Willow recruitment and channel patterns in beaver dominated stream systems

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Biotic influence on geomorphic processes

How do biotic interactions affect channel form and process?

Wood in rivers received focus beginning in the 1990's, a focus that continues today.

Recently a renewed interest in beaver activity and impacts on streams.

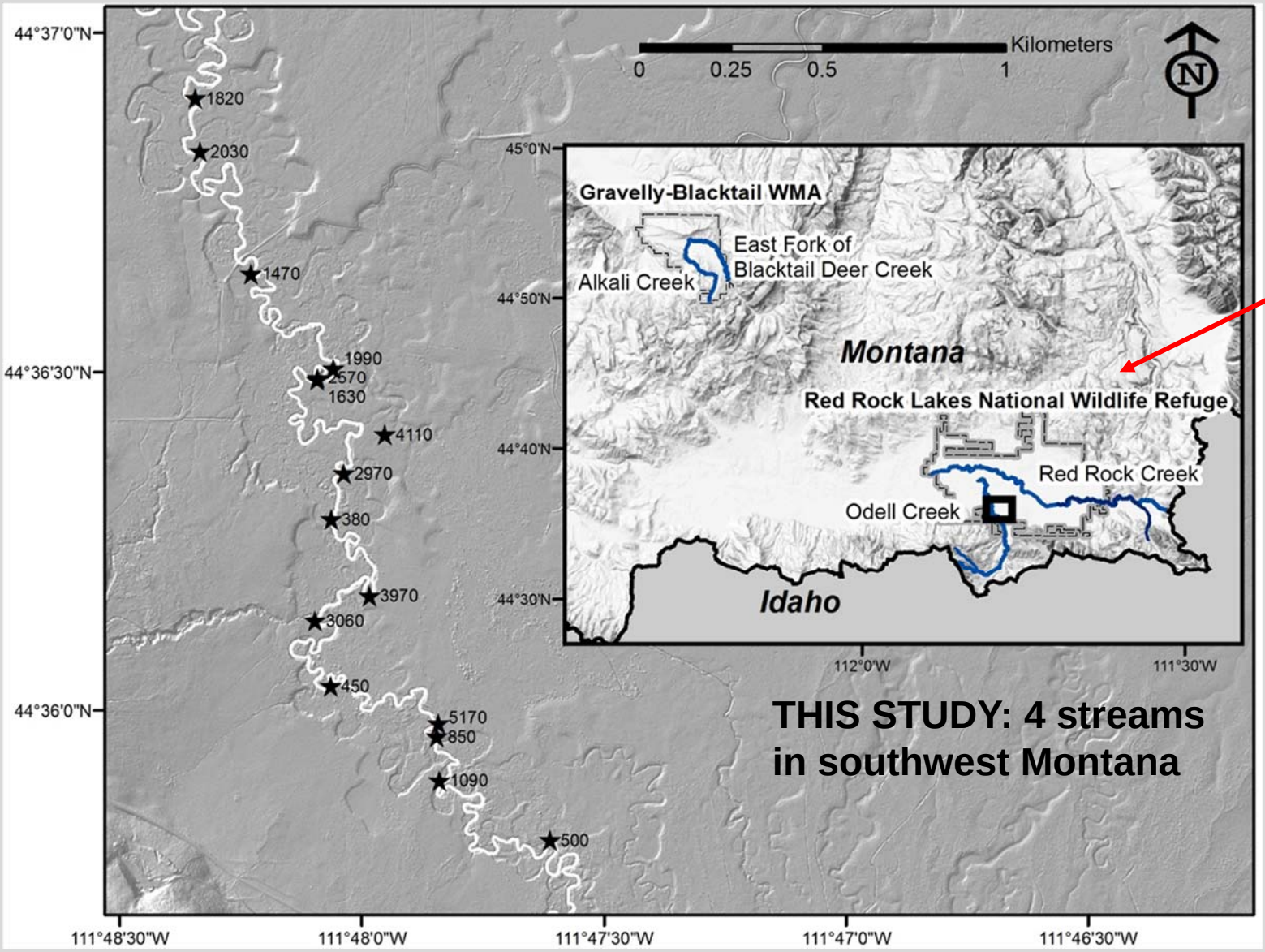
Original Study Goals

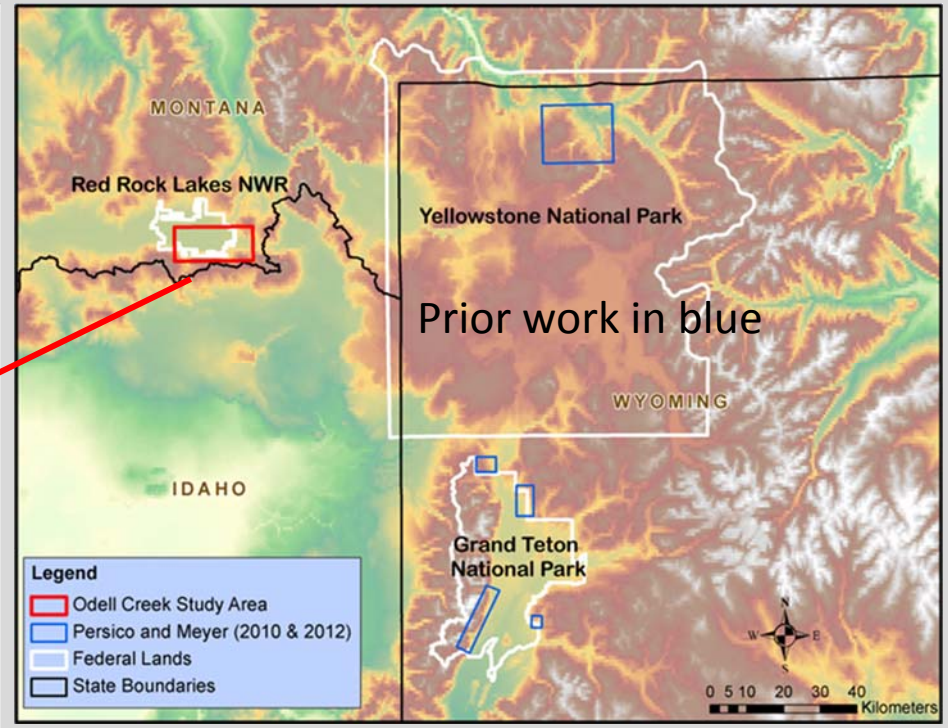
1. Look at ancient beaver deposits and try to understand the nature of beaver related deposits found in stream systems to understand beaver occupancy over millennial time scales.
   a) Were beaver impacting valley floor processes?

THEN…

2. …Realize that beaver are contributing to modern stream dynamics through cutting willow stems and adding to point bar sedimentation -make that a new project

Study Area





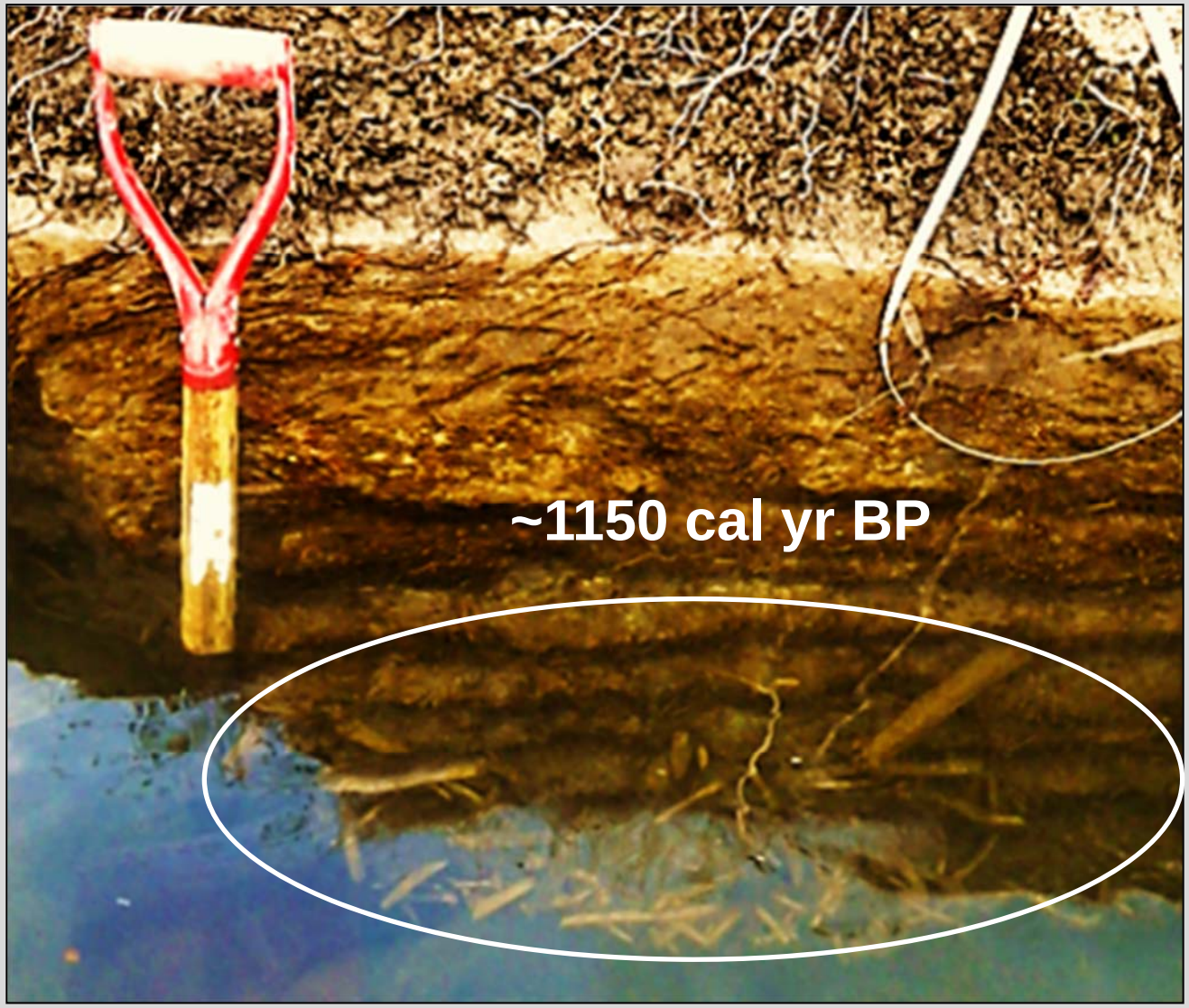
Following on other work on Holocene beaver deposits

Expanded west into other protected areas in southwest Montana

Preserved beaver stick deposits were common on Odell and Red Rock Creeks.

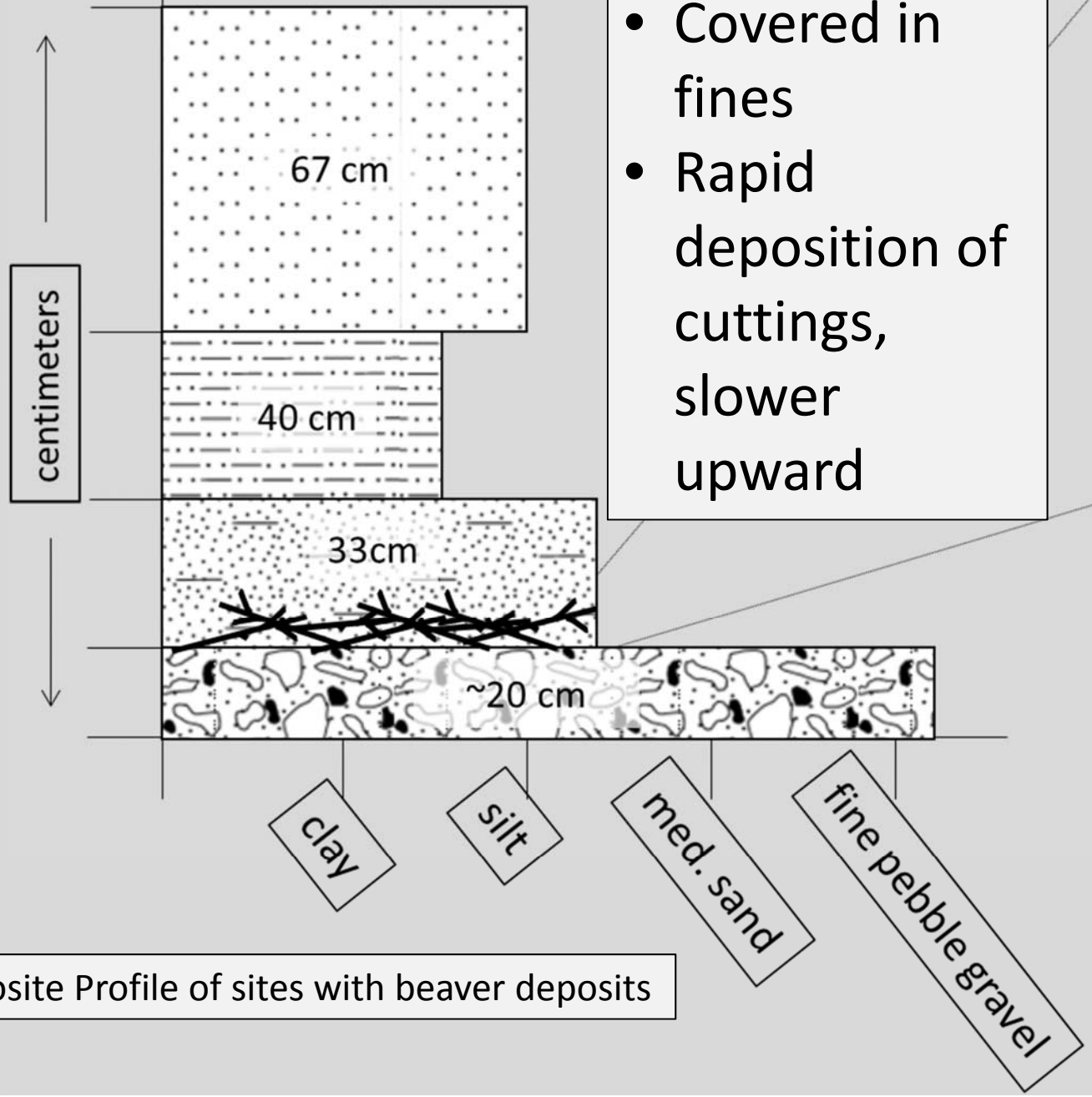
Stars show sites (and calibrated radiocarbon ages) for beaver stick deposits On Odell Creek. The box in the inset shows location for Odell Creek.

What We Found: Holocene Beaver Deposits



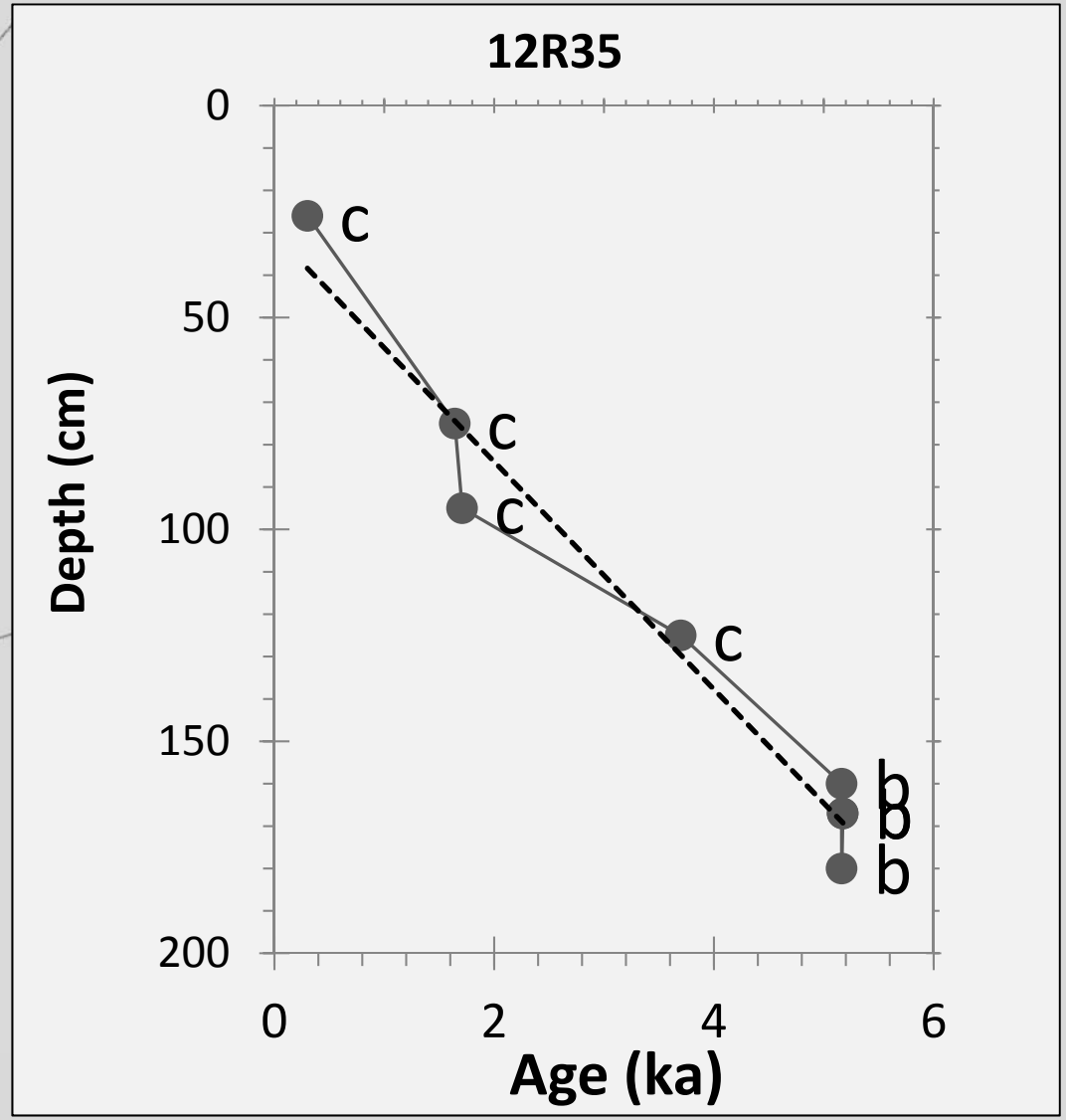
Beaver chewed willow stems (Beaver cuttings/ beaver stick deposits) – note the distinct beaver chewed angle

What We Found: Holocene Beaver Deposits



- Covered in fines
- Rapid deposition of cuttings, slower upward

Composite Profile of sites with beaver deposits



Age-Depth Plot, c = charcoal, b = beaver cuttings

Other work on Holocene beaver deposits

Abandoned pond deposits.

Is this what we are having preserved?

Our sites did not display the same characteristics as those described in prior studies, particularly those in Yellowstone.

Gleyed colors and berms were not evident.

Prior Geologic Investigations of Beaver Deposits

Persico and Meyer (2009,2013)

Polvi and Wohl (2012)

Kramer et al. (2011)

Another issue ... preservation of pond deposits?

5 Active Dams in 10.5 km of stream

Breach frequency 1- 5 years on Odell Creek

Dams are being breached and rarely preserved in the channel

Contemplating the deposits while laying in frustration on a point bar...

- Long, concentrated layers in the bank deposits
- fine grained material on top

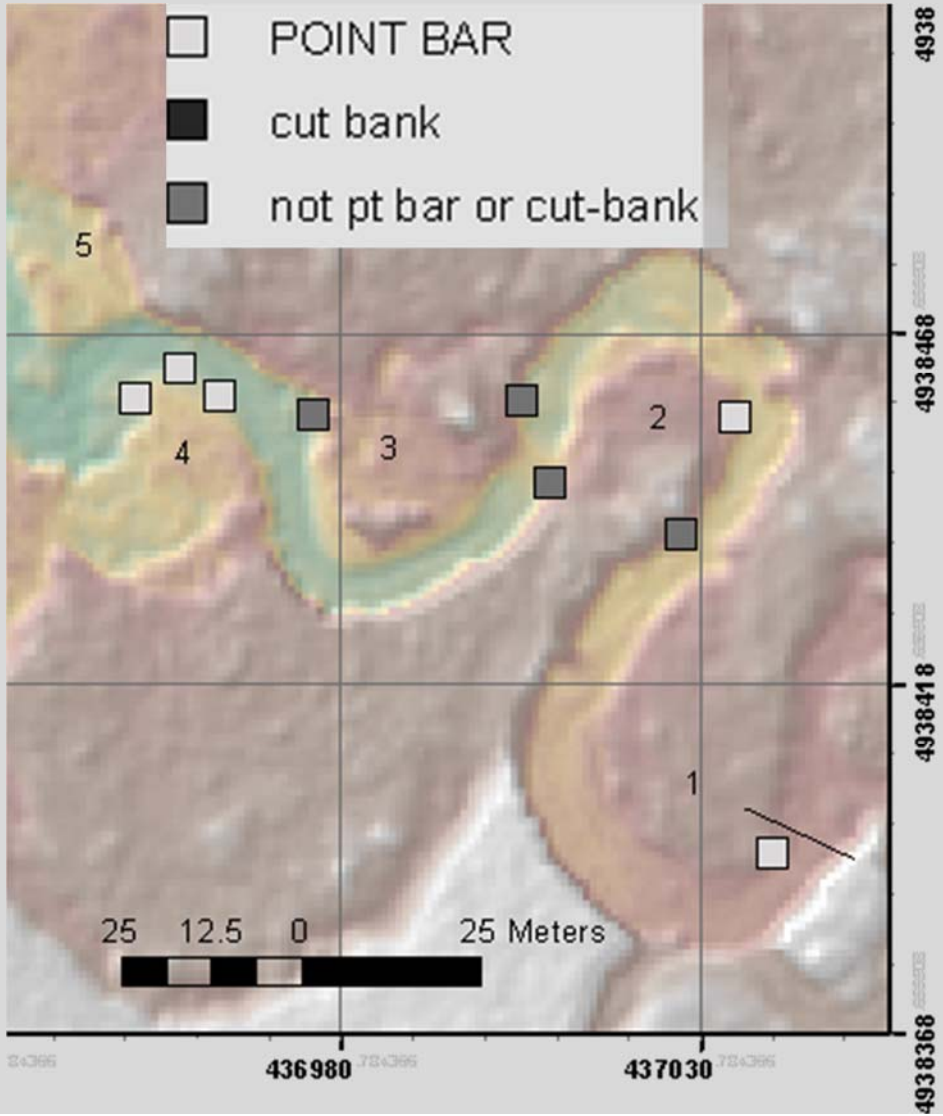
GOAL:
Document beaver contribution to modern stream dynamics through willow cutting addition and point bar sedimentation

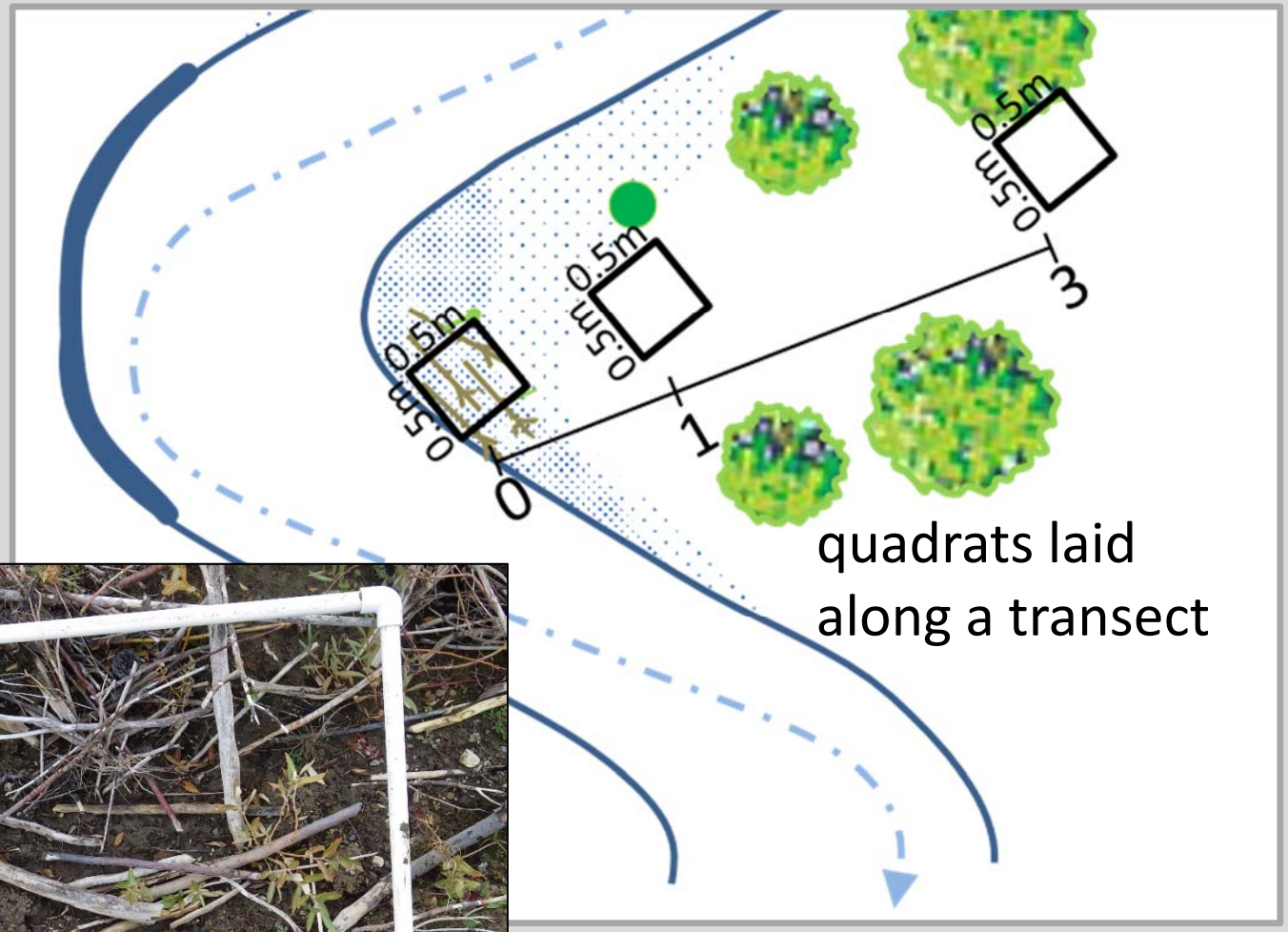
Aha! Piles of beaver chewed sticks right at my lunch spot.

Are these everywhere?

METHODS: Stratified random sampling by reach, morphological class and location on a point bar

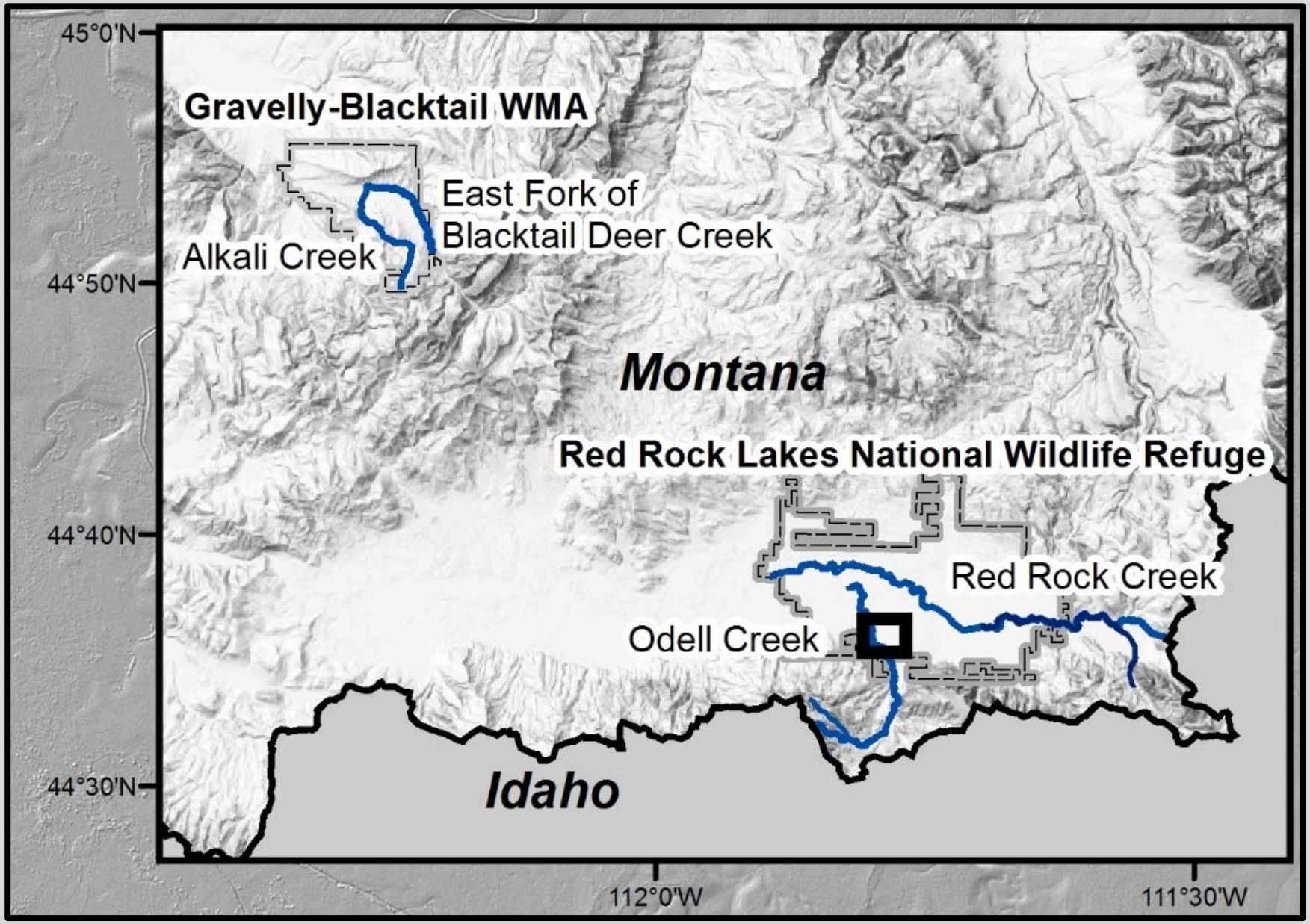
Are beaver chewed sticks common on modern point bars?





- Cutting lengths measured
- sprouts counted
- Dominant grain size recorded

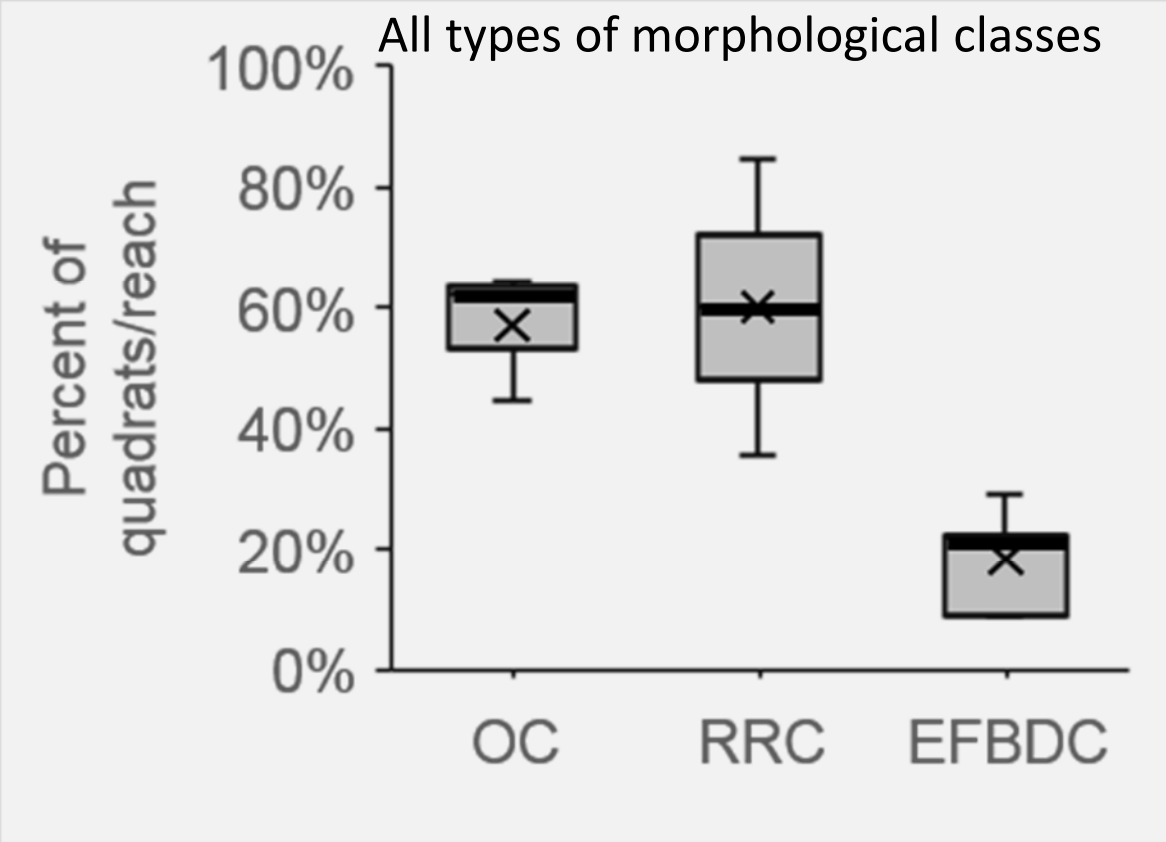
Data collected at other sites in the Upper Missouri Headwaters



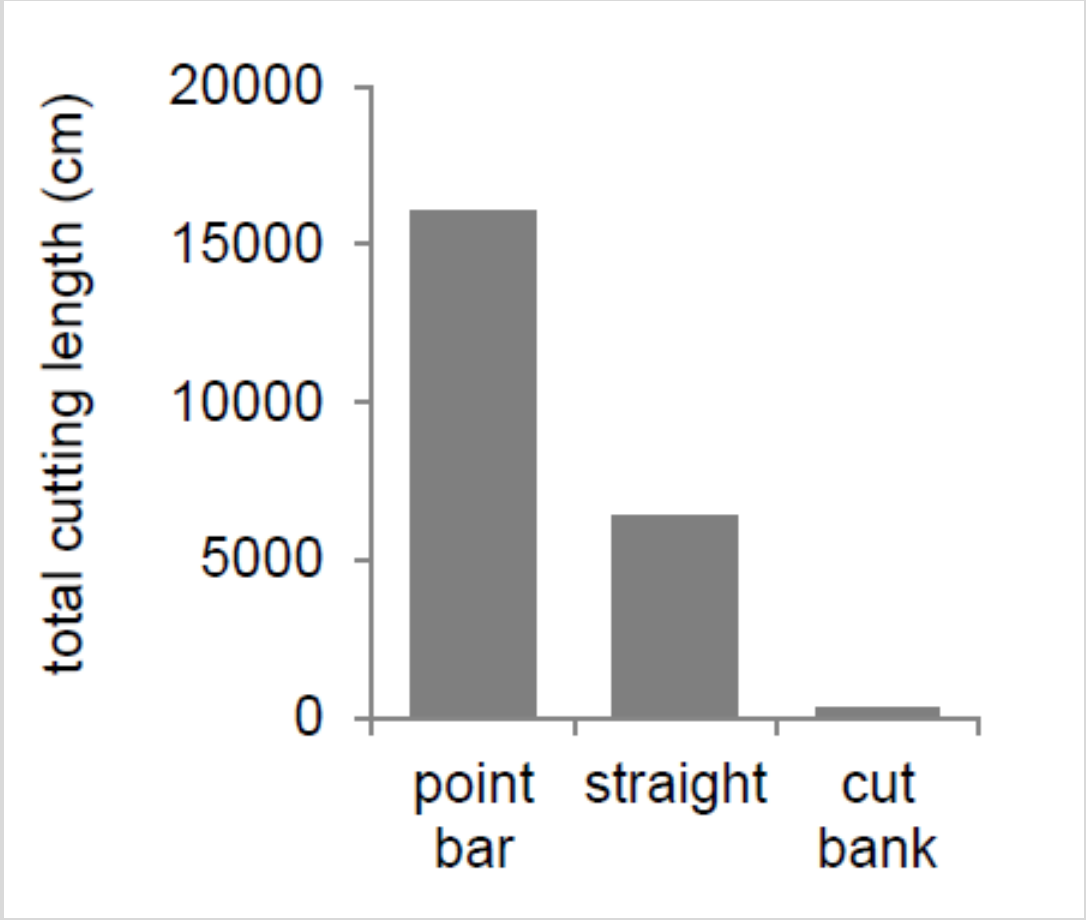
Stream	Channel Type	Mean Slope (m/m)*	Basin Area (km^2)^	Mean Annual Q (m^3/s)	Mean Peak Q (m^3/s)	Mean Reach Sinuosity*
Odell Creek (OC)	gravel bed, pool-riffle, meandering channel	0.004	45	1.32 (1.5 in 1998)	10.01	2.9
Red Rock Creek (RRC)	gravel bed, pool-riffle, meandering channel	0.003	97	1.35 (2.07 in 1998)	4.62	2.1
East Fork of Blacktail Deer Creek (EFBDC)	gravel bed, pool-riffle, meandering channel	0.009	125	0.85#	6.62#	1.8
Alkali Creek	gravel bed, plane bed, limited meandering, narrow floodplain	0.016	20	0.1##	1.42##	1.4

Bigger basin – less sinuous

Beaver cuttings are common



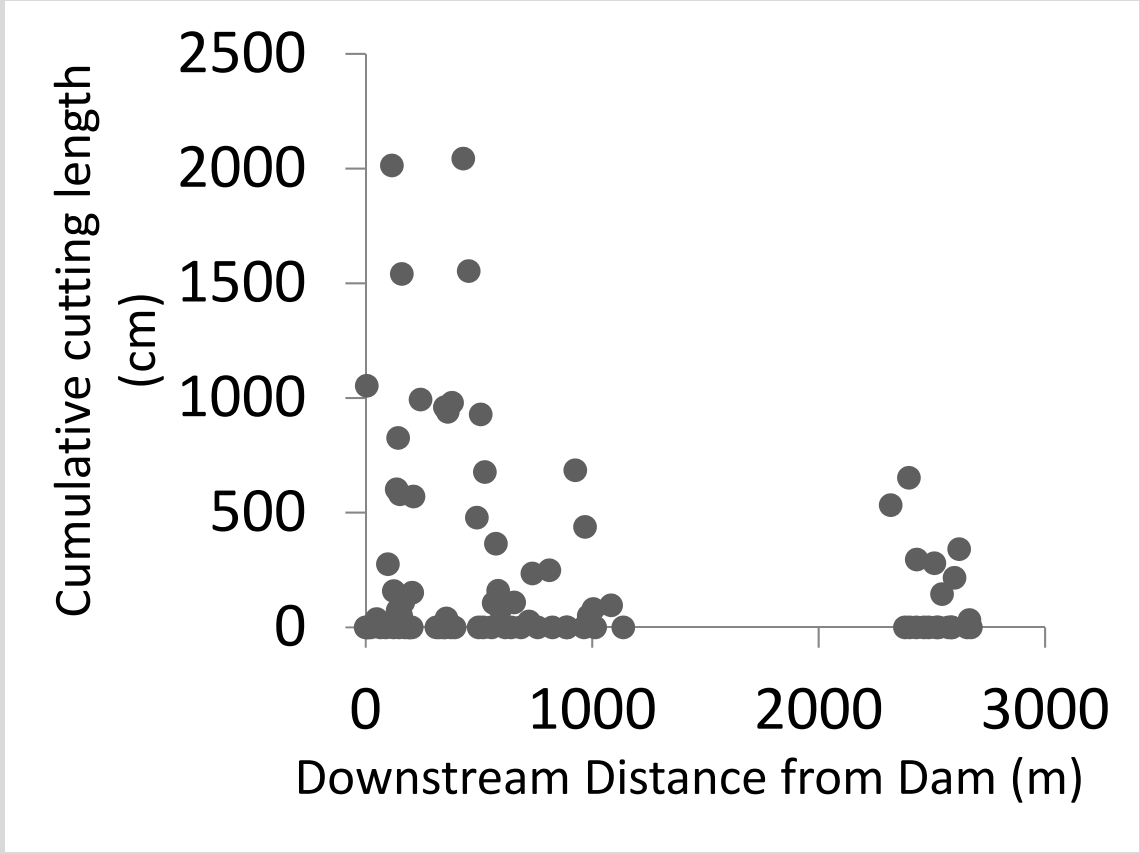
Cuttings are really common on point bars!



Sinuosity and gradient may play a role in effectiveness of trapping cuttings

Greater distance from a dam decreases accumulation

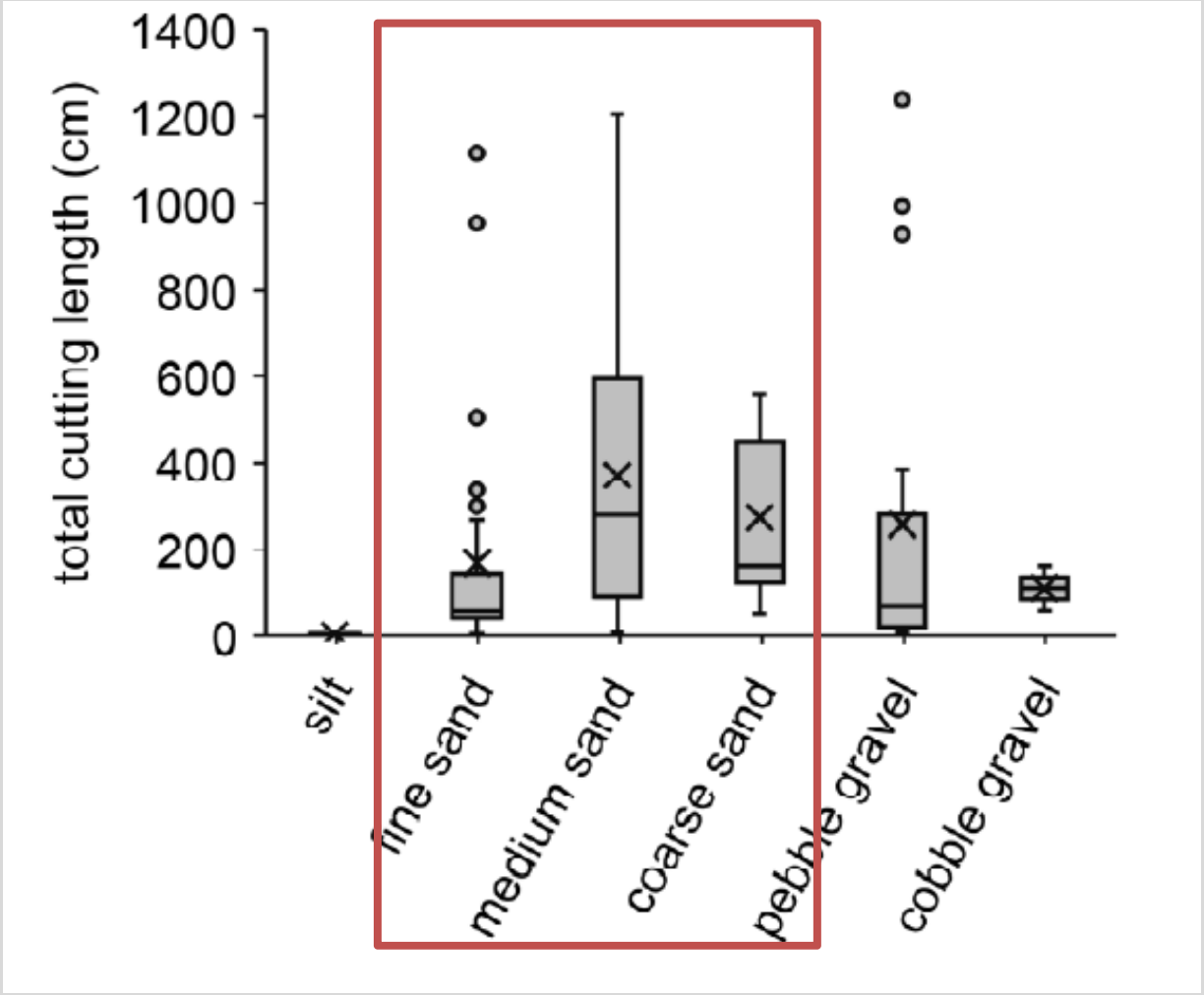
Linear mixed effects models – explaining variability



cutting length ↓ 0.06 cm/m
(SE ± 0.03 cm/m)

χ^2 (1) = 4.487, p = 0.03415

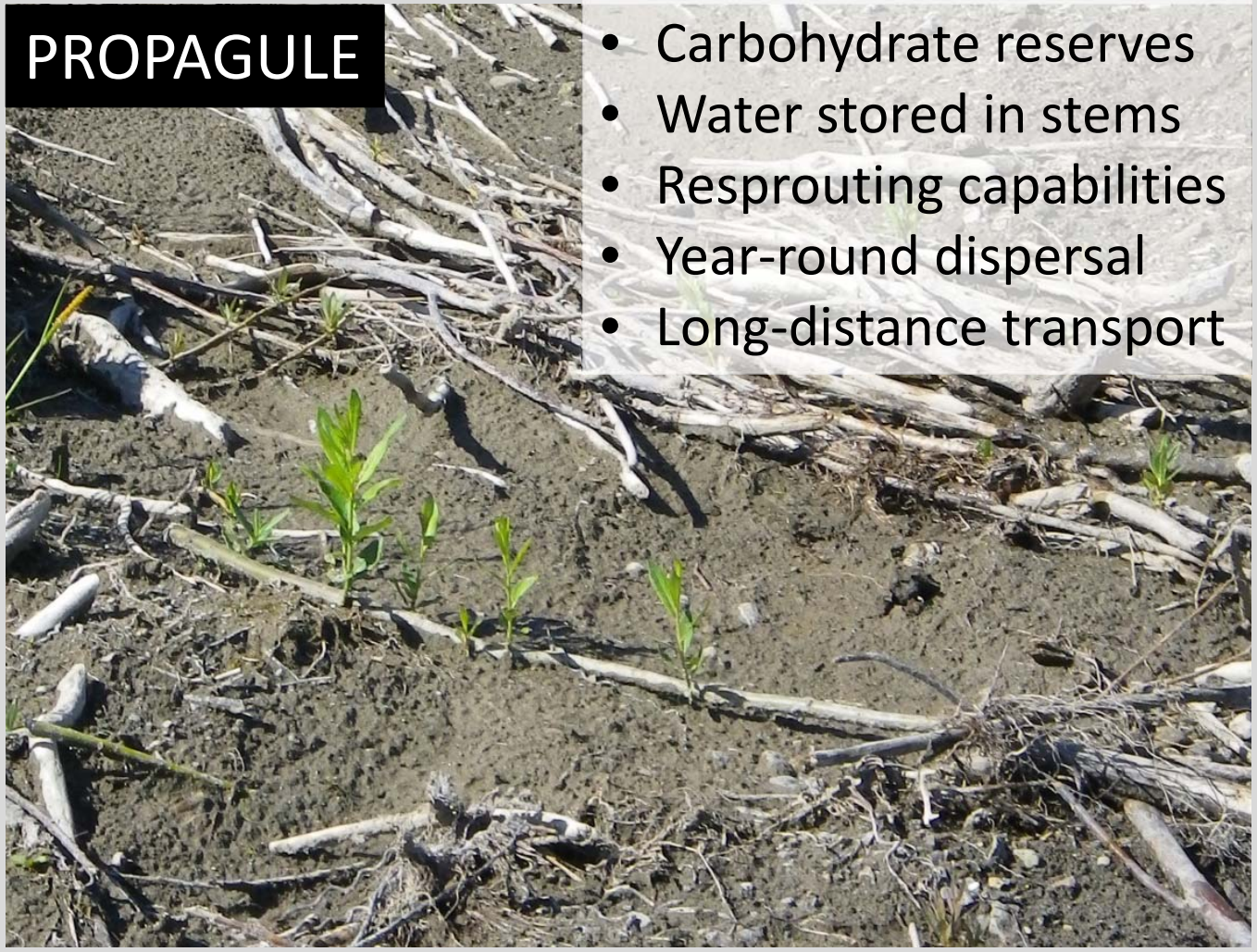
SAND



Cuttings are most commonly associated with medium sand

Sediment and cuttings work together to promote regeneration

- 25% of all sites (3 quadrats/site) had >1 sprout on a cutting



Beaver promote both modes of regeneration

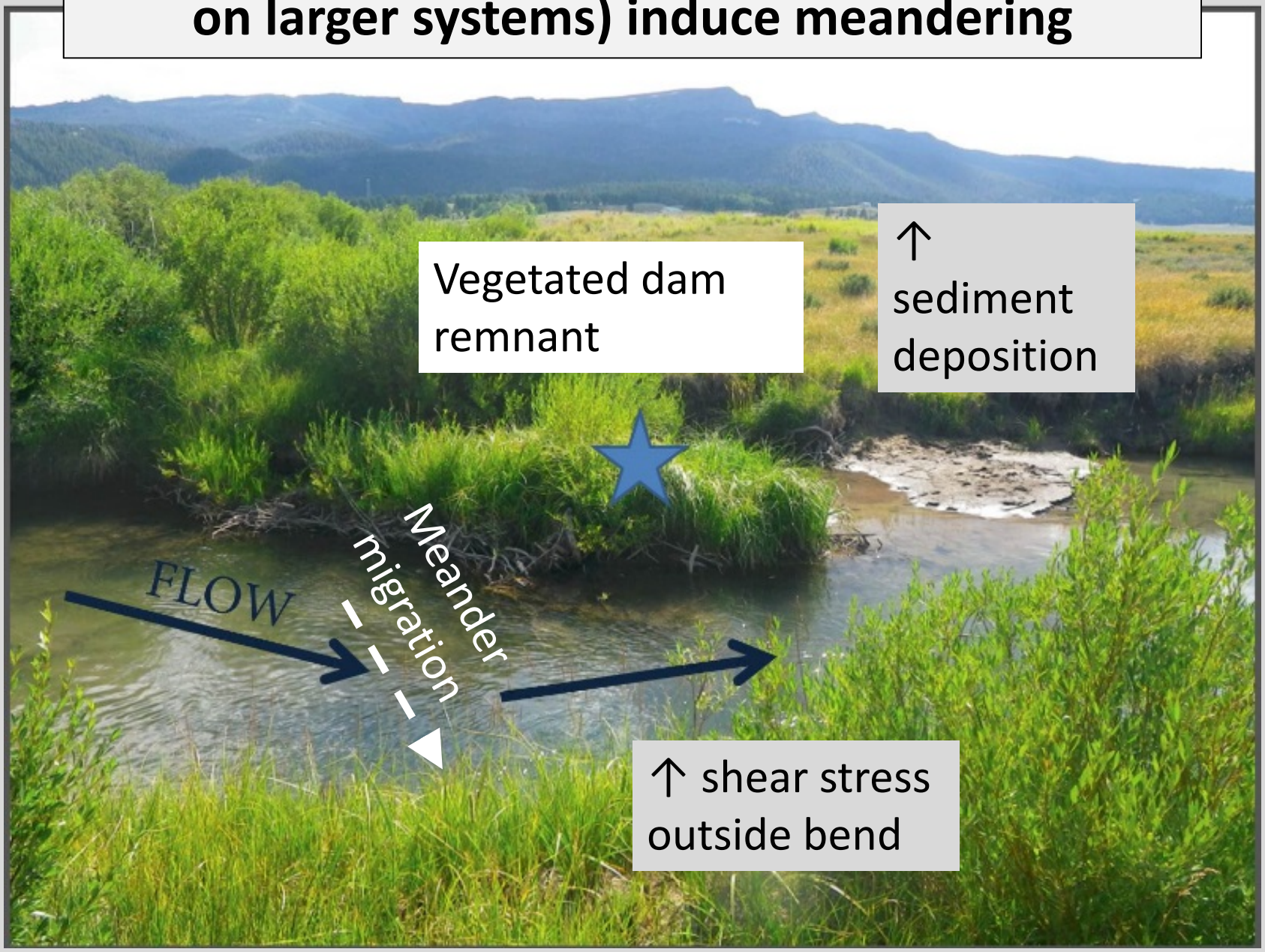
Beaver are a mechanism for propagule generation

Most willows species are FLEXIBLE
But are not resistant to beaver chewing

How to generate and get the benefits of plant propagule regeneration?

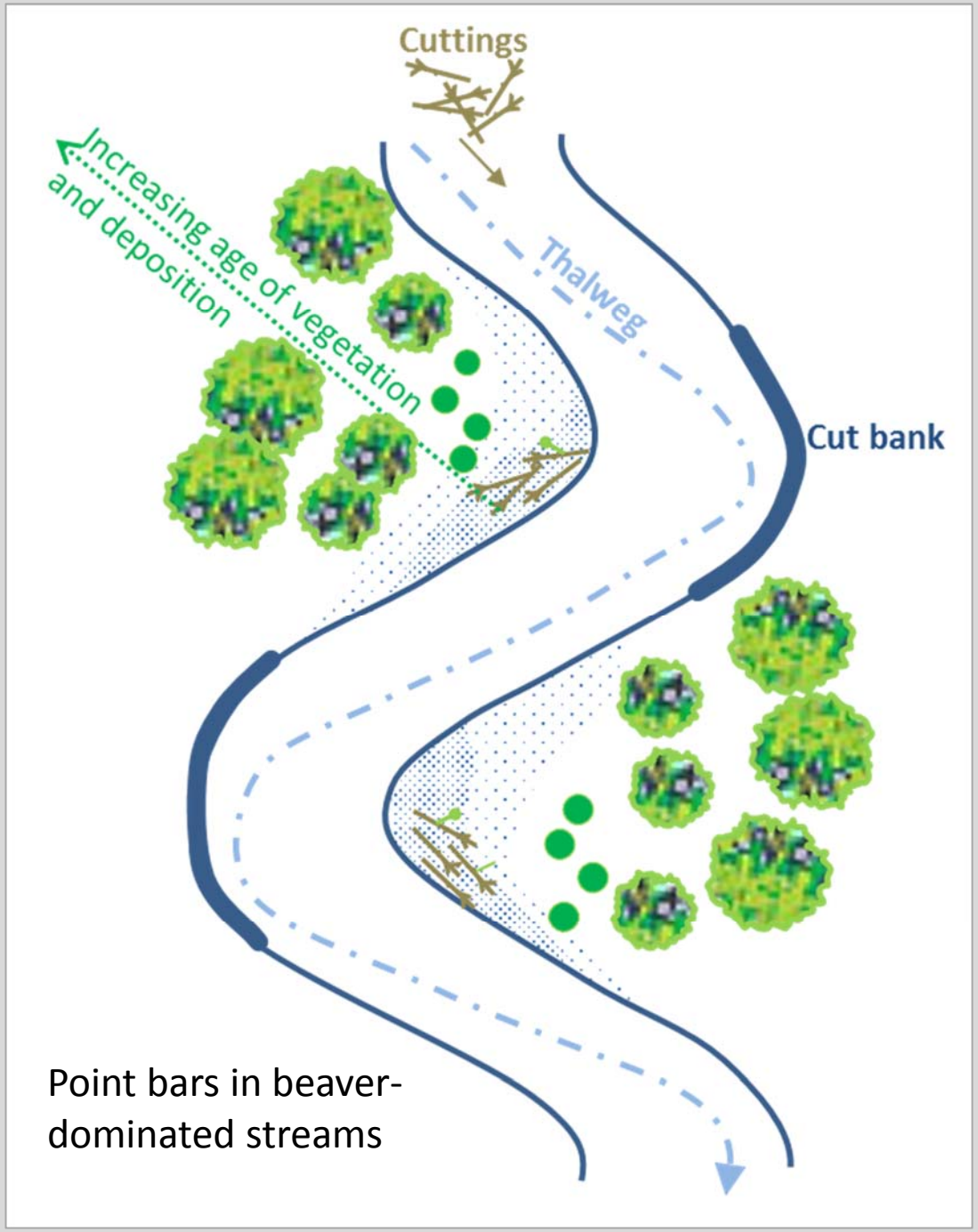
Requires a generator of propagules in relatively large numbers

Dam Remnants that are preserved (not ponds on larger systems) induce meandering



Eventual incorporation of dam into floodplain sediments as the channel shifts laterally away from the dam remnant

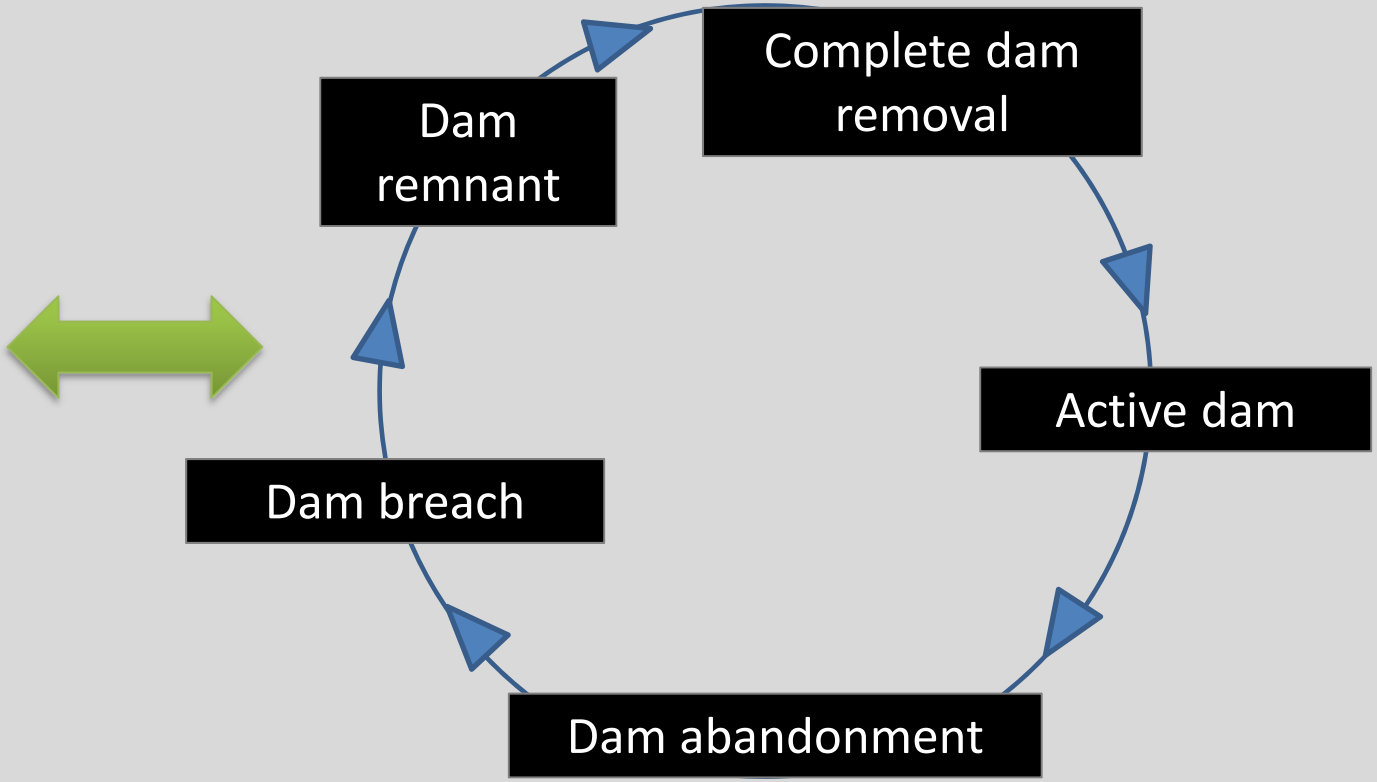
Dam failure and the beaver cycle promote dynamism and propagule movement



Point bars in beaver-dominated streams

Beaver cycle

Habitat heterogeneity



OR

Not appropriate for beaver damming

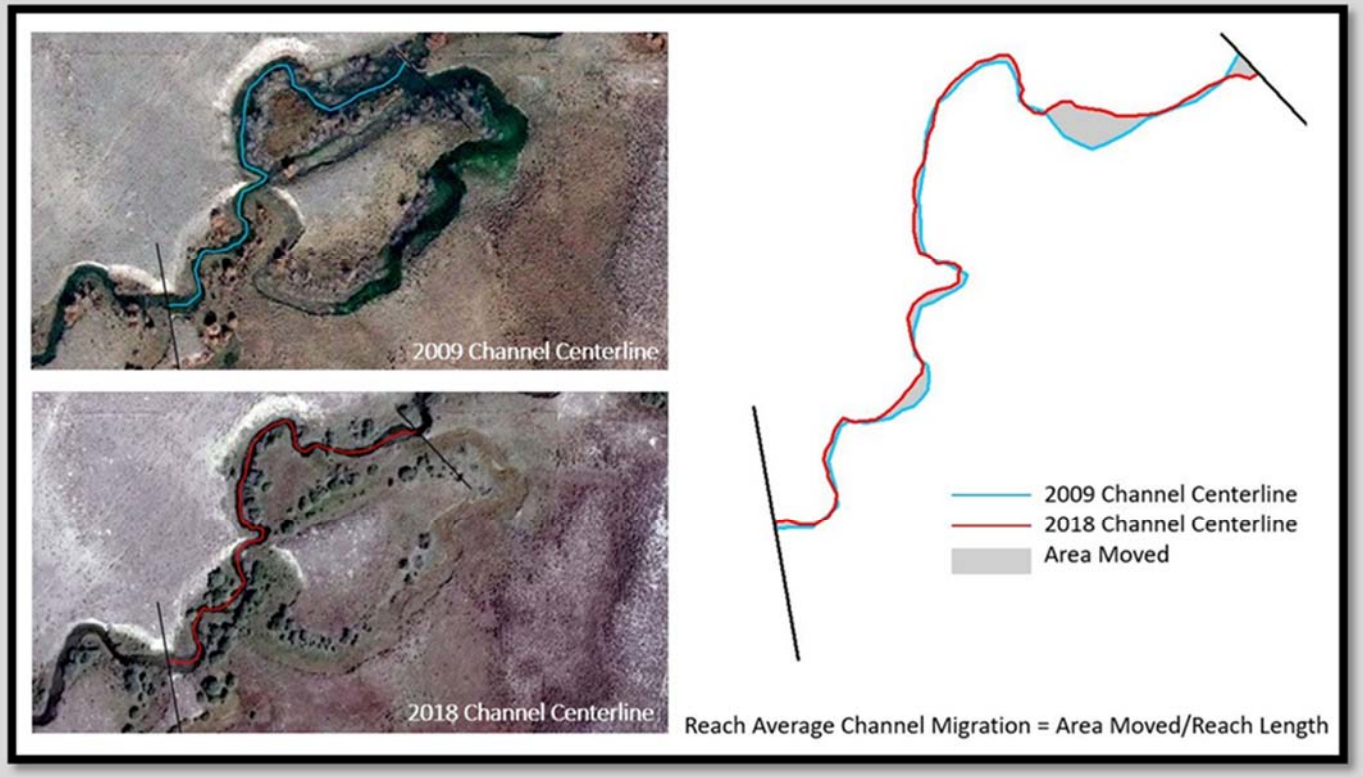
But how dynamic do beavers make rivers, at what scales?

Are beaver having an effect on long-term evolution of fluvial systems? Are beaver systems more dynamic? Do beaver influence valley floor development?

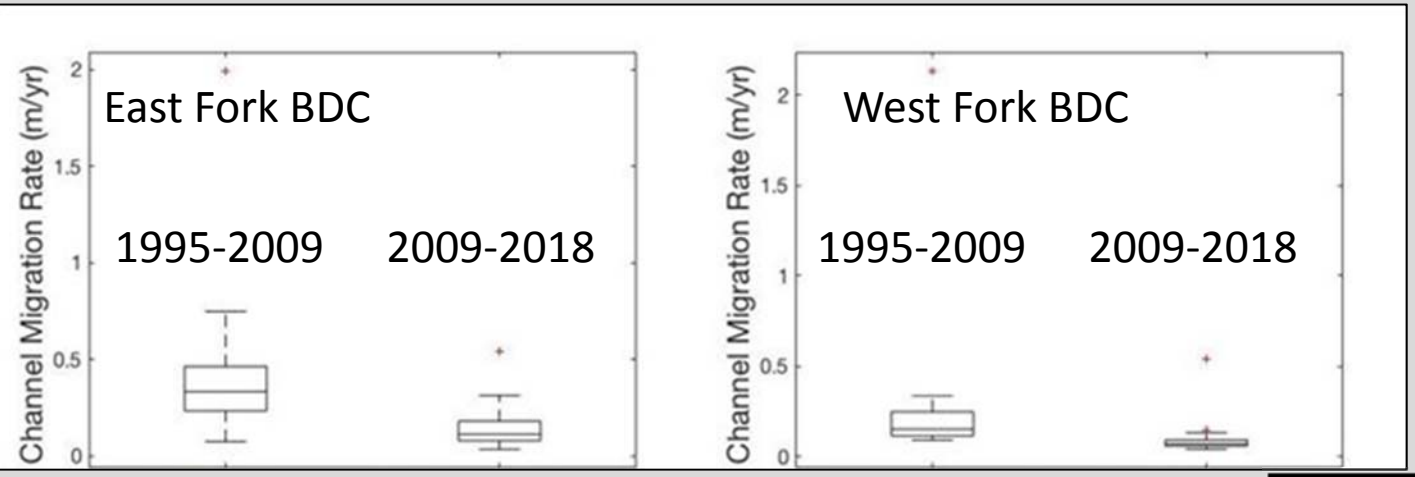
We are beginning to look at migration rates on beaver streams across southwest Montana to try to address these questions.

We started with Blacktail Deer Creek Drainage and have just finished looking at the data.

We compared centerlines between pre and post damming, and undammed reaches between two time periods to assess differences in migration rates between dammed and undammed reaches



Beaver Dams versus Discharge influencing channel dynamics



Damming status (dammed and undammed) was not significant in determining trends in migration rate.

Time period is what mattered.

1995 – 2009 gauging stations recorded many large floods across the region. On our streams: 2 x the migration rate and a statistically significant difference.

2009 – 2018 saw many fewer flood events and less migration of our study streams

Statistical Analyses	Test Utilized	Confidence Level	p-value	Significant Difference
W. Fork Dammed vs. Undammed Reaches (1995-2009)	Wilcoxon Rank Sum	95%	0.8911	No
W. Fork Dammed vs. Undammed Reaches (2009-2018)	Wilcoxon Rank Sum	95%	0.2177	No
E. Fork Dammed vs. Undammed Reaches (1995-2009)	Wilcoxon Rank Sum	95%	0.3070	No
E. Fork Dammed vs. Undammed Reaches (2009-2018)	Wilcoxon Rank Sum	95%	0.0532	No
W. Fork Pre-Dam (1995-2009) vs. Post-Dam (2009-2018)	Sign Test	95%	<0.001	Yes
E. Fork Pre-Dam (1995-2009) vs. Post-Dam (2009-2018)	Sign Test	95%	0.0025	Yes
W. Fork All Reaches (1995-2009) vs. All Reaches (2009-2018)	Wilcoxon Rank Sum	95%	<0.001	Yes
E. Fork All Reaches (1995-2009) vs. All Reaches (2009-2018)	Wilcoxon Rank Sum	95%	<0.001	Yes
W. Fork Dammed Upstream vs. Downstream (1995-2009)	Wilcoxon Rank Sum	95%	1.0000	No
W. Fork Dammed Upstream vs. Downstream (2009-2018)	Wilcoxon Rank Sum	95%	0.2123	No
E. Fork Dammed Upstream vs. Downstream (1995-2009)	Wilcoxon Rank Sum	95%	0.3833	No
E. Fork Dammed Upstream vs. Downstream (2009-2018)	Wilcoxon Rank Sum	95%	0.8777	No

CONCLUSIONS

- Deposits on Odell Creek appear to be buried point bar deposits rather than pond deposits raising interesting questions about the role of beaver in floodplain evolution
    - Initial data shows that beaver may be along for the climatological ride as river channels adjust to changing discharge.
- Beavers are messy builders they add to point bars and thus enhance riparian habitat and river dynamics
- Beaver dam breaches enhance meandering too! (More messiness)
- Beavers appear to enhance carbon storage in floodplains through burial of plant material.
- Beavers affect the whole system (though not the climate) … It is not just about the dam! We need to keep this in mind as we think about managing beaver dominated systems and using beaver in restoration.

For more on this: Levine and Meyer, 2019 Scientific Reports

Thanks!

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