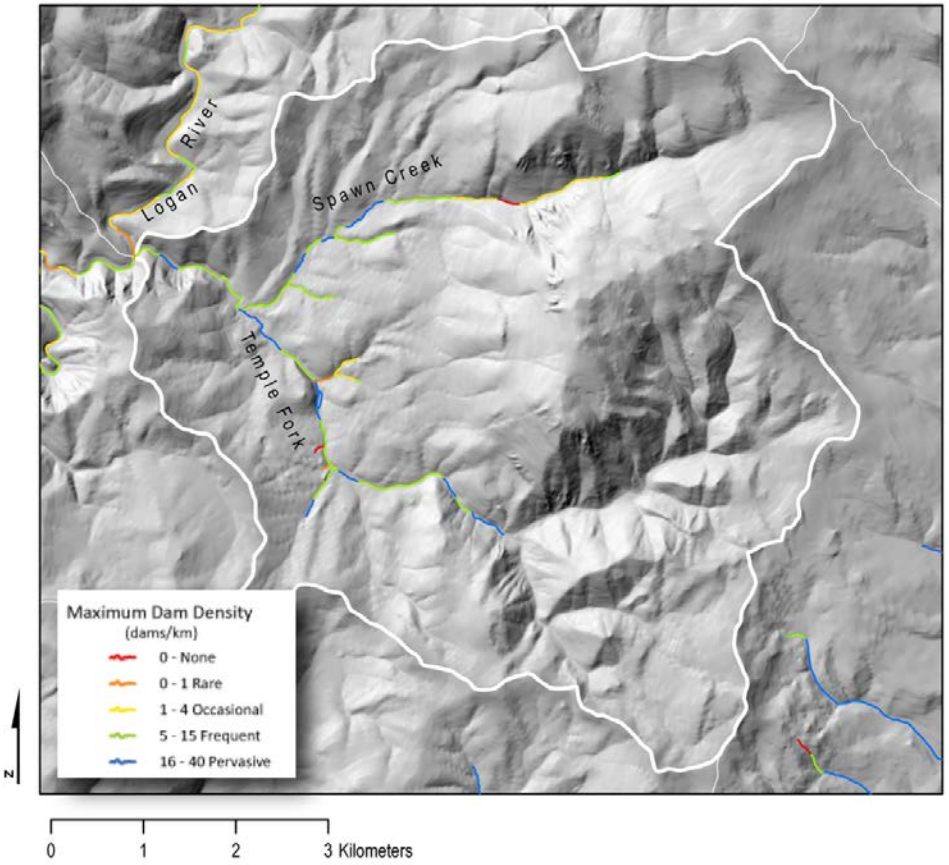
LOOKING CLOSER AT OUTPUT

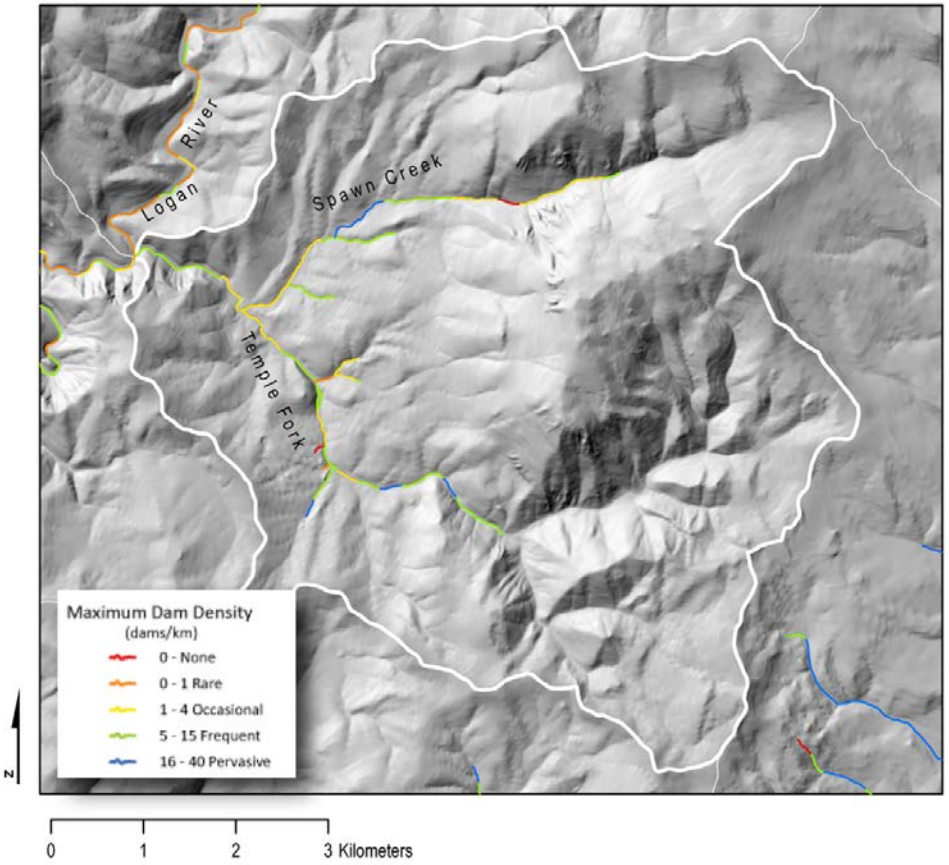
- Logan River
  - Max Capacity: 7402 dams
  - Currently 1313 dams
  - Current average of 1.8 dams/km
  - Current capacity of 10.1 dams/km



	Length of Stream	Existing Capacity (Density)	Historic Capacity (density)	Existing Capacity	Historic Capacity	Existing Count	Existing Dam Density	% of Existing Capacity	% of Historic Capacity
	iGeoLength	*oCC_EX*	*oCC_PT*	*mCC_EX_Ct*	*m_CC_PT_CT*	*e_DamCT*			
	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%
∟ Logan River HUC10	211	10.2	15.4	2,146	3,255	449	2.1	21%	14%
∟ Temple Fork HUC12	14	7.7	11.3	108	158	42	3.0	39%	27%
∟ Beaver Creek HUC12	25	11.2	16.2	281	405	142	5.7	51%	35%
∟ Right Hand Fork HUC12	14	7.7	11.3	108	158	42	3.0	39%	27%
∟ Franklin Basin HUC12	32.7	15.5	17.7	506	578	138	4.2	27%	24%
∟ Red Banks Logan HUC12	43.2	11.3	13.8	488	596	58	1.3	12%	10%
∟ Blacksmith Fork HUC 10	205	9.6	13.8	1,968	2,827	437	2.1	22%	15%
∟ Curtis Creek HUC12	13.5	8.2	13.8	111	186	16	1.2	14%	9%
∟ Rock 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	0.1	1%	0%

HOW ABOUT A LITTLE WATERSHED?

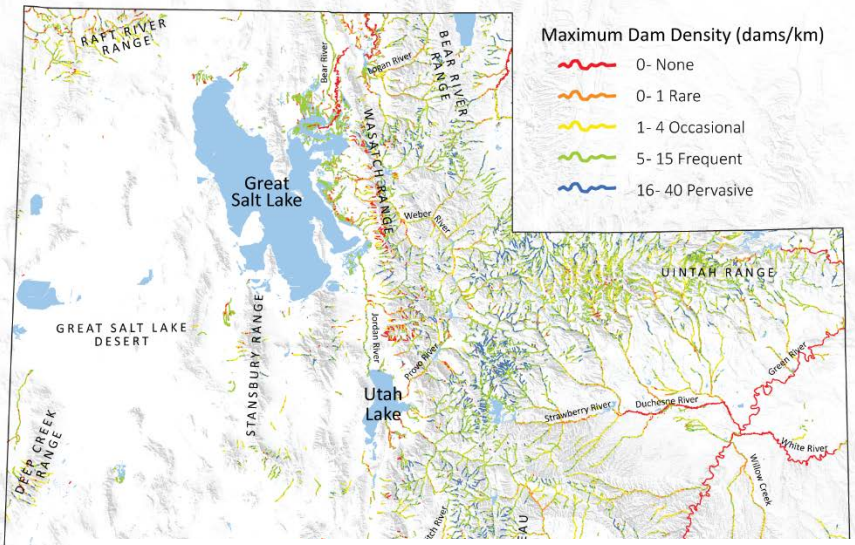




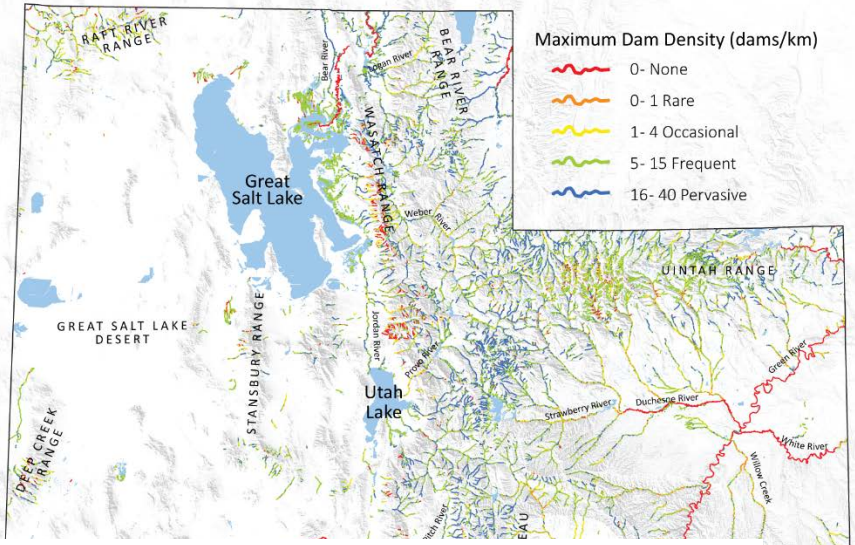
- 186 historic capacity vs. 111 existing capacity
- 11.3 dams/km historic vs. 7.7 dams/km currently

EXISTING VS. HISTORIC CAPACITY - UTAH

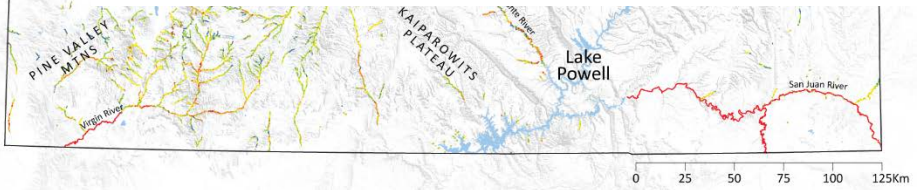
WHAT IT IS...

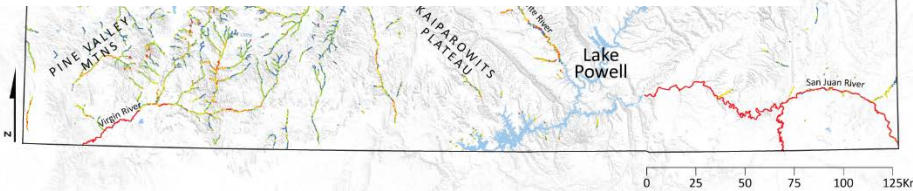


WHAT IT WAS...



Category	Existing Capacity: Stream Length (km)	Existing Capacity: % of Stream Network	Existing Capacity: Estimated Dam Capacity	Historic Capacity: Stream Length (km)	Historic Capacity: % of Stream Network	Historic Capacity: Estimated Dam Capacity	% Capacity of Historic
Pervasive	3,502	13%	81,811	7,830	29%	184,890	44%
Frequent	12,584	46%	129,224	12,377	45%	127,705	101%
Occasional	5,799	21%	15,256	2,939	11%	7,721	198%
Rare	2,323	8%	648	1,158	4%	342	189%
None	3,137	11%	-	3,040	11%	-	0%
Total	**27,345**		**226,939**	**27,344**		**320,658**	**71%**





SOME NUMBER GAMES…

- Don’t believe this… but Estimated Existing:

Category	Stream Length (km)	Estimated Dam Capacity	Extrapolated Dam Counts			Estimated Colonies			Population Estimate		
			Average	High	Low	Average (Assuming 6 dams/ colony)	High (Assuming 4 dams/ colony)	Low (Assuming 10 dams/ colony)	Average (Assuming 4 beaver/ colony)	High (Assuming 6 beaver/ colony)	Low (Assuming 2 beaver/ colony)
Pervasive	3,502	81,811	5,186	11,060	836	864	2,765	83.64	3,457	16,590	167
Frequent	12,584	129,224	11,364	21,895	578	1,894	5,474	58	7,576	32,843	116
Occasional	5,799	15,256	2,608	5,820	144	435	1,455	14	1,739	8,730	29
Rare	2,323	648	157	346	-	26	86	-	105	518	-
None	3,137	-	-	-	-	-	-	-	-	-	-
Total	**27,345**	**226,939**	19,315	**39,120**	**1,558**	3,219	**9,780**	**156**	12,877	**58,680**	**312**
Per Kilometer	NA	**8.3**	**0.7**	**1.4**	**0.1**	**0.1**	**0.4**	**0.0**	**0.5**	**2.1**	**0.0**

- Estimated Historic:

Category	Stream Length (km)	Estimated Dam Capacity	Extrapolated Dam Estimate			Estimated Colonies			Population Estimate		
			Average	High	Low	Average (Assuming 6 dams/ colony)	High (Assuming 4 dams/ colony)	Low (Assuming 10 dams/ colony)	Average (Assuming 4 beaver/ colony)	High (Assuming 6 beaver/ colony)	Low (Assuming 2 beaver/ colony)
Pervasive	7,830	184,890	73,956	92,445	29,582	12,326	23,111	2,958.24	49,304	138,668	5,916
Frequent	12,377	127,705	51,082	63,853	20,433	8,514	15,963	2,043	34,055	95,779	4,087
Occasional	2,939	7,721	3,088	3,861	1,235	515	965	124	2,059	5,791	247
Rare	1,158	342	137	171	55	23	43	5	91	257	11
None	3,040	-	-	-	-	-	-	-	-	-	-
Total	**27,344**	**320,658**	128,263	**160,329**	**51,305**	21,377	**40,082**	**5,131**	85,509	**240,494**	**10,261**
Per Kilometer	NA	**11.7**	**4.7**	**5.9**	**1.9**	**0.8**	**1.5**	**0.2**	**3.1**	**8.8**	**0.4**

http://brat.joewheaton.org

BEAVER RESTORATION ASSESSMENT TOOL

UtahStateUniversity
ECOGEOMORPHOLOGY & TOPOGRAPHIC ANALYSIS LABORATORY

BRAT

Beaver Links > Beaver News & Annoucements >

UTAH-Wide BRAT Project Completed!

posted Oct 12, 2014, 11:06 AM by Joe Wheaton **[updated 19 hours ago]**

Utah State University researchers Wally MacFarlane, Martha Jensen and Joe Wheaton recently completed the extension of the BRAT (Beaver Restoration Assessment Tool) Across the entire state of Utah. The model is truly ready to be run now for all western states. The decision support system and capacity model have been dramatically improved and expanded and the methods are well documented. The research was prepared for the Utah Division of Wildlife Resources and is intended to help them implement the Utah Beaver Management Plan. The work is summarized in:

- Wheaton JM and Macfarlane WW. 2014. The Utah Beaver Restoration Assessment Tool: A Decision Support & Planning Tool – Manager Brief, Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Utah Division of Wildlife Resources, Logan, UT, 16 pp.

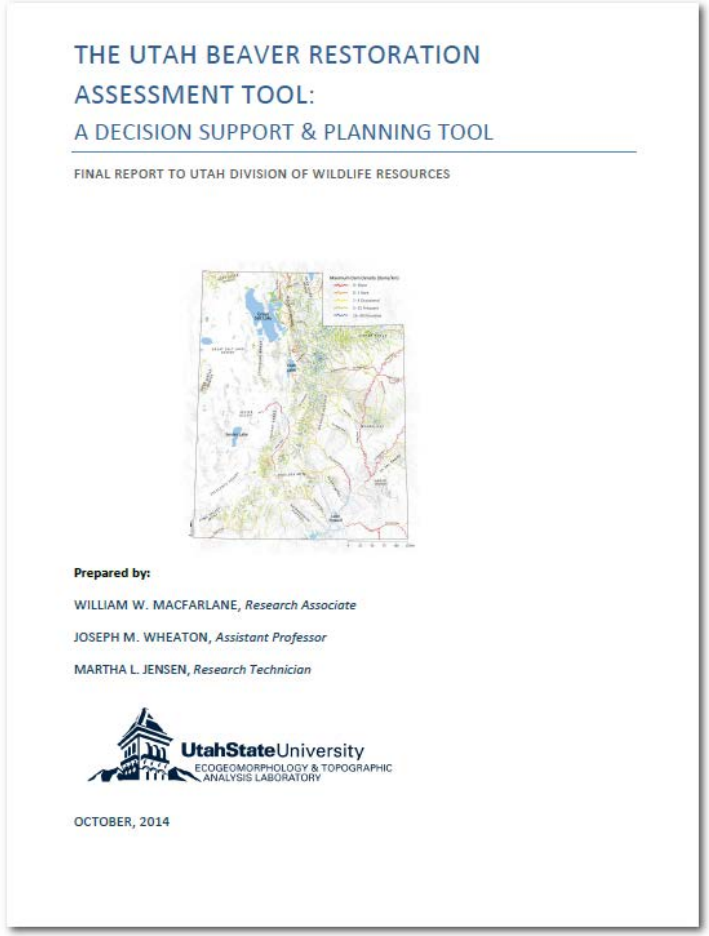
and fully reported in:

- Macfarlane W.W., Wheaton J.M., and Jensen, M.L. 2014. The Beaver Restoration Assessment Tool: A Decision Support & Planning Tool for Utah. Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Utah Division of Wildlife Resources, Logan, Utah, 142 pp.

All the data is available here and will soon be available on the Utah Automated Geographic Reference Center.

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

FINAL REPORT TO UTAH DIVISION OF WILDLIFE RESOURCES


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*

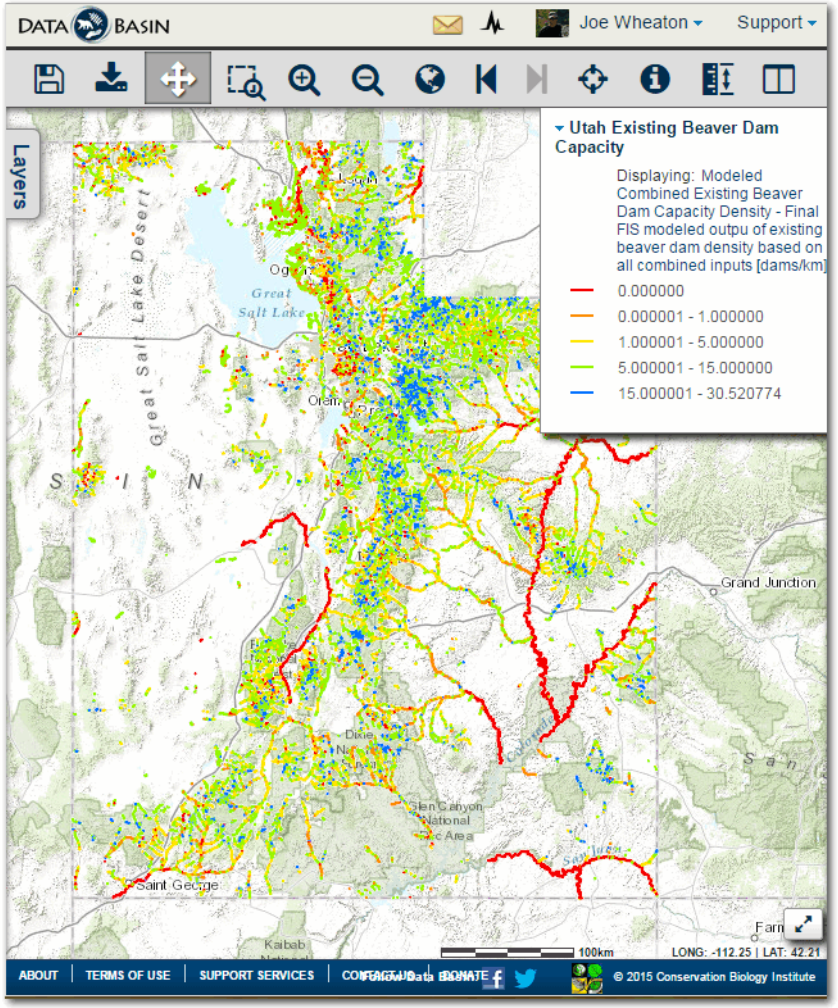
UtahStateUniversity
ECOGEOMORPHOLOGY & TOPOGRAPHIC ANALYSIS LABORATORY

OCTOBER, 2014

UtahStateUniversity
RESTORATION CONSORTIUM

FUTURE & DOWNLOADS...

- We're running for as many regions as we can...
- So far, some in Idaho, Wyoming, Colorado, Utah, Nevada, Oregon, New York, New Mexico
- Discussions/proposals for Washington, Oregon, Montana, New England



BEAVER RESTORATION ASSESSMENT TOOL
UtahStateUniversity
ECOGEOMORPHOLOGY & TOPOGRAPHIC ANALYSIS LABORATORY
BRAT

For more information on BRAT, visit:
http://brat.joewheaton.org

TAKE AWAYS…

- The heart of BRAT is a capacity model that predicts the upper limit of dam density (dams/km) the landscape can support
- The model can use nationally available datasets, but can be implemented logically in the field or at the desktop with higher-resolution inputs
- The outputs help build realistic expectations about what beaver may achieve locally, but also helps scale up those expectations regionally
- Its just a model… don’t let it be a substitute for thinking

TODAY'S PLAN

I. Wrap up Ecological Feedbacks

II. Review Homework – Dam Mapping

III. Intro to Beaver Dam Capacity Modelling

IV. Lab – How to run BRAT capacity model

Bridge Creek © Wheaton

From: http://www.howstuffworks.com/beaver-dam.htm

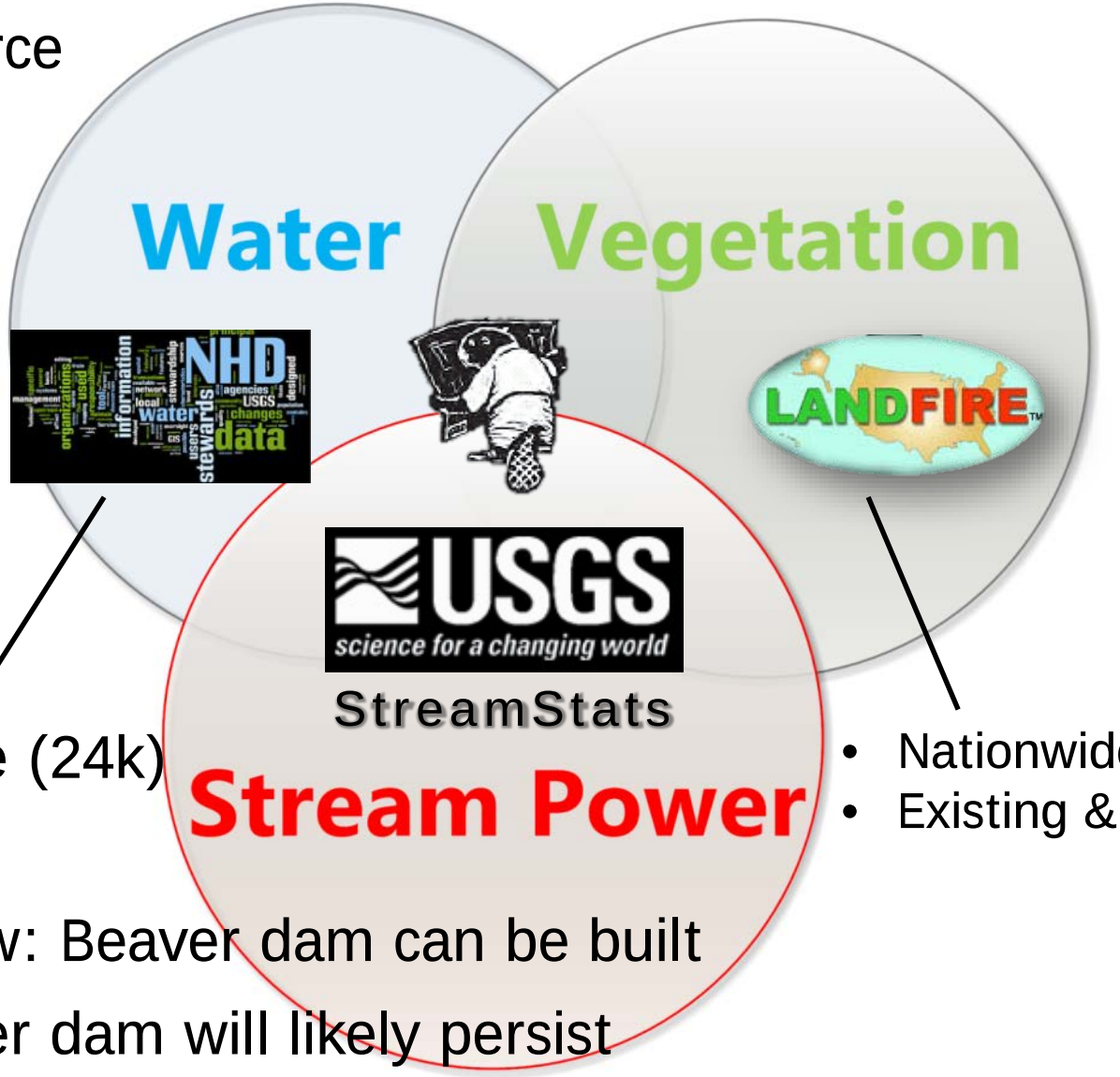
YOUR OPTIONS

- If you want to learn the most about BRAT, and GIS, do full lab using BRAT capacity model toolbar v 2.0
  - http://brat.joewheaton.org/home/documentation/manual-implementation/the-beaver-restoration-assessment-tool-brat---v-2-0
  - If you prefer Matlab, you can use v 1.0 see: http://brat.joewheaton.org/home/documentation/manual-implementation/beaver-dam-capacity-model
- If you don't have GIS experience, but want to learn, refer to http://gis.joewheaton.org
- If you don't have GIS experience, and don't have time to learn:
  - Look over someone's shoulder tonight (and just follow conceptually)
  - Apply BRAT workflow and inference systems manually on a reach by reach basis in a small watershed (i.e. < 10 km of stream)

MODEL INPUTS & DATA SOURCES

Evidence of Perennial Water Source

Evidence of Wood for Building Material



- Nationwide (24k)

- Nationwide (30-m)
- Existing & potential

- Base Flow: Beaver dam can be built
- Q2: Beaver dam will likely persist

DATA PREPARATION PLAN

I. **Get Context**

II. Get Drainage Network ready (NHD)

III. Get DEMs ready (NED)

IV. Get Vegetation ready (LANDFIRE)

WHATEVER YOU NEED…

DATA PREPARATION PLAN

I. Get Context

II. Get Drainage Network ready (NHD)

III. Get DEMs ready (NED)

IV. Get Vegetation ready (LANDFIRE)

DRAINAGE NETWORK… WHAT DO I REALLY NEED?

1. A drainage network layer (in NHD, this is the NHDFlowline layer) - This is the layer which we will segment, and run our model on.
2. A watershed boundary (in NHD this will be a WBD or watershed boundary dataset) - This is the layer you will use to choose your watershed(s) of interest and clip your drainage network and other inputs to.
3. A waterbodies layer that includes ponds, reservoirs and lakes (in NHD this will be NHDWaterbody)

BRAT Resources

- BRAT
- Vision
- Documentation
  - Manual Implementation of Capacity Models
- Escalante Pilot Project
- Beaver Restoration Information
- © 2013 Copyright & Disclaimers

Other Links

joewheaton.org
Ecogeomorphology & Topographic Analysis Lab

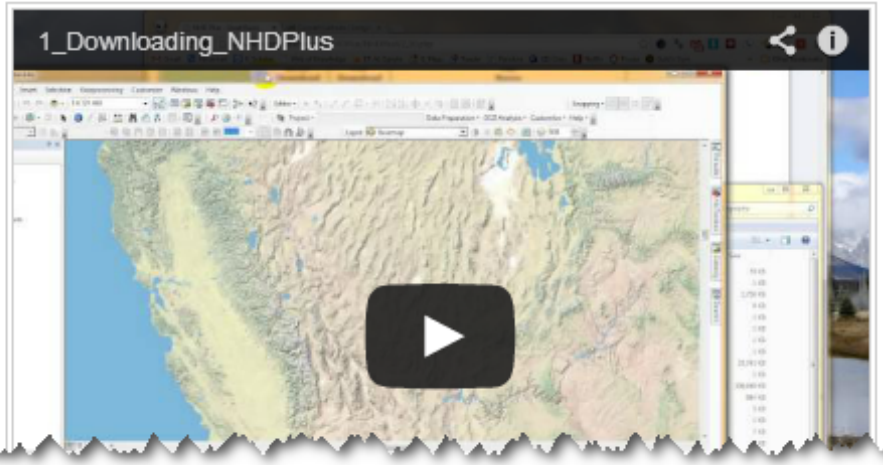
1. Getting NHD Data

NHD stands for National Hydrography Dataset and is the surface water component of the United States Geologial Survey's National Map. The NHD datasets include a wide variety of layers and there are multiple versions and multiple download sources. In the context of BRAT, there are three primary layers we are after:

1. A drainage network layer (in NHD, this is the NHDFlowline layer) - This is the layer which we will segment, and run our model on.
2. A watershed boundary (in NHD this will be a WBD or watershed boundary dataset) - This is the layer you will use to choose your watershed(s) of interest and clip your drainage network and other inputs to.
3. A waterbodies layer that includes ponds, reservoirs and lakes (in NHD this will be NHDWaterbody)

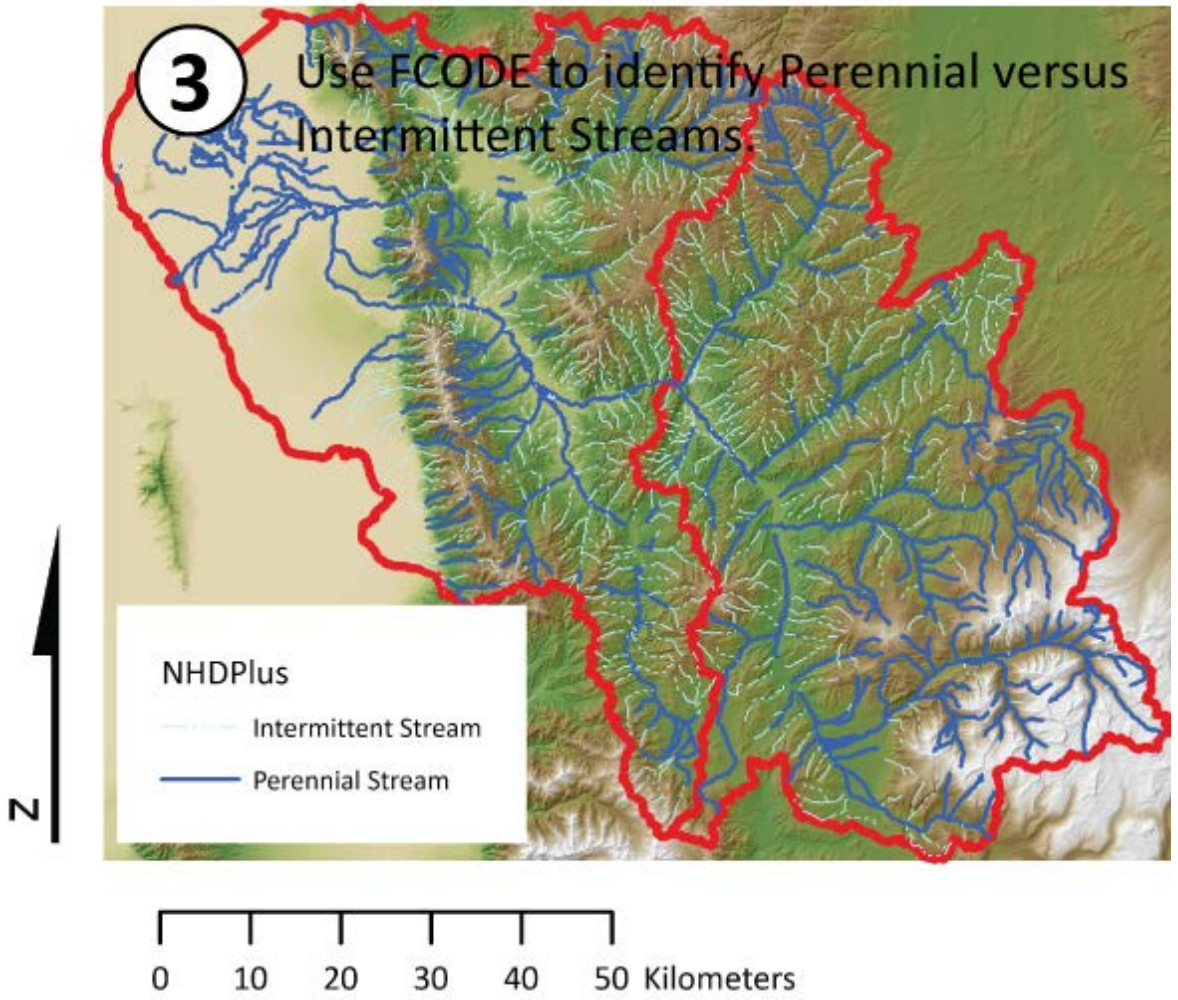
You don't have to use NHD or any specific version of NHD to run BRAT. As long as you can get a drainage network layer (whether you download it or derive it yourself), you can run BRAT. However, for most applications we reccomend using NHDPlus Version 2.1 , which (as of 2013) is the most current version of the NHD. You can download the original NHD data files here from the USGS among many other sites. However, we have found it easiest and fasted to download NHDPlus version 2.1 from here.

The video below walks you through the download.



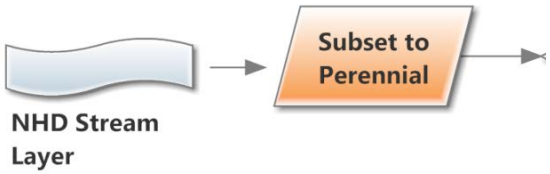
PERENNIAL VS. INTERMITTENT

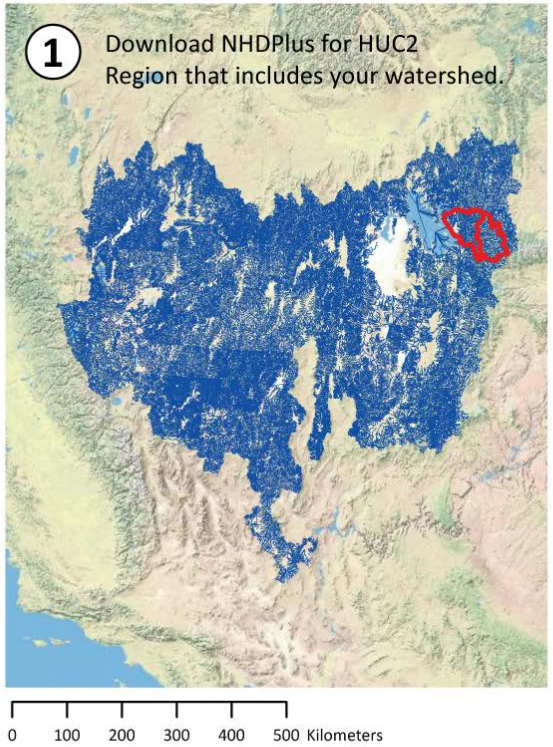
- 4861 km of NHD ‘streams’
  - 1900 km Perennial Streams (39%)
  - 2227 km Intermittent (46%)
  - Rest are canals and pipelines (5%)

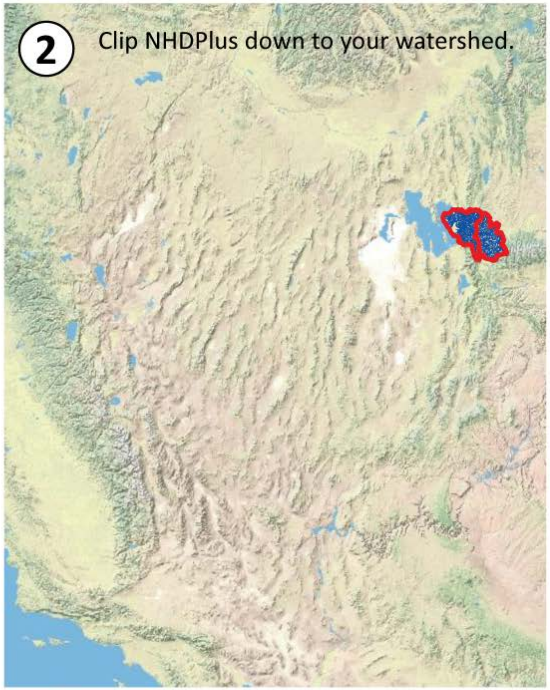


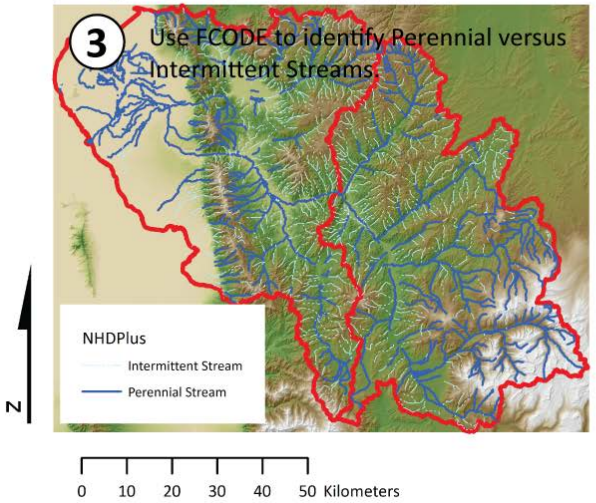
ONCE WE HAVE IT…

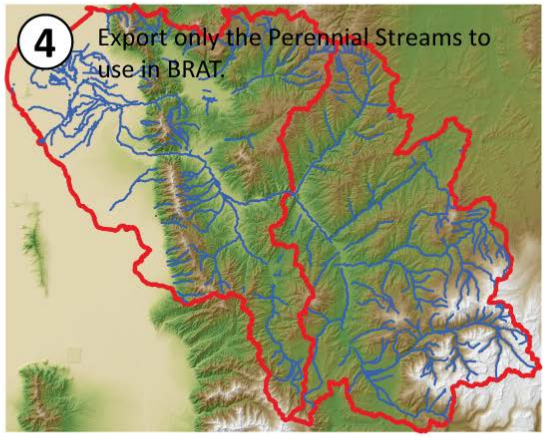
- Clip it down to watershed
- Extract out only Perennial Streams











DATA PREPARATION PLAN

I. Get Context

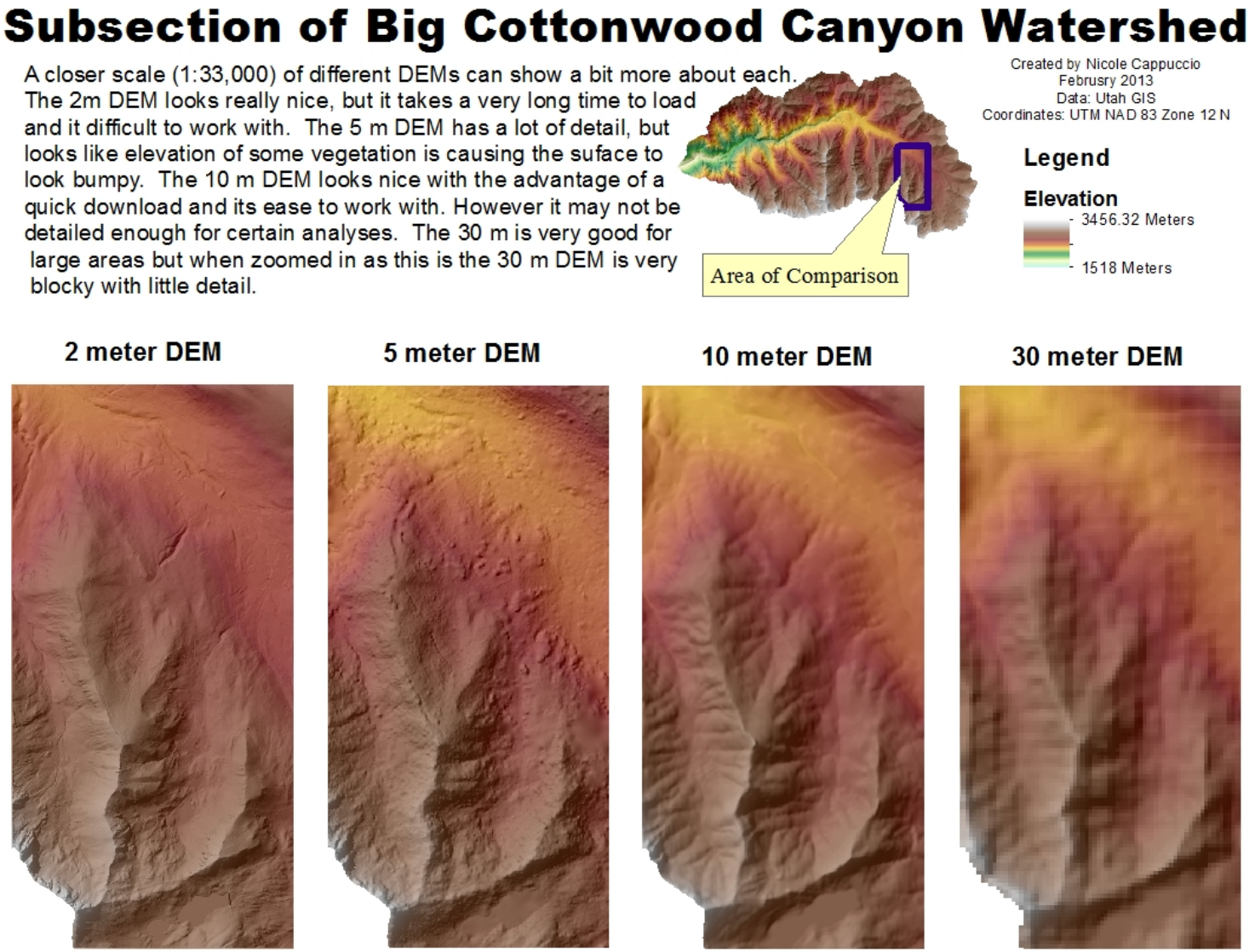
II. Get Drainage Network ready (NHD)

III. Get DEMs ready (NED)

IV. Get Vegetation ready (LANDFIRE)

DEM… WHAT DO I REALLY NEED?

- Is higher resolution always better?



BRAT Resources

- BRAT
- Vision
- Documentation
  - Manual Implementation of Capacity Models
- Escalante Pilot Project
- Beaver Restoration Information
- © 2013 Copyright & Disclaimers

Other Links

joewheaton.org
Ecogeomorphology & Topographic Analysis Lab

BRAT > Workshops > April 2013 - Logan >

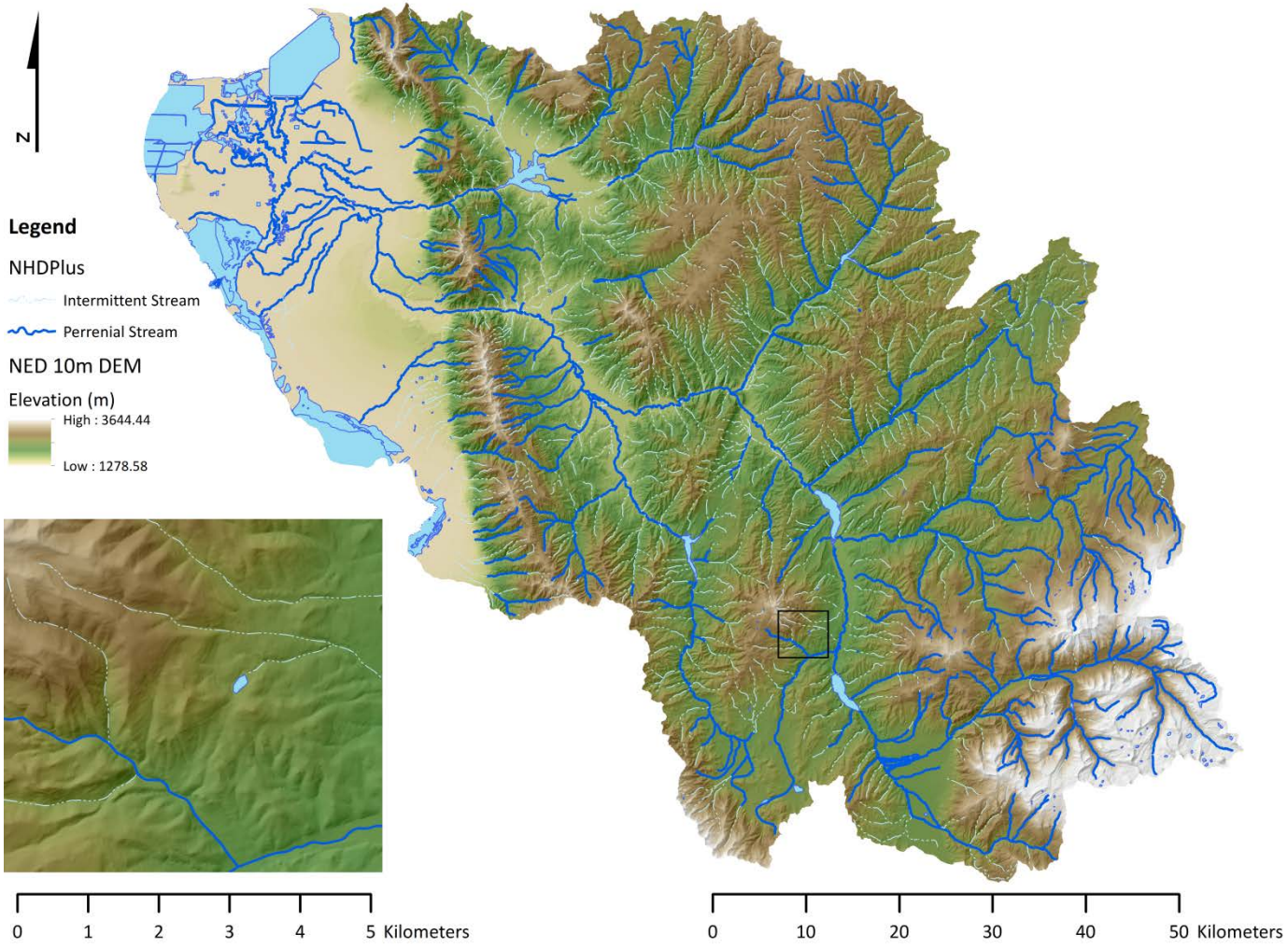
2. Getting DEM Data

A digital elevation model (DEM) is needed in BRAT to help us estimate stream power and a hillshade derived from the DEM will give us cartographic context. In principle, you could use any DEM that covers your entire watershed of interest. In practice, a 10 m DEM will be more then adequate for estimating reach slopes and for estimating contributing drainage area for each reach. The USGS's National Elevation Dataset is broadly available and will work for our purposes. Of the many places you can download a DEM for your study site from, we find the USDA's Geospatial Data Gateway the simplest, quickest and most reliable.

The video below walks you through the download, mosaicing the tiles together and deriving a hillshade.

NED FOR WEBER

- 10 m resolution from USGS National Elevation Dataset



DATA PREPARATION PLAN

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VEGETATION… WHAT DO I REALLY NEED?

- Something that is good enough to differentiate the presence of appropriate building materials from an abundant supply of such building materials.

BRAT Resources
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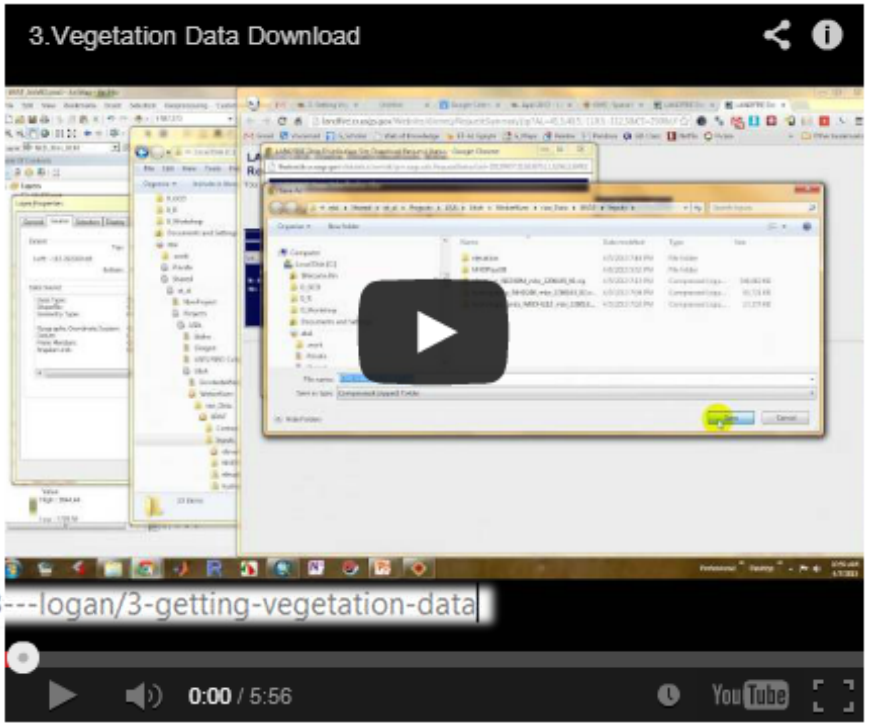
- Ecogeomorphology & Topographic Analysis Lab

BRAT > Workshops > April 2013 - Logan >

3. Getting Vegetation Data

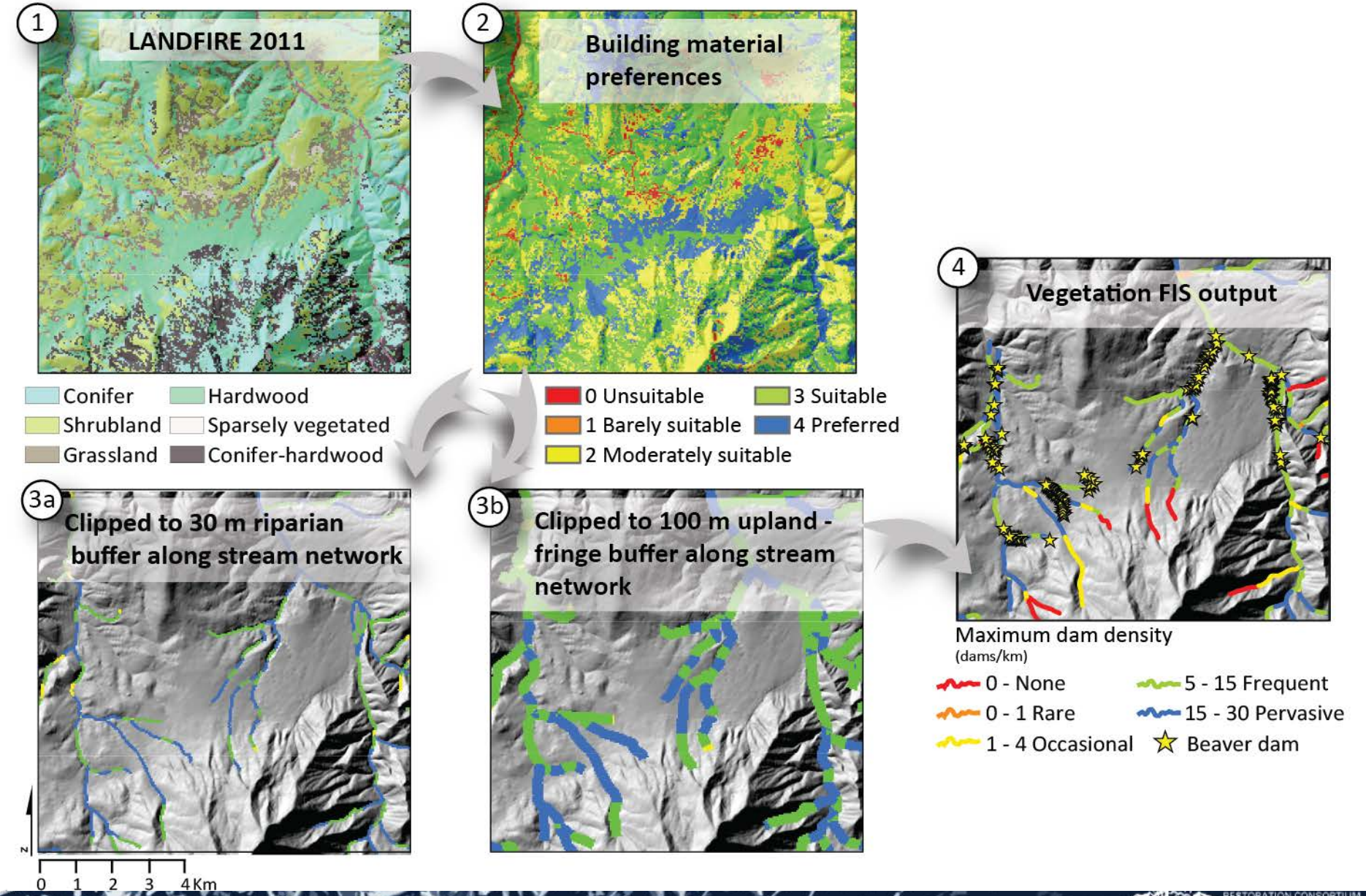
There are many ways you could acquire vegetation data to feed BRAT. You could use USGS's GAP dataset or in some states they have higher resolution vegetation layers, or you could classify your own imagery at higher resolution. For BRAT, we primarily use LANDFIRE's vegetation layers as our intputs. These datasets were derived from LANDSAT 30 m resolution imagery and their 'EVT' - existing vegetation type - layer does a surprisingly good job of characterizing the availability of suitable dam building materials for beaver even in small streams.

The video below walks you through the download.



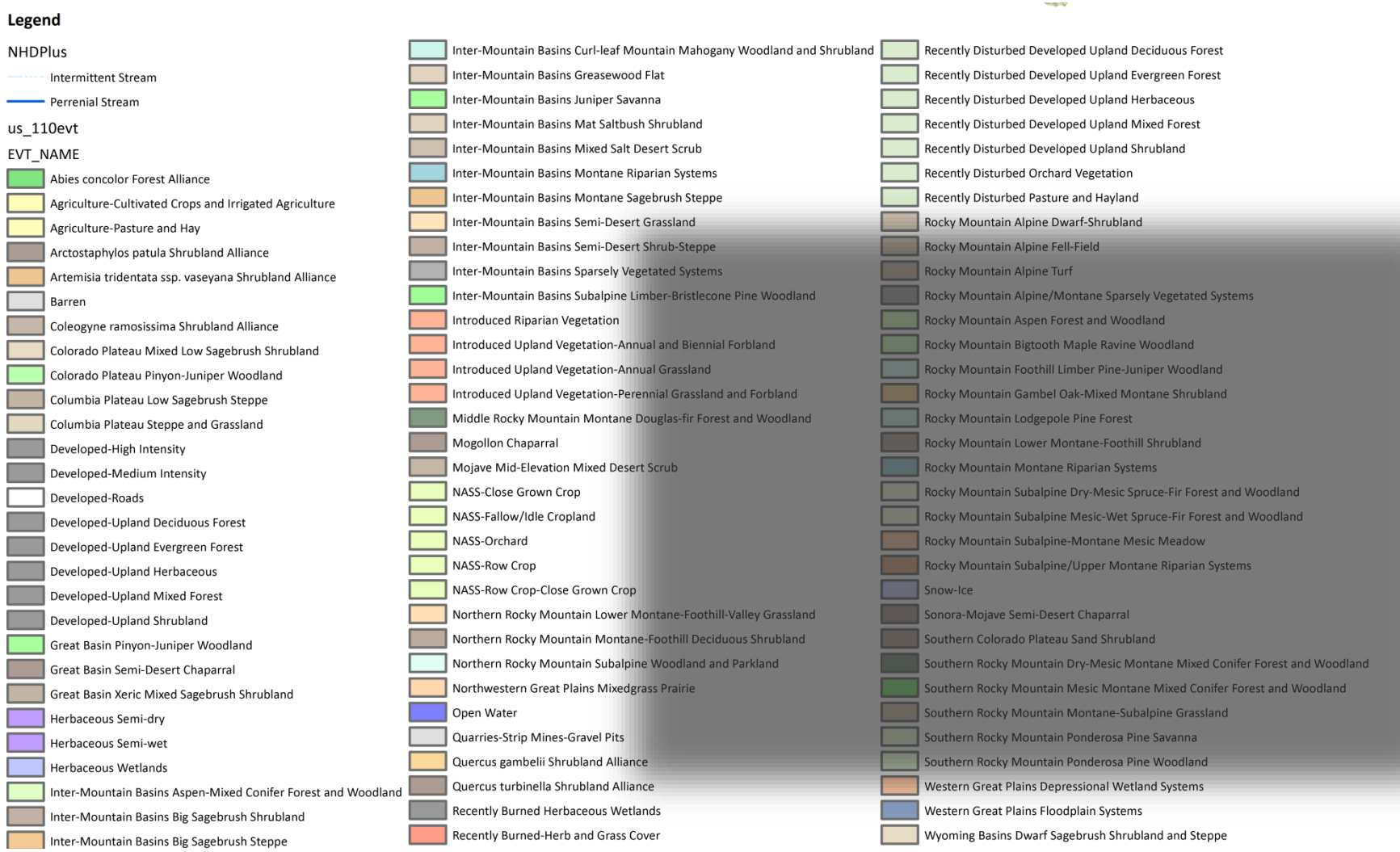
brat.joewheaton.org/home/workshops/april-2013---logan/3-getting-vegetation-data

WORK FLOW DIAGRAM: VEGETATION CLASSIFICATION



LANDFIRE FOR WEBER WATERSHED

LANDFIRE FOR WEBER WATERSHED



DATA PREPARATION PLAN

I. Get Context
II. Get Drainage Network ready (NHD)
III. Get DEMs ready (NED)
IV. Get Vegetation ready (LANDFIRE)

BACK TO THAT DRAINAGE NETWORK....

BRAT > Documentation > Manual Implementation of Capacity Models > Beaver Dam Capacity Model >

2. Perennial Water Sources

The NHD data processing consists of thee straightforward GIS processing tasks:

Contents

1 Task 1: Subset the NHD stream layer (NHD_All_Streams) to perennial (NHD_Perennial_Streams)
2 Task 2: Divide the NHD perennial streams by 250 m lengths
3 Task 3: Buffer NHD perennial streams

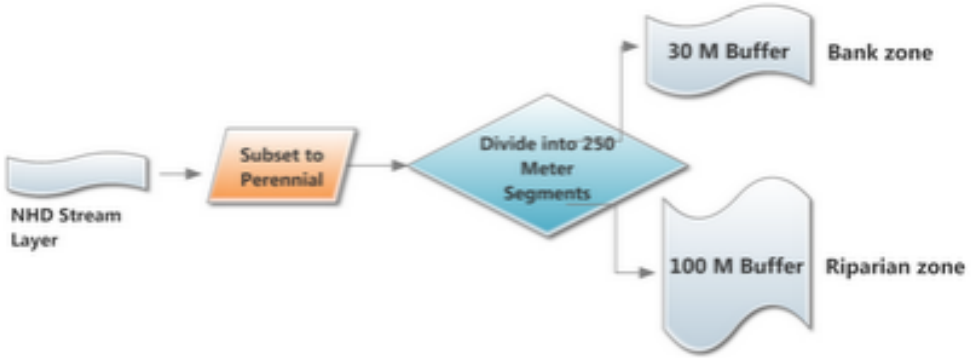
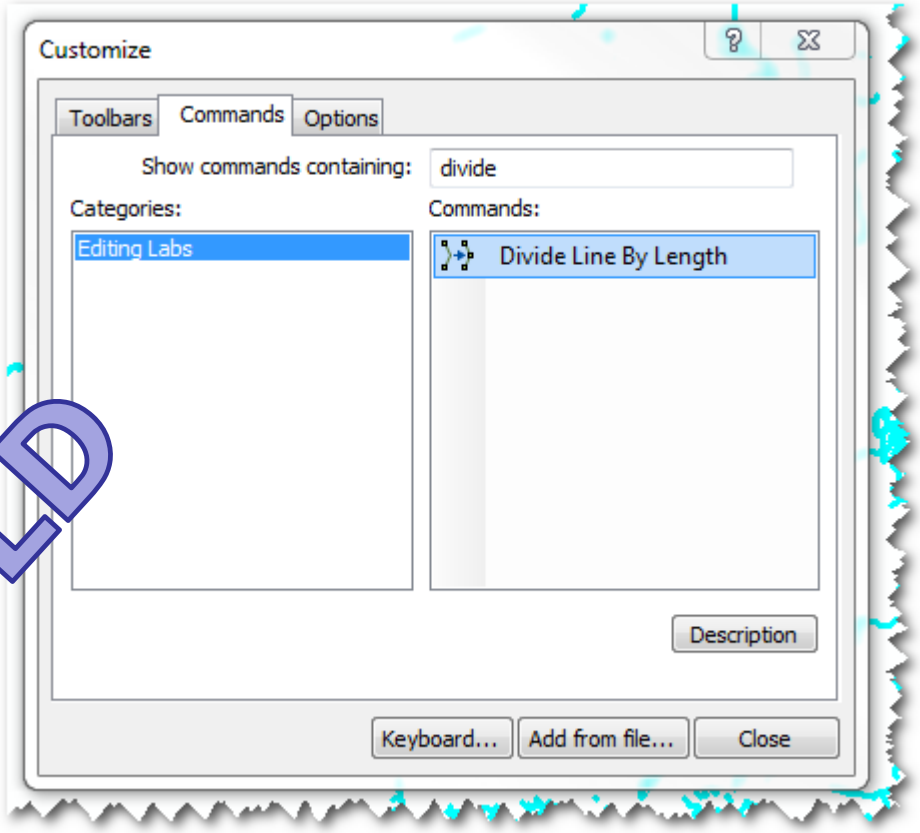


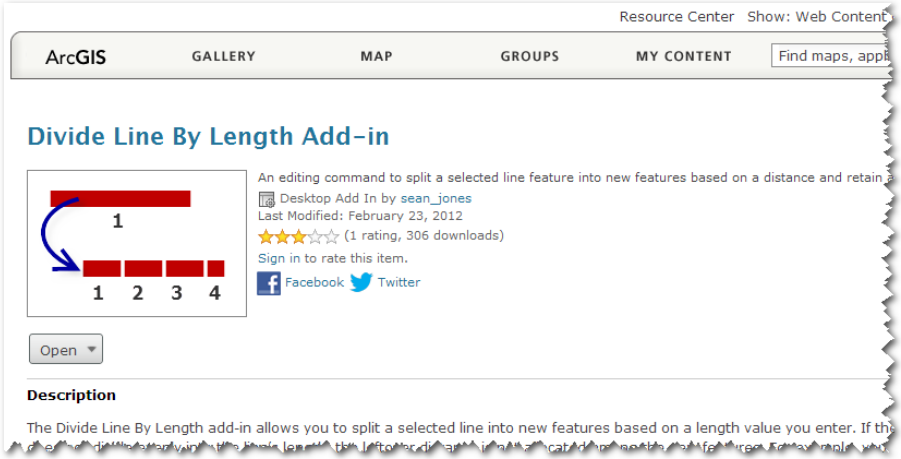
Figure 1 - Diagram showing NHD stream GIS processing tasks.

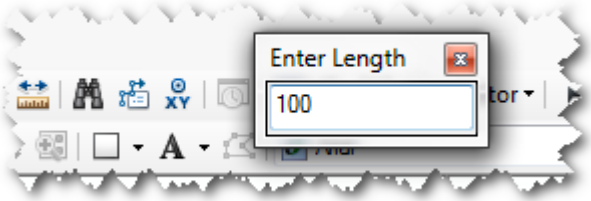
brat.joewheaton.org/home/documentation/manual-implementation/beaver-dam-capacity-model

BREAK UP INTO ANALYSIS SEGMENTS…

- Use 250 m long segments…
  - Good for averaging vegetation over…
  - Reasonable for reach averaged slope
- Lots of way to do this…
  - Divide Line by Length Add-In a simple way

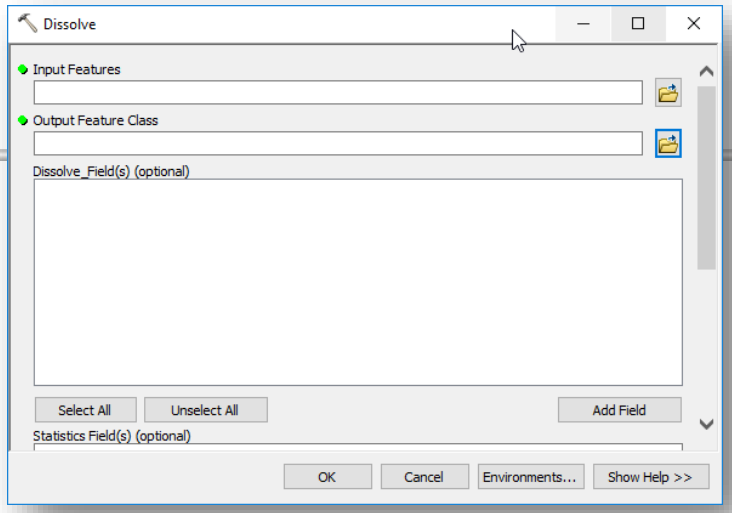


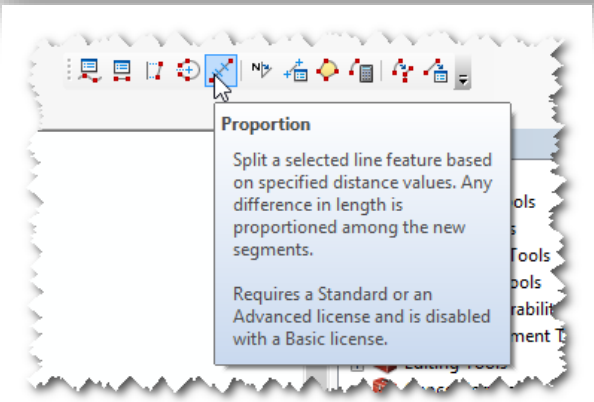


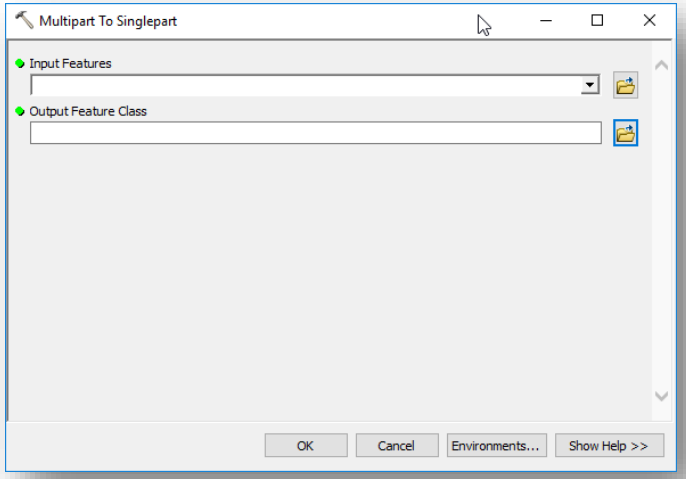


ALTERNATIVELY

1. Dissolve network
2. Start edit session
3. Use COGO to segment into 250 m segments
4. Stop & Save Edits
5. Run Multipart to Singleplart





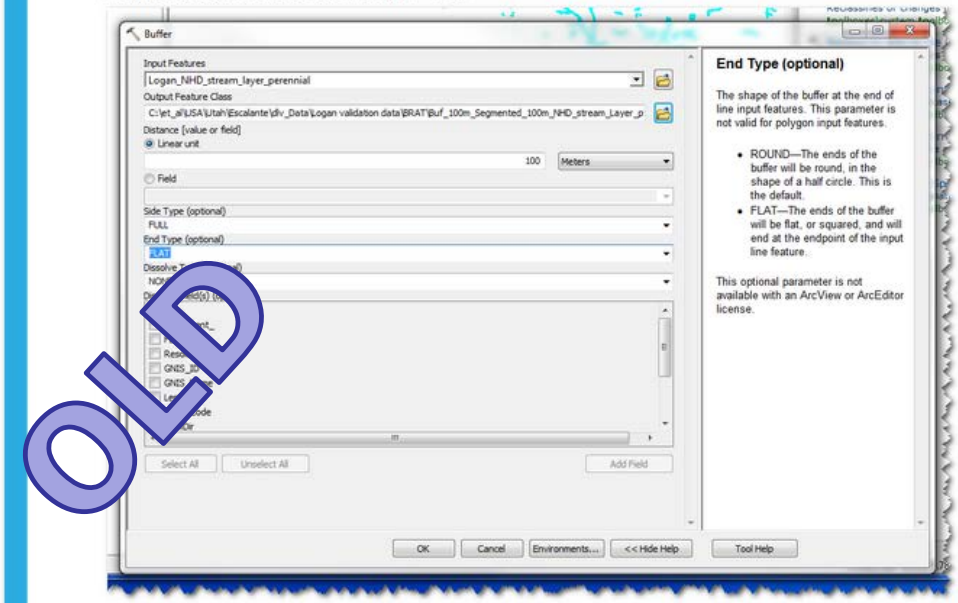


CREATE BUFFERS FROM SEGMENTS

- Bank Zone (30 m)
- Riparian & Adjacent Zone (100 m)

Task 3: Buffer NHD perennial streams

- Step 1: Create a 100 meter (riparian and upland fringe) buffer using the "Buffer" command under the Geoprocessing Tab. Note: Use End Type "FLAT"

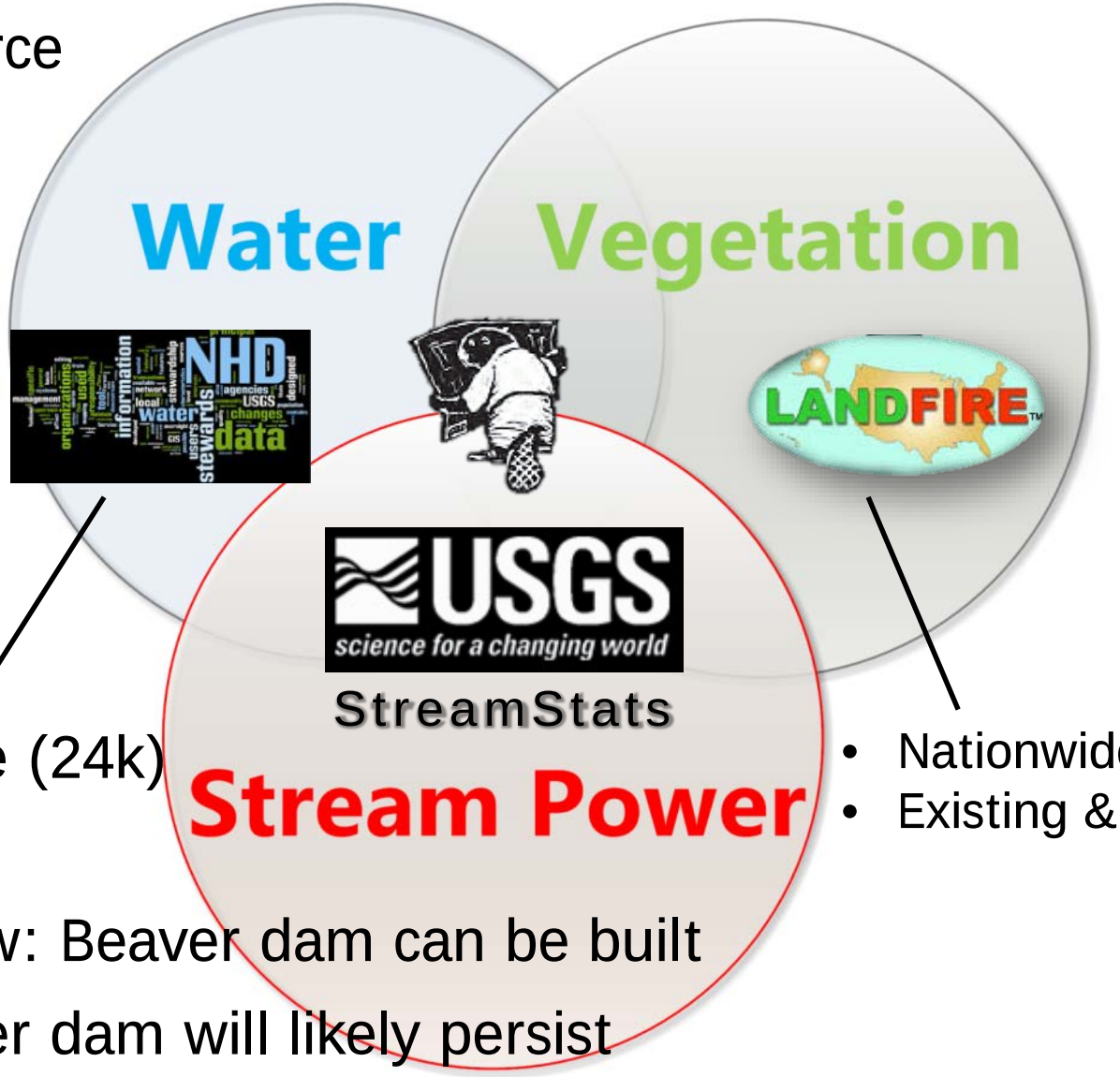


- Step 2: Repeat the above step but this time generate a 30 m (bank and channel level) buffer. Note: Use End Type "FLAT"
- **Outputs**:
  - `Buf_100m_Seg_250m_NHD_Perennial.shp` and
  - `Buf_30m_Seg_250m_NHD_Perennial.shp`

MODEL INPUTS & DATA SOURCES

Evidence of Perennial Water Source

Evidence of Wood for Building Material



- Nationwide (24k)

- Nationwide (30-m)
- Existing & potential

- Base Flow: Beaver dam can be built
- Q2: Beaver dam will likely persist

- In documentation

3. Wood for Building Materials

Figure 2 shows how the LANDFIRE land cover data for both existing (2008) and potential vegetation is classified by beaver food/building material preferences established in the literature.

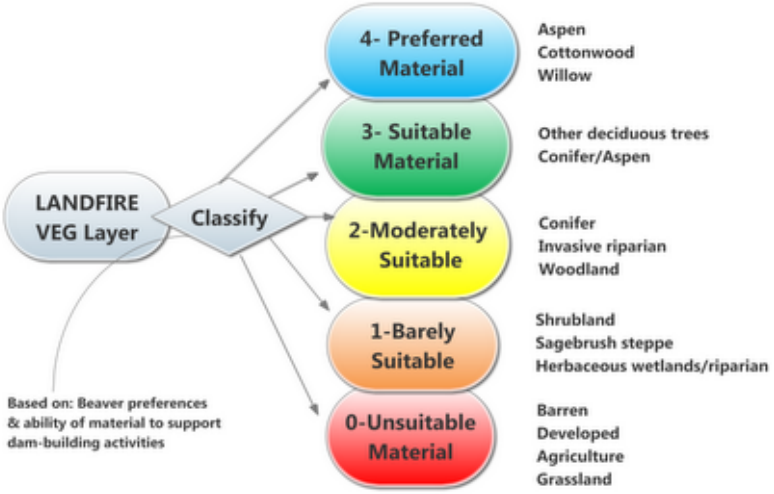


Figure 2. Diagram showing LANDFIRE land cover data classification for the beaver dam capacity model.

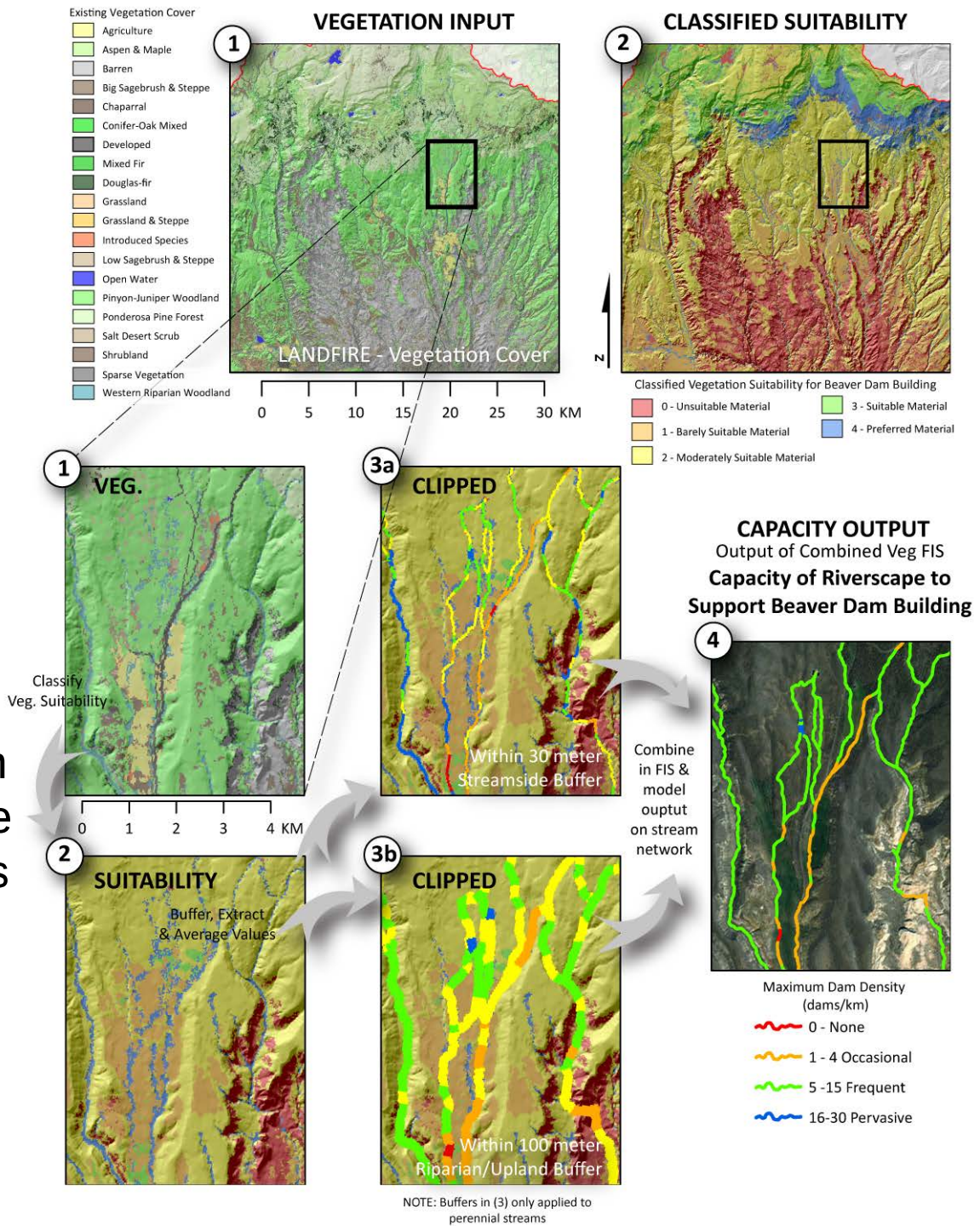
Note: The potential vegetation layer (biophysical settings (BpS)) represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime. It is a refinement of the environmental site potential map; in this refinement, we attempt to incorporate current scientific knowledge regarding the functioning of ecological processes - such as fire - in the centuries preceding non-indigenous human influence. Map units are based on NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units.

Contents

1 Task 1: Classify the LANDFIRE land cover data
2 Task 2: Make two copies of Segmented_250m_NHD _Perennial for use in the next processing steps
3 Task 3: Use the raster datasets (Task 1) to populate the NHD_Perennial stream shapefiles with food/dam-building material suitability values
4 Task 4: Run the beaver dam building capacity two input FIS (VEG_FIS)

WORKFLOW

- Get LANDFIRE
- Classify it
- Clip it to streamside and riparian/upland buffers
- Run it through fuzzy inference system
  - Takes inputs and estimates the maximum dam density that can be supported based on this



VEGETATION CAPACITY MODEL PLAN

I. **Classify LANDFIRE vegetation cover types**

II. Clip Raster to Buffered Areas
   I. For 30 m ‘Bank Zone’
   II. For 100 m ‘Riparian and Adjacent Zone’

III. Extract from Buffered Areas to Stream Segments
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IV. Run Vegetation Capacity Model in Matlab

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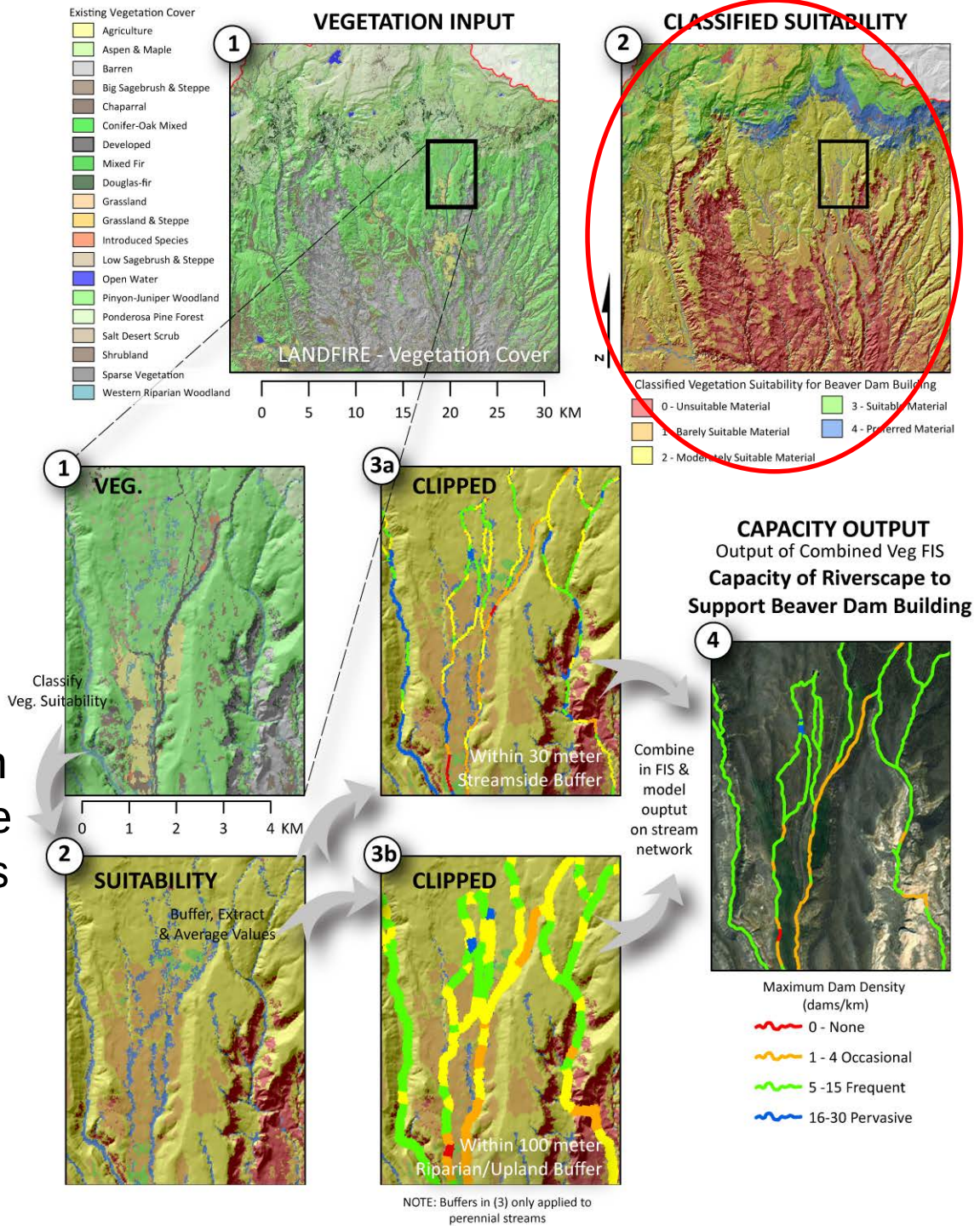
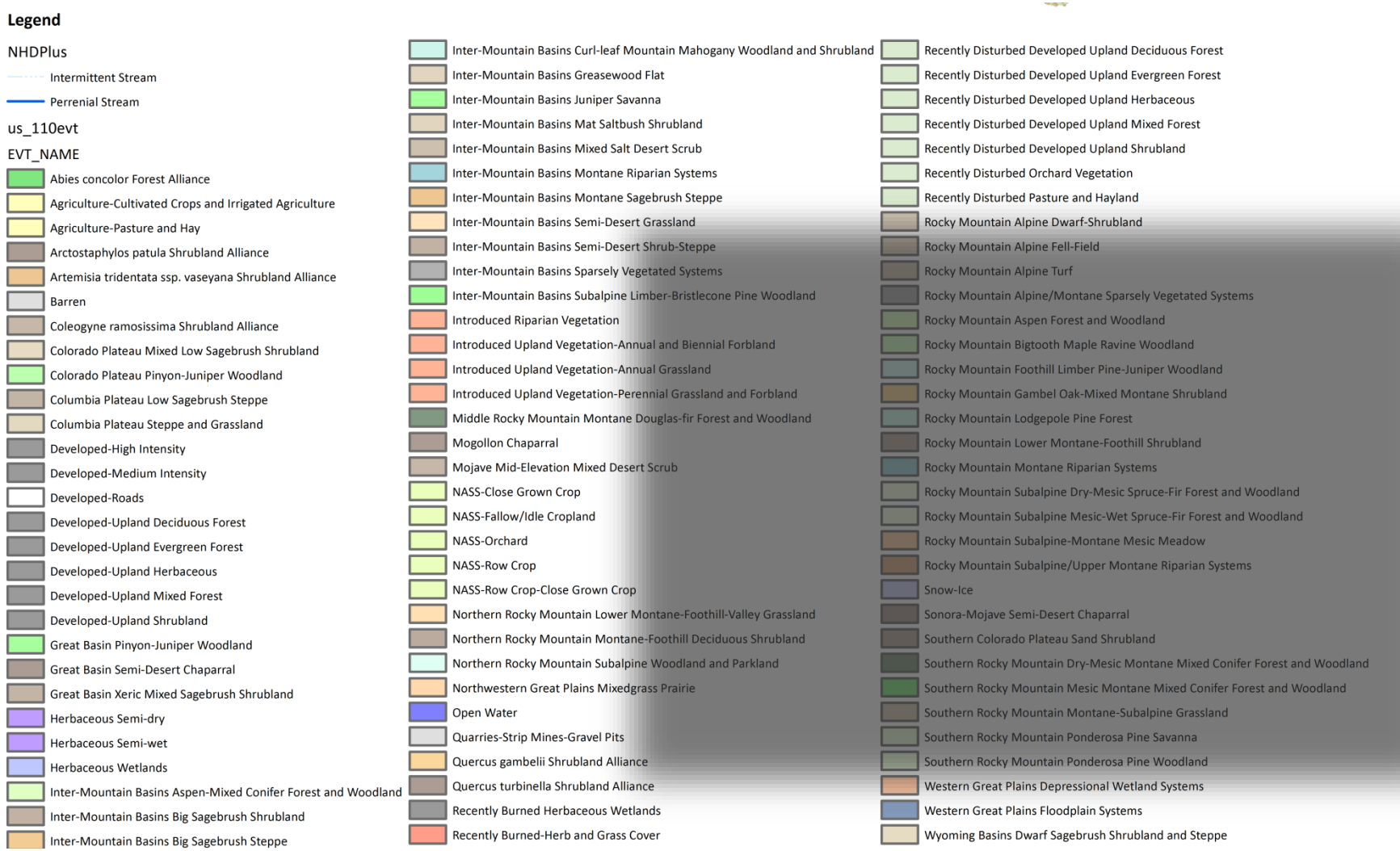
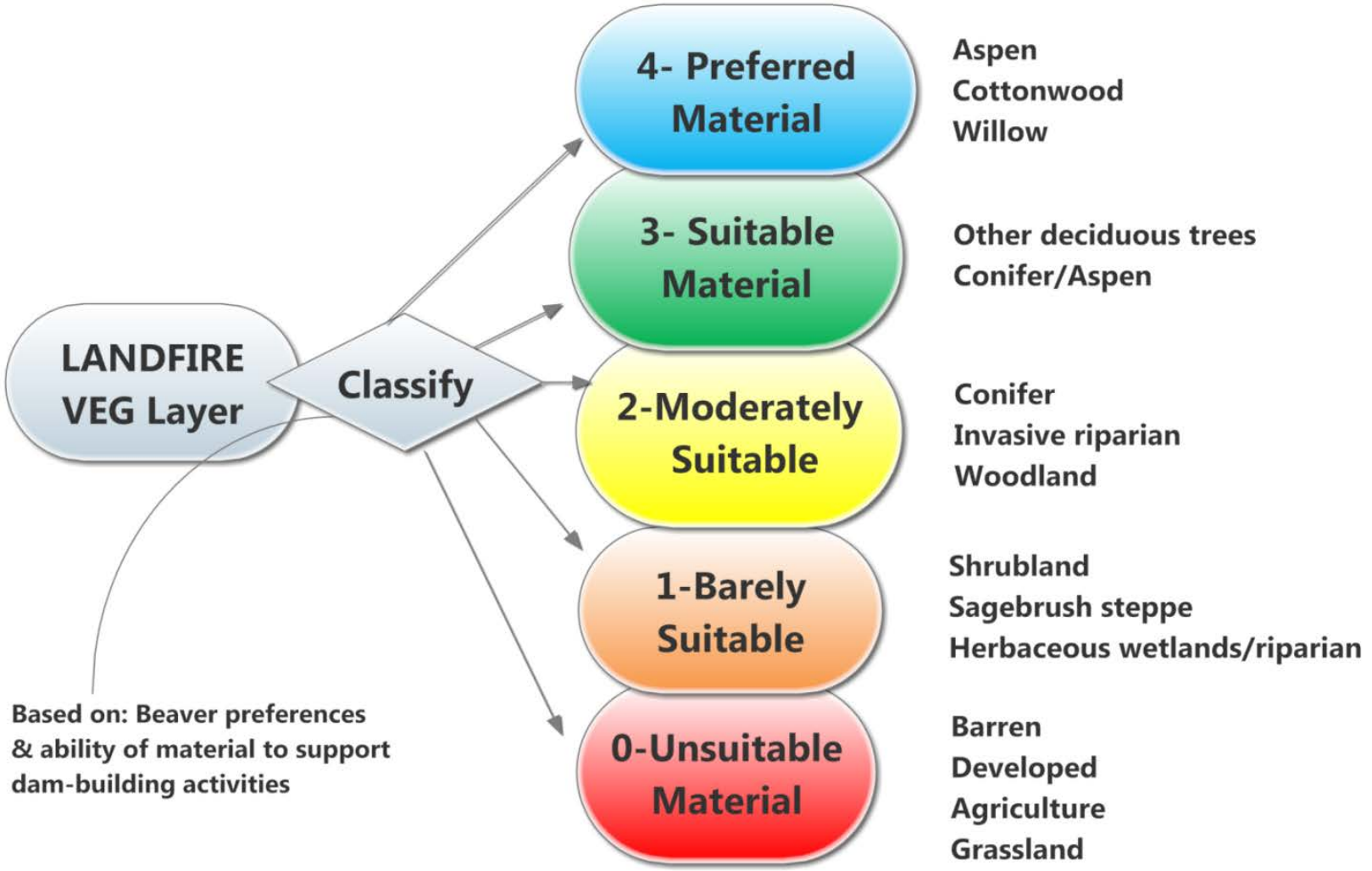


LANDFIRE FOR WEBER WATERSHED

LANDFIRE FOR WEBER WATERSHED



LOOK UP TABLE

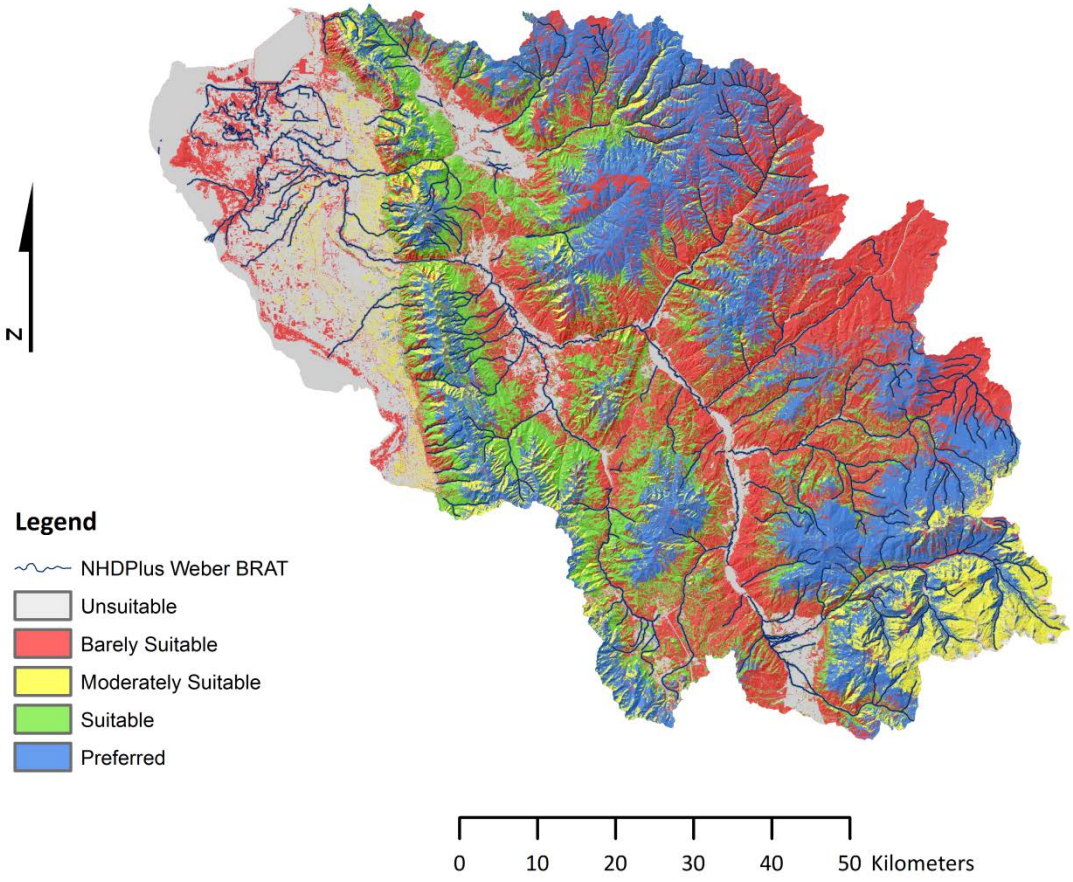


CLASSIFY USING COMMON SENSE...

OID_	VALUE_	COUNT_	EVT_NAM	SYSTEMGF	SYSTMGRI	SAF_SRM	NVCSORD	NVCSCLAS	NVCSSUB	SYSTMGRI	R	G	B	RED	GREEN	BLUE	VEG_CODI
	11	2800577	Open Wat	11	Open Wat	LF 11: Wat	Non-vege	Non-vege	Non-vege	Non-vege	0	0	255	0	0	1	0
	12	290	Snow-Ice	12	Snow-Ice	LF 12: Sno	Non-vege	Non-vege	Non-vege	Non-vege	159	161	240	0.623529	0.631372	0.941176	0
	13	239455	Develope	13	Develope	LF 20: Dev	Tree-dom	Open tree	Deciduou	Develope	52	52	52	0.203921	0.203921	0.203921	2
	14	63157	Develope	14	Develope	LF 20: Dev	Tree-dom	Open tree	Evergreen	Develope	52	52	52	0.203921	0.203921	0.203921	1
	15	18249	Develope	15	Develope	LF 20: Dev	Tree-dom	Open tree	Mixed eve	Develope	52	52	52	0.203921	0.203921	0.203921	1
	16	158464	Develope	16	Develope	LF 20: Dev	Herbaceo	Herbaceo	Deciduou	Develope	52	52	52	0.203921	0.203921	0.203921	0
	17	47047	Develope	17	Develope	LF 20: Dev	Shrub-dor	Shrubland	Mixed eve	Develope	52	52	52	0.203921	0.203921	0.203921	0
	23	208011	Develope	23	Develope	LF 20: Dev	No Domin	No Domin	No Domin	Develope	52	52	52	0.203921	0.203921	0.203921	0
	24	98328	Develope	24	Develope	LF 20: Dev	No Domin	No Domin	No Domin	Develope	52	52	52	0.203921	0.203921	0.203921	0
	25	431959	Develope	25	Develope	LF 20:Dev	No Domin	No Domin	No Domin	Develope	255	255	255	1	1	1	0
	31	620672	Barren	31	Barren	LF 31: Barr	Non-vege	Non-vege	Non-vege	Non-vege	191	191	191	0.749019	0.749019	0.749019	0
	32	43204	Quarries-	32	Quarries-	LF 31: Barr	Non-vege	Non-vege	Non-vege	Develope	191	191	191	0.749019	0.749019	0.749019	0
	60	2480	NASS-Orc	60	NASS-Orc	LF 80: Agri	Tree-dom	Open tree	Deciduou	Agricultur	255	210	119	0.82352	1	0.466666	1
	63	17019	NASS-Row	63	NASS-Row	LF 80: Agri	Herbaceo	Herbaceo	Annual Gr	Agricultur	255	210	119	0.82352	1	0.466666	1
	64	42336	NASS-Row	64	NASS-Row	LF 80: Agri	Herbaceo	Herbaceo	Annual Gr	Agricultur	255	210	119	0.82352	1	0.466666	1
	65	641757	NASS-Clos	65	NASS-Clos	LF 80: Agri	Herbaceo	Herbaceo	Annual Gr	Agricultur	255	210	119	0.82352	1	0.466666	0
	66	79837	NASS-Fall	66	NASS-Fall	LF 80: Agri	Herbaceo	Herbaceo	Annual Gr	Agricultur	255	210	119	0.82352	1	0.466666	0
	75	8947	Herbaceo	75	NLCD-Her	LF 60: Trar	Herbaceo	Herbaceo	Perennial	Grassland	127	56	255	0.498039	0.219607	1	0
	76	485	Herbaceo	76	NLCD-Her	LF 60: Trar	Herbaceo	Herbaceo	Perennial	Grassland	127	56	255	0.498039	0.219607	1	1
	81	615380	Agricultur	81	Agricultur	LF 80: Agri	Herbaceo	Herbaceo	Perennial	Agricultur	255	255	119	1	1	0.466666	0
	82	66154	Agricultur	82	Agricultur	LF 80: Agri	Herbaceo	Herbaceo	Annual Gr	Agricultur	255	255	119	1	1	0.466666	0
	95	328774	Herbaceo	95	NLCD-Her	LF 80: Agri	Herbaceo	Herbaceo	Perennial	Grassland	127	143	255	0.498039	0.560784	1	1
	2001	2866	Inter-Mou	700	Sparse Ve	LF 33: Spa	No Domin	Sparsely v	Sparsely v	Sparsely v	100	100	100	0.392156	0.392156	0.392156	1
	2006	116938	Rocky Mo	700	Sparse Ve	LF 33: Spa	No Domin	Sparsely v	Sparsely v	Sparsely v	100	100	100	0.392156	0.392156	0.392156	1
	2011	2284766	Rocky Mo	602	Aspen For	SAF 217: A	Tree-dom	Open tree	Deciduou	Hardwood	192	255	138	0.752941	1	0.541176	4

YOU SHOULD END UP WITH...

- A map of vegetation suitability to beaver for dam building
- Of course... preferred species on top of a mountain 10 kilometers from water don't do much for beaver



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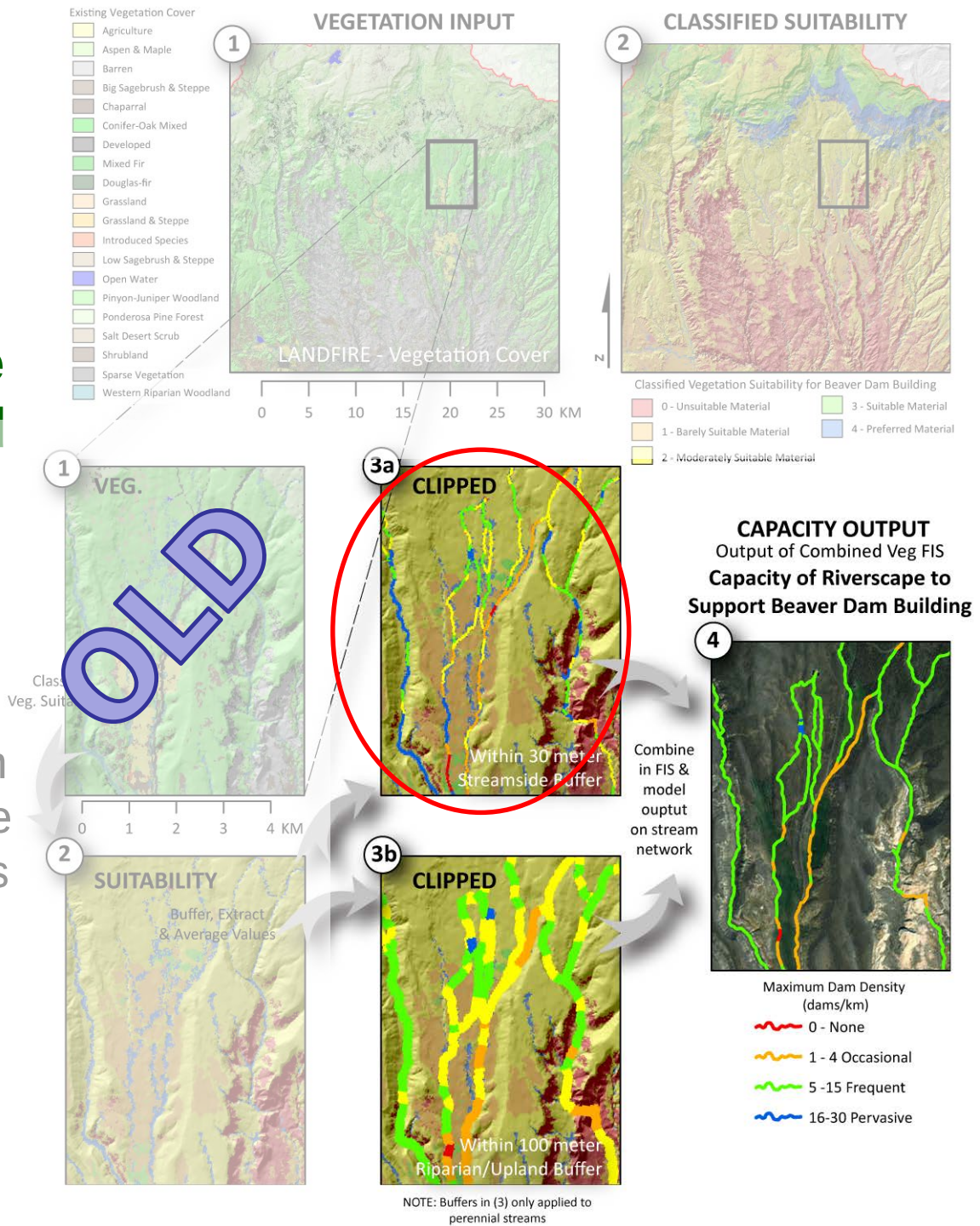
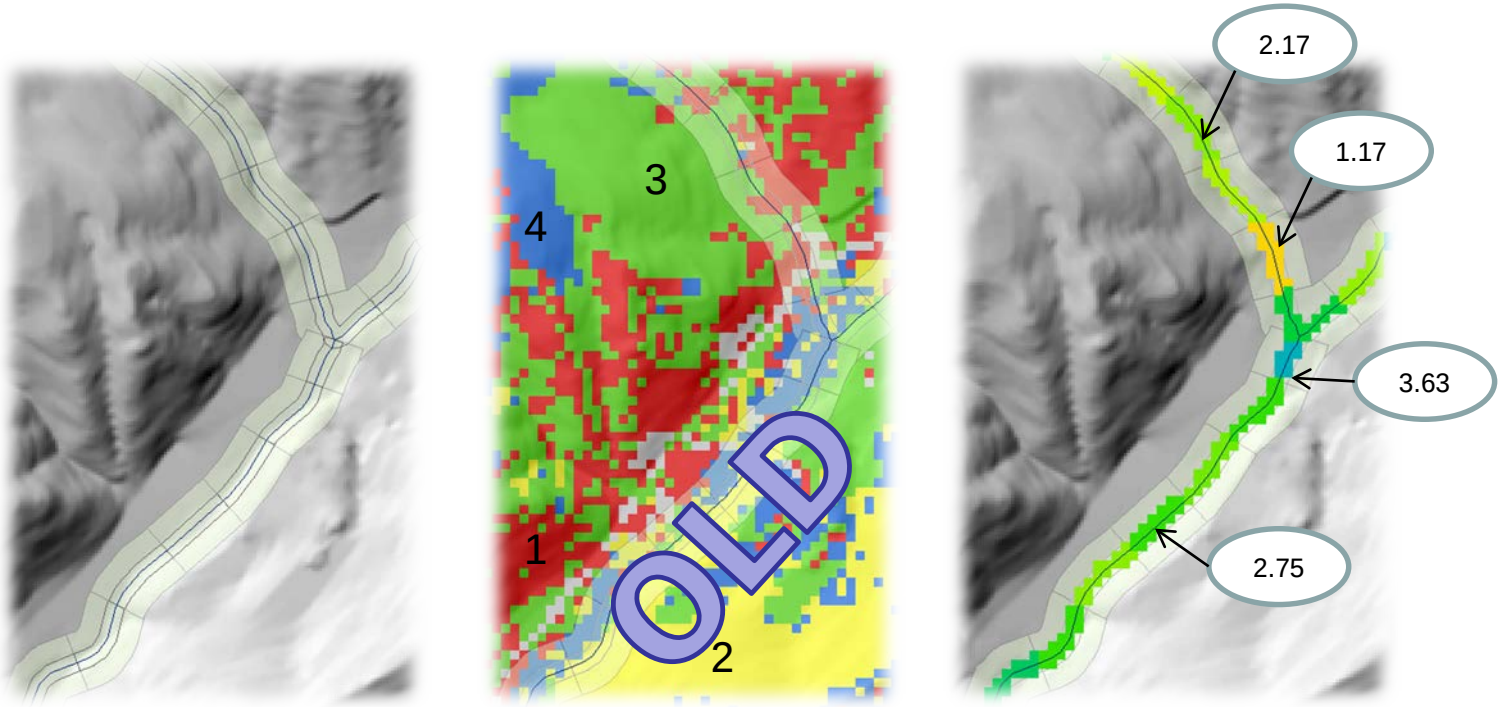


USING ZONAL STATS



- Use Mean… to average all the pixels in segments
- Switches from a categorical to a continuous input

VEGETATION CAPACITY MODEL PLAN

I. Classify LANDFIRE vegetation cover types

II. Clip Raster to Buffered Areas

I. For 30 m 'Bank Zone'

II. For 100 m 'Riparian and Adjacent Zone'

III. Extract from Buffered Areas to Stream Segments

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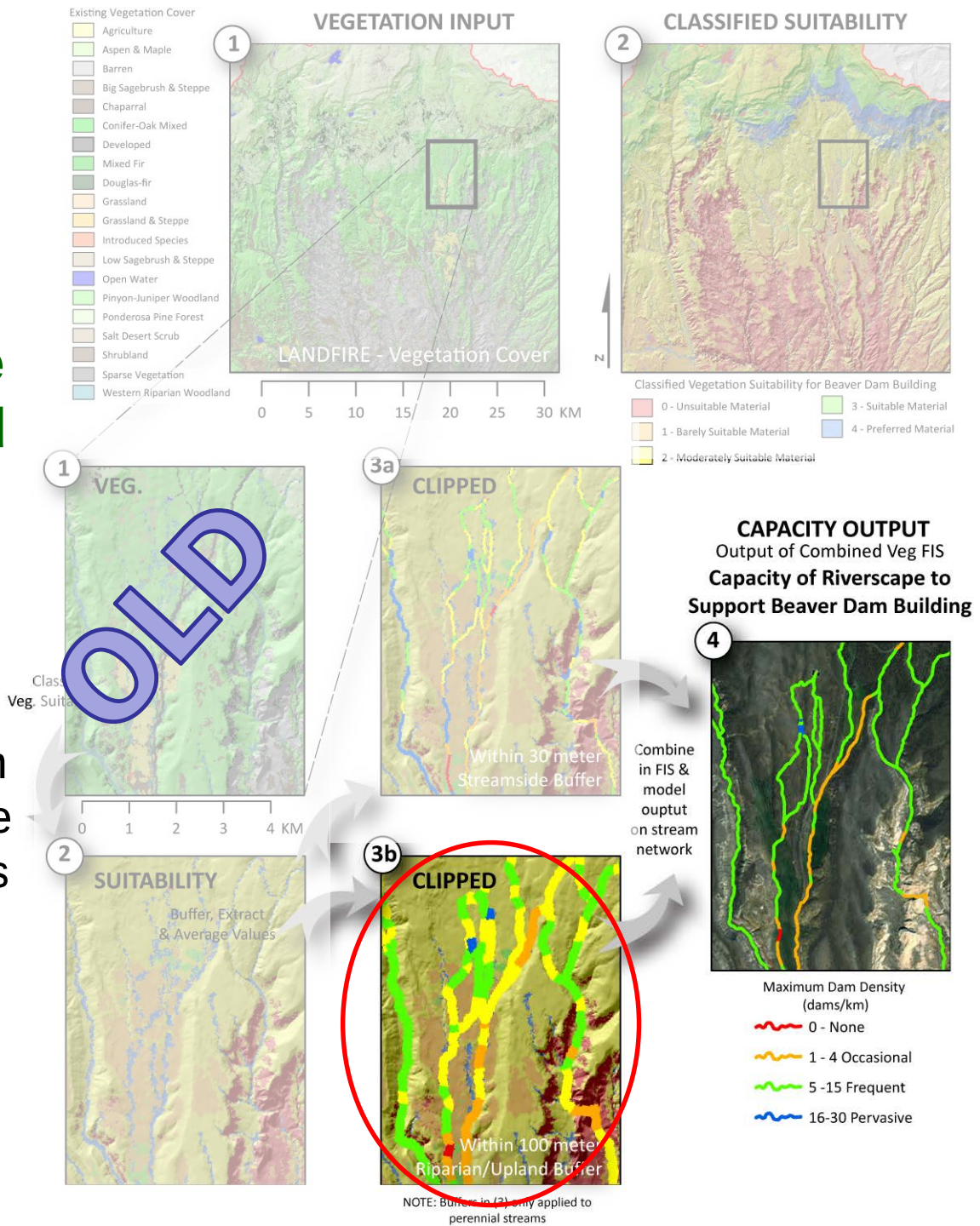
IV. Run Vegetation Capacity Model in Matlab

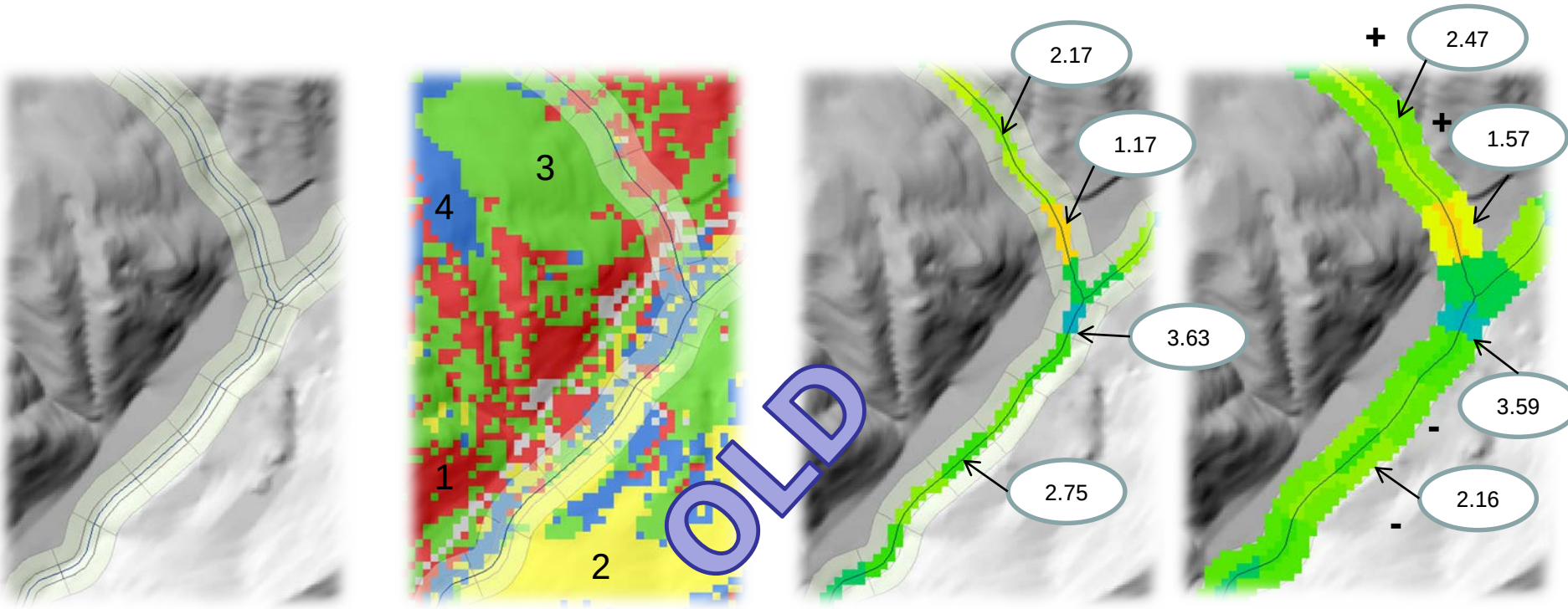
OLD

WORKFLOW

- Get LANDFIRE
- Classify it
- **Clip it to streamside and riparian/upland buffers**
- Run it through fuzzy inference system
  - Takes inputs and estimates the maximum dam density that can be supported based on this



USING ZONAL STATS AGAIN



- Notice differences... based on buffer sample width
- For some it goes up... for some it goes down...
- Rarely does it stay exactly the same

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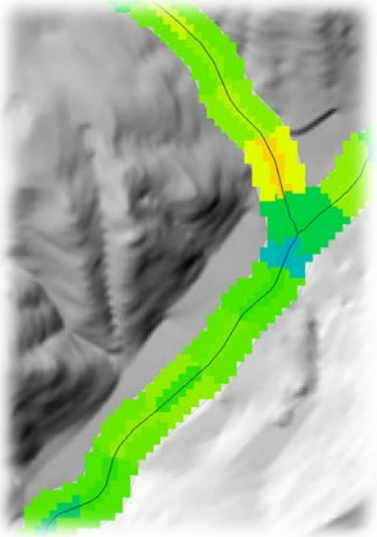
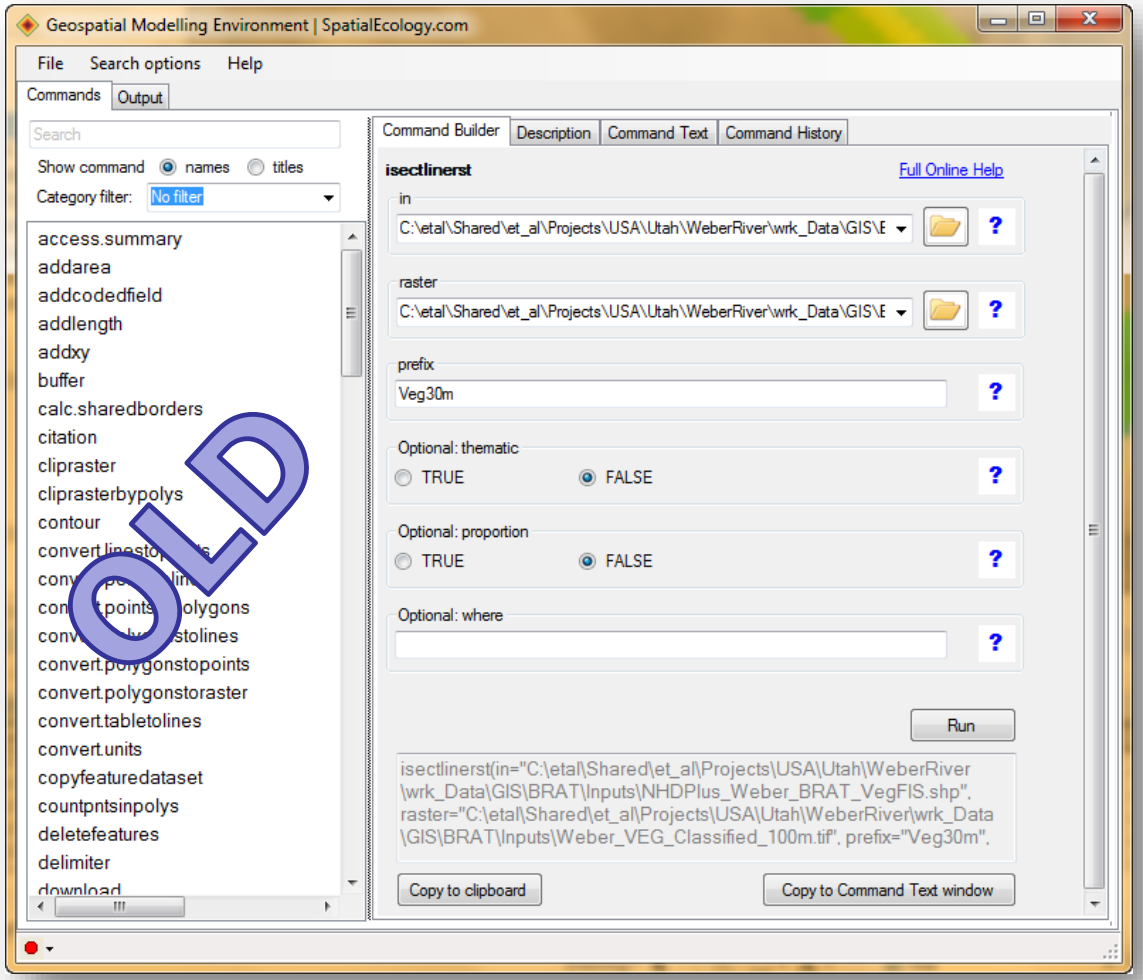
ASSIGN VALUE TO LINE...

- Trick is to get the values from **30 m** and 100 m raster buffers back into the vector line drainage network...





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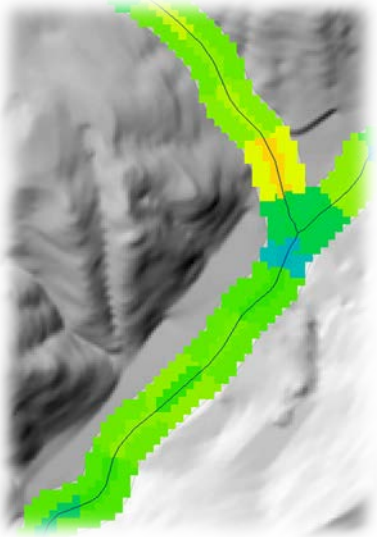

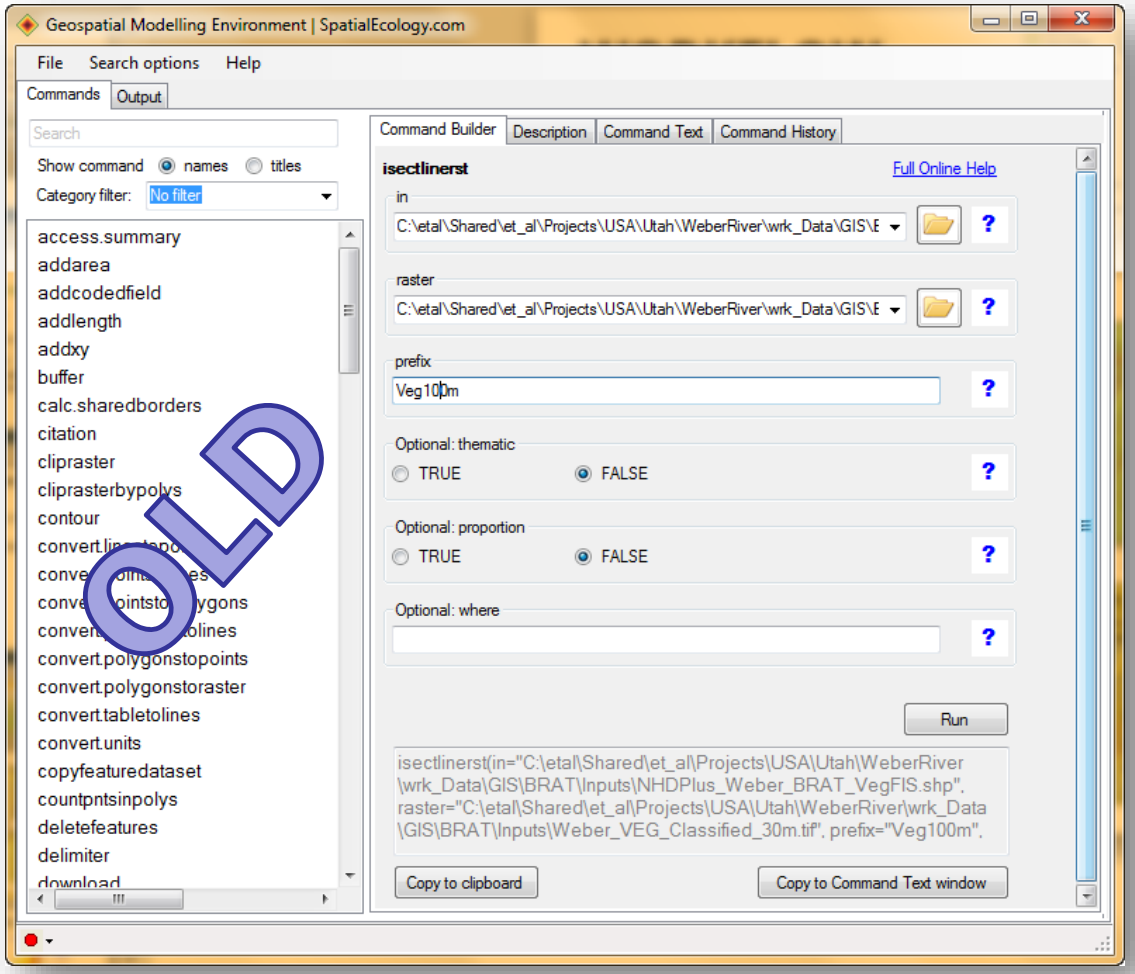

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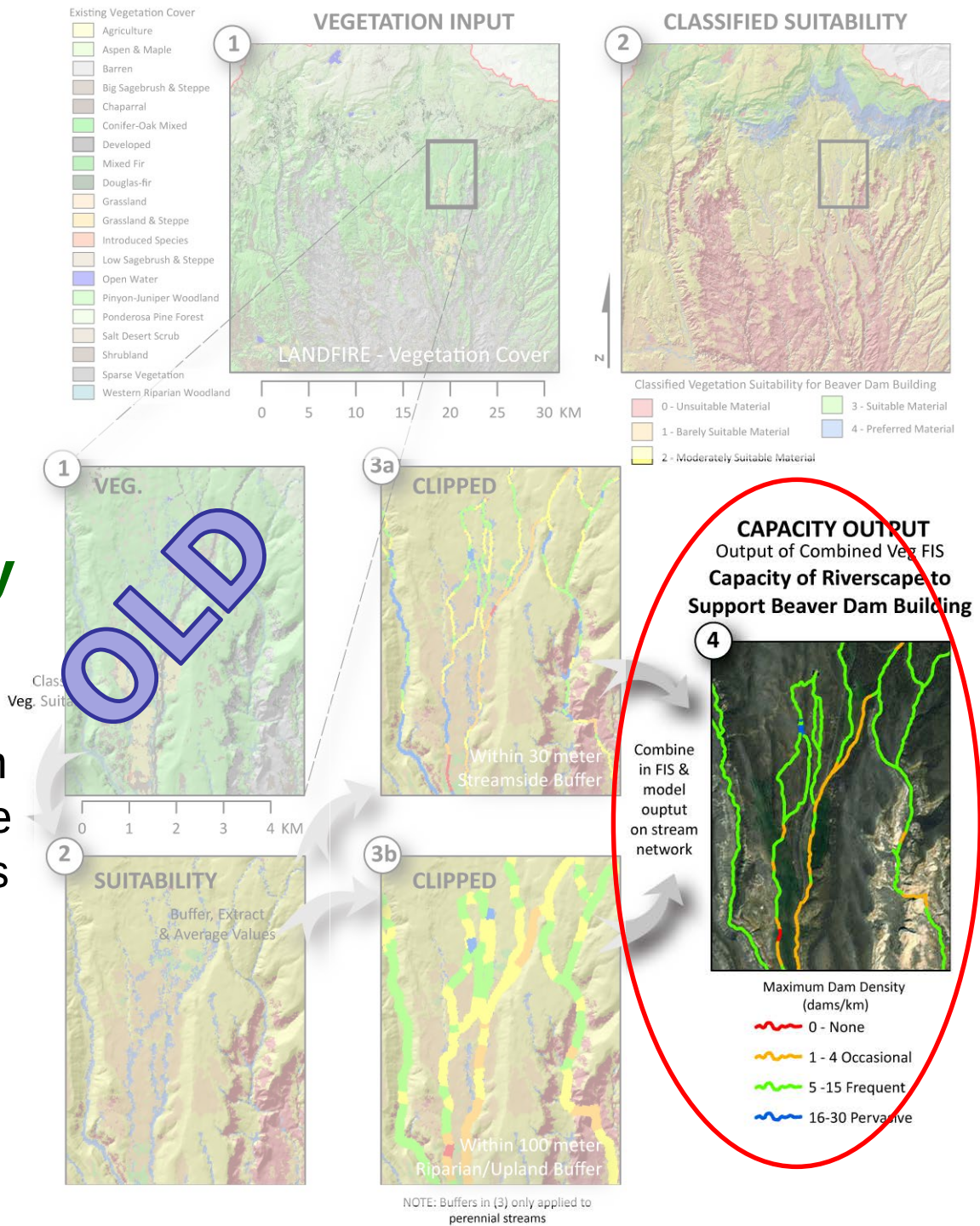


WELL… WE'LL RUN IT LATER ACTUALLY

- All you need to do is make sure these two vegetation inputs end up in columns 8 (H) & 9 (I)

	A	B	C	D	E	F	G	H	I	J
1	FID	ElevMIN	ElevMAX	ElevBEG	ElevEND	Length	Slope	Veg30m	Veg100m	DrainKM
2	1	2629.832	2658.415	2658.415	2637.74	446.44	0.064024	3.102293	3.202512	58.919
3	2	3304.854	3305.191	3304.909	3304.572	99.9996	0.003369	3.333333	3.428571	0.012
4										

OLD

BRAT – BEAVER RESTORATION ASSESSMENT TOOL

Exercise 3

Deriving Stream Power

WHAT DO BEAVER CARE?

- Total stream power was calculated at
  - **Base flow** to gauge the maximum stream power at which beaver can build dams
  - and at the 2-year recurrence interval flow ($\mathbf{Q_2}$) to gauge the likelihood of dams persisting from year-to-year due to typical floods

HOW TO CALCULATE?

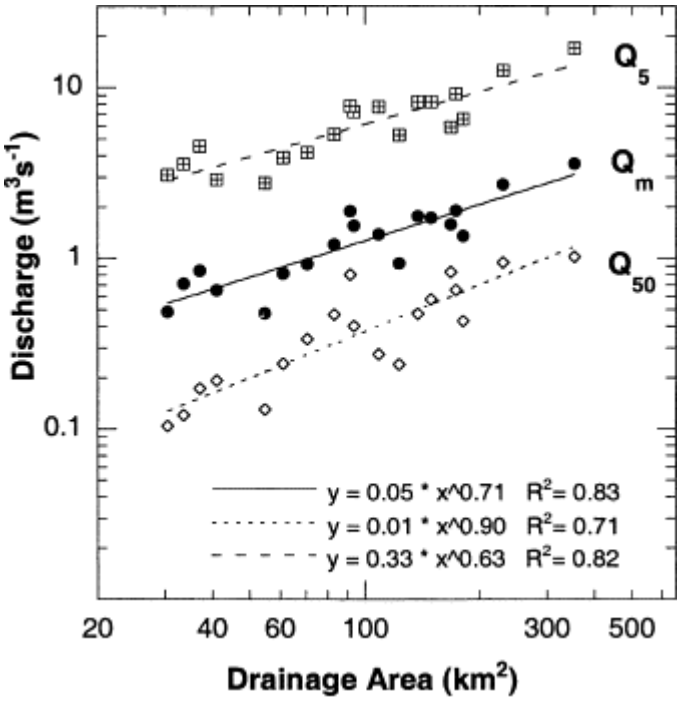
- Stream power is an expression of flow strength and the erosive capacity of streams. Stream power is calculated as:

- $\Omega = \rho g Q S$

- Where Ω is the stream power (in Watts), ρ is the density of water (1000 kg/m3), g is acceleration due to gravity (9.8 m/s2), Q is discharge (m3/s), and S is the channel slope.

WHAT DO I NEED THEN?

- $\Omega = \rho g Q S$
  - Well ρ and g are constants
  - S is slope… so we know segment length, and can get rise… (rise/run)
  - Q?… Which Q?
    - We will use regional curves to get Q and relate it to drainage area…



DERIVING STREAM POWER

I. **Calculate Flow Accumulation Drainage Area**

II. Extract drainage areas from DEM to reach segments

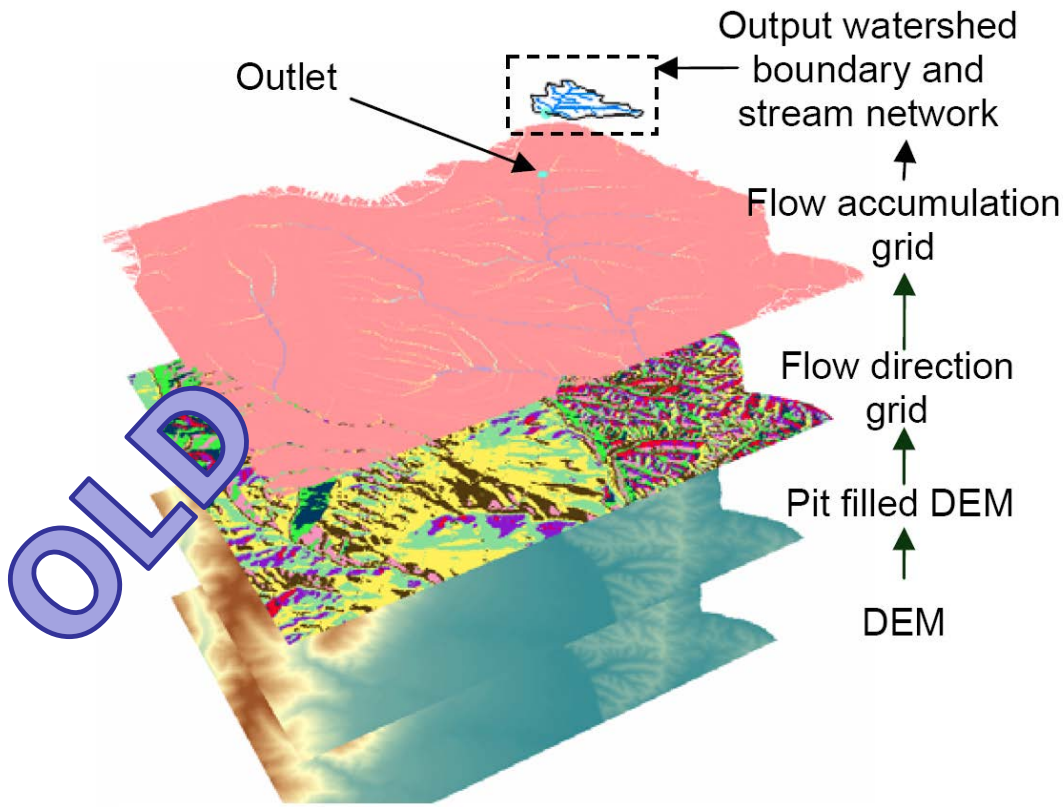
III. Extract elevations from DEM to reach segments for reach slope calculation

IV. Export and prepare table for Matlab code...

OLD

SIMPLE STEPS

1. Pit-fill DEM
2. Calculate Flow Direction
3. Calculate Flow Accumulation



Images from Multi-Watershed Delineation Tool Manual

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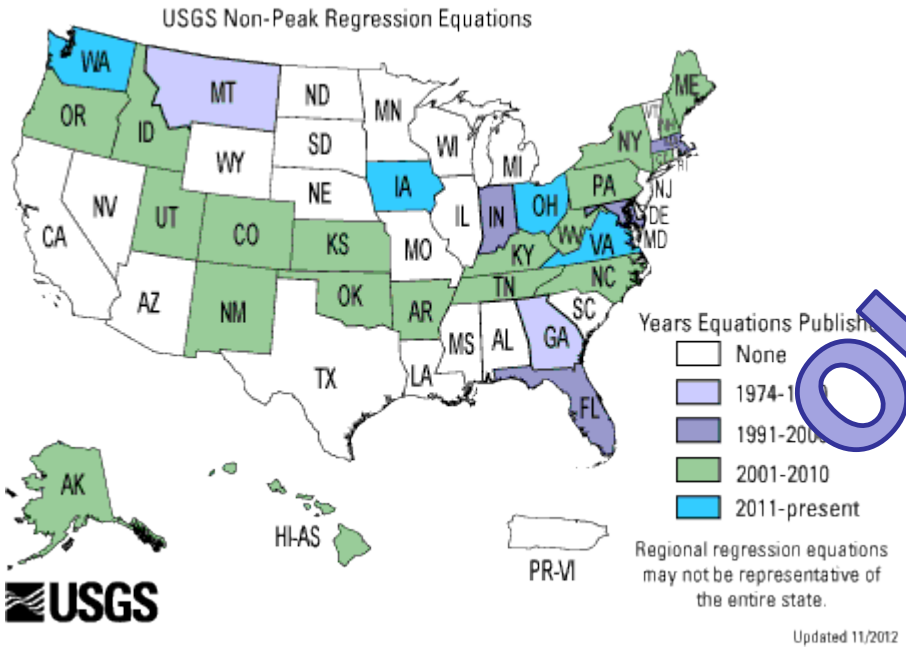
WHILE THAT IS RUNNING...

- Find yourself some regression equations



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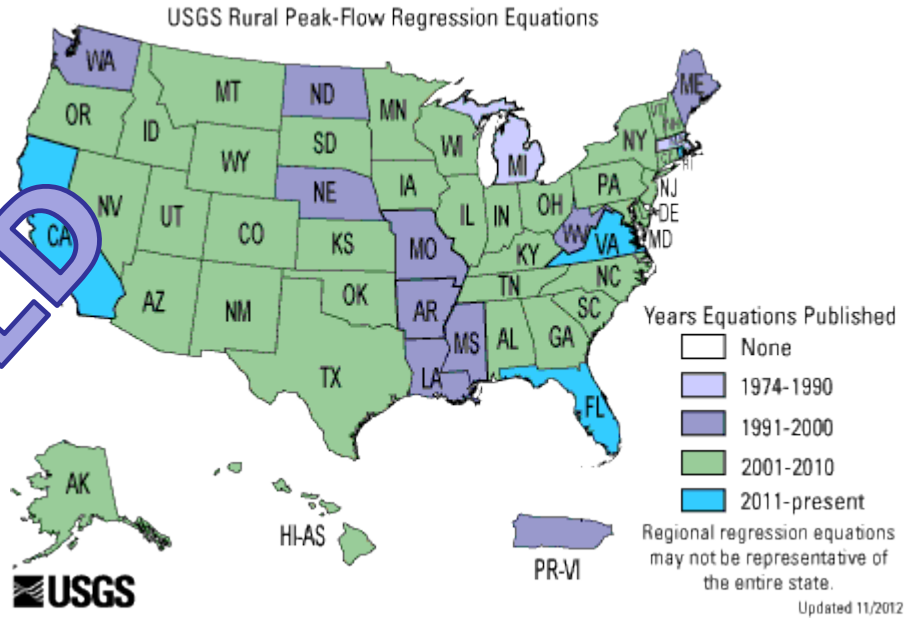
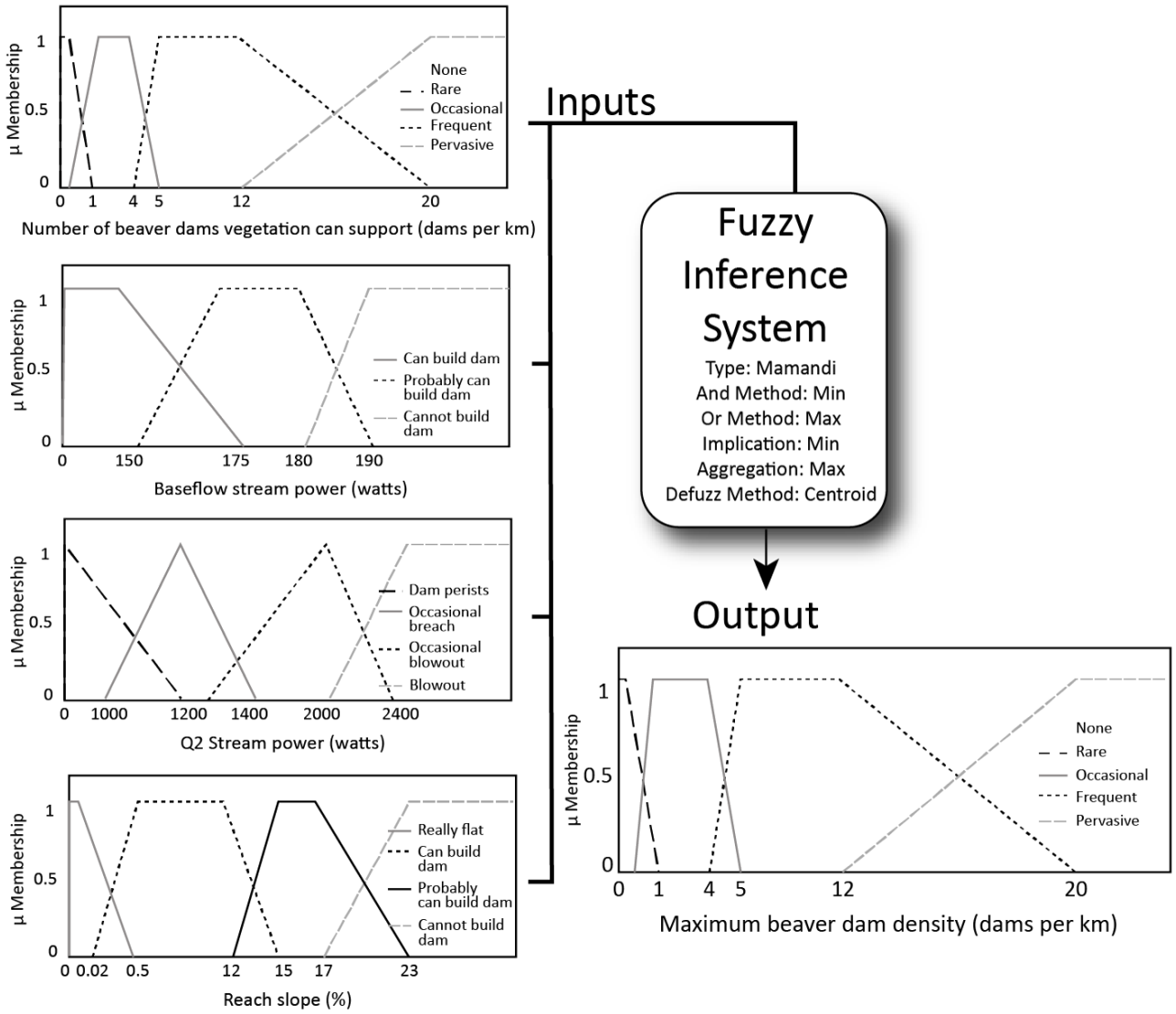
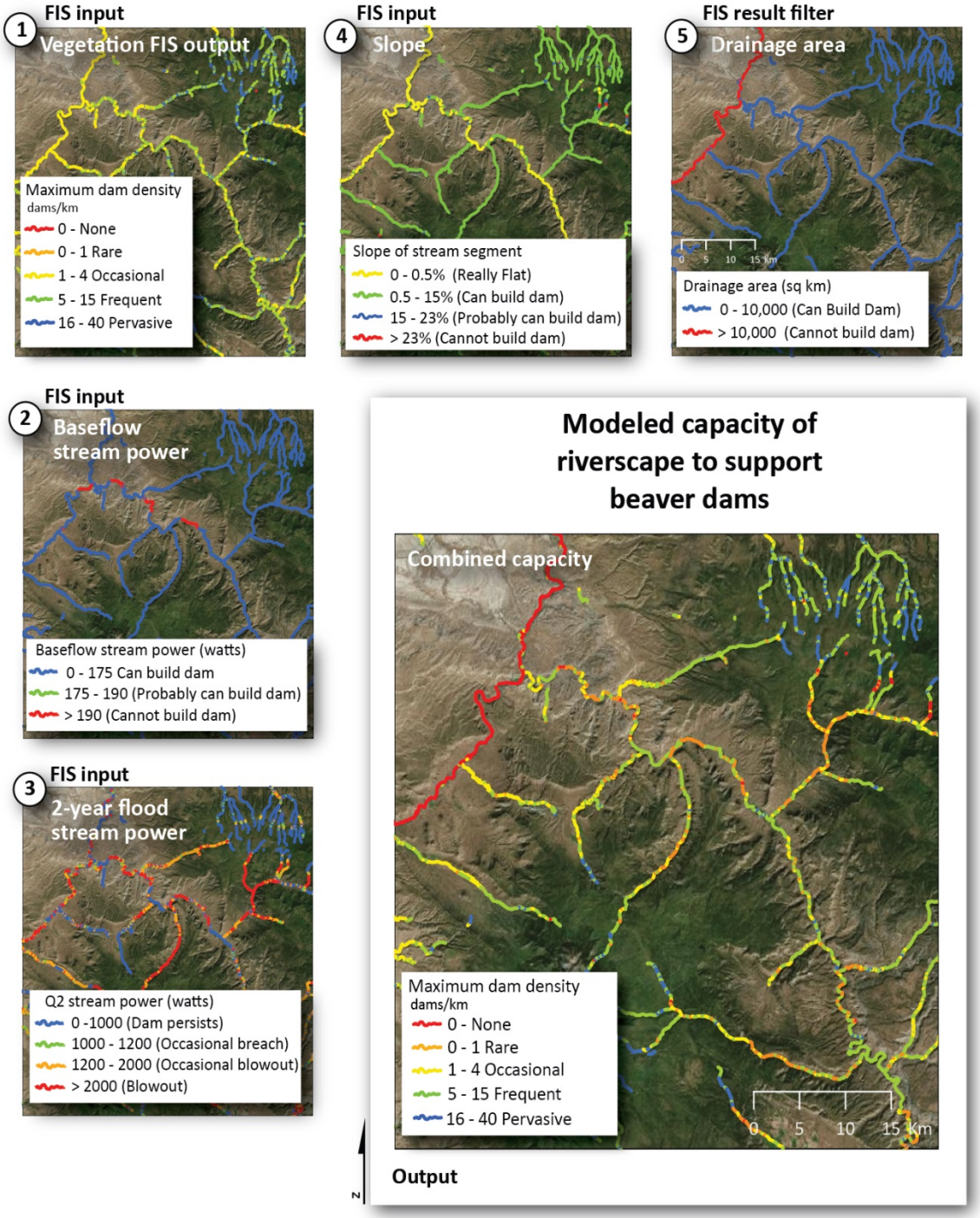


VISIT: http://water.usgs.gov/osw/programs/nss/low-flow.html

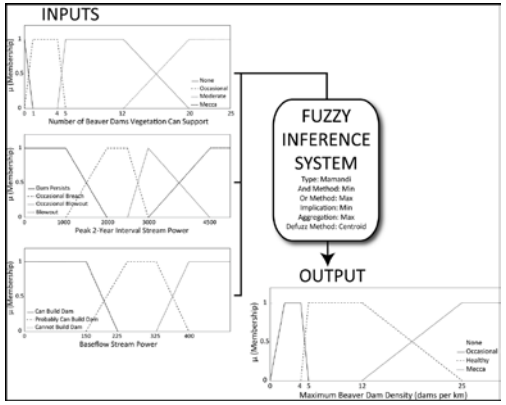
PERENNIAL STREAM VEGETATION & STREAM POWER FIS



FLOW DIAGRAM: BEAVER DAM CAPACITY MODEL



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
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	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