Willow recruitment and channel patterns in beaver dominated stream systems

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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.

How do biotic interactions affect channel form and process?
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
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

~1150 cal yr BP

~4510 cal yr BP
What We Found: Holocene Beaver Deposits

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

Age-Depth Plot, c = charcoal, b = beaver cuttings
Prior Geologic Investigations of Beaver Deposits
Persico and Meyer (2009, 2013)
Polvi and Wohl (2012)
Kramer et al. (2011)

Other work on Holocene beaver deposits

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.*

Abandoned pond deposits.

Is this what we are having preserved?
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
<table>
<thead>
<tr>
<th>Stream</th>
<th>Channel Type</th>
<th>Mean Slope (m/m)*</th>
<th>Basin Area (km²)</th>
<th>Mean Annual Q (m³/s)</th>
<th>Mean Peak Q (m³/s)</th>
<th>Mean Reach Sinuosity*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Odell Creek (OC)</strong></td>
<td>gravel bed, pool-riffle, meandering channel</td>
<td>0.004</td>
<td>45</td>
<td>1.32 (1.5 in 1998)</td>
<td>10.01</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Red Rock Creek (RRC)</strong></td>
<td>gravel bed, pool-riffle, meandering channel</td>
<td>0.003</td>
<td>97</td>
<td>1.35 (2.07 in 1998)</td>
<td>4.62</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>East Fork of Blacktail Deer Creek (EFBDC)</strong></td>
<td>gravel bed, pool-riffle, meandering channel</td>
<td>0.009</td>
<td>125</td>
<td>0.85*</td>
<td>6.62*</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Bigger basin – less sinuous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alkali Creek</strong></td>
<td>gravel bed, plane bed, limited meandering, narrow floodplain</td>
<td>0.016</td>
<td>20</td>
<td>0.1**</td>
<td>1.42**</td>
<td>1.4</td>
</tr>
</tbody>
</table>
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

Cuttings are most commonly associated with medium sand

**Cutting length ↓ 0.06 cm/m**

\( \chi^2 (1) = 4.487, p = 0.03415 \)
Sediment and cuttings work together to promote regeneration

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

**PROPAGULE**
- Carbohydrate reserves
- Water stored in stems
- Resprouting capabilities
- Year-round dispersal
- Long-distance transport

**SEED**
- Wide dispersal
- Germination rates ~100%, but 10-20% survival
- Specific time of year

Beaver promote both modes of regeneration
Beaver are a mechanism for propagule generation

How to generate and get the benefits of plant propagule regeneration?
Requires a generator of propagules in relatively large numbers

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

Vegetated dam remnant

↑ sediment deposition

↑ shear stress outside bend

FLOW

Meander migration
Dam failure and the beaver cycle promote dynamism and propagule movement. 

**Beaver cycle**

**Habitat heterogeneity**

- Complete dam removal
- Active dam
- Dam abandonment
- Dam breach
- Dam remnant

**OR**

Not appropriate for beaver damming

Point bars in beaver-dominated streams.
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.
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**

<table>
<thead>
<tr>
<th>Test Utilized</th>
<th>Confidence Level</th>
<th>p-value</th>
<th>Significant Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. Fork Dammed vs. Undammed Reaches (1995-2009)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>0.8911</td>
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<tr>
<td>W. Fork Dammed vs. Undammed Reaches (2009-2018)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>0.2177</td>
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<tr>
<td>E. Fork Dammed vs. Undammed Reaches (1995-2009)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>0.3070</td>
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<tr>
<td>E. Fork Dammed vs. Undammed Reaches (2009-2018)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>0.0532</td>
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<tr>
<td>W. Fork Pre-Dam (1995-2009) vs. Post-Dam (2009-2018)</td>
<td>Sign Test 95%</td>
<td>&lt;0.001</td>
<td>Yes</td>
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<tr>
<td>E. Fork Pre-Dam (1995-2009) vs. Post-Dam (2009-2018)</td>
<td>Sign Test 95%</td>
<td>0.0025</td>
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<tr>
<td>W. Fork All Reaches (1995-2009) vs. All Reaches (2009-2018)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>&lt;0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>E. Fork All Reaches (1995-2009) vs. All Reaches (2009-2018)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>&lt;0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>W. Fork Dammed Upstream vs. Downstream (1995-2009)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>1.0000</td>
<td>No</td>
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<tr>
<td>W. Fork Dammed Upstream vs. Downstream (2009-2018)</td>
<td>Wilcoxon Rank Sum 95%</td>
<td>0.2123</td>
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<tr>
<td>E. Fork Dammed Upstream vs. Downstream (1995-2009)</td>
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<td>E. Fork Dammed Upstream vs. Downstream (2009-2018)</td>
<td>Wilcoxon Rank Sum 95%</td>
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</tbody>
</table>
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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