CAN BEAVER DAMS AGGRADE INCISED STREAMS TO THE POINT OF FLOODPLAIN RECONNECTION AND RECOVERY?

Joe Wheaton
Florie Consolati
Kenny DeMeurichy
Nick Bouwes

Michael Pollock
Chris Jordan
Carol Volk

A FEW YEARS AGO...

• All I knew was that...

| Image 1 | Image 2 | Image 3 | Image 4 |
THEN I MET THESE GUYS...

Nick Bouwes  Michael Pollock  Chris Jordan

BRIDGE CREEK EXPERIMENTAL WATERSHED

- 697 km²
- 42 cm Annual Precipitation
PROCESS OF CHANNEL INCISION
AGGRADATION - FLOODPLAIN RECONNECTION
BEAVER DAMS JUST DON'T LAST IN BRIDGE

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Robert Buechler, College of Forestry, Oregon State University, Corvallis, Oregon, USA

Recent History (1986-2006) of Beaver Dams along Bridge Creek in Central Oregon

Abstract

Beaver (Castor canadensis) dams on Bridge Creek in the Southwestern United States are a major geomorphic feature affecting stream morphology and aquatic habitats. Beaver activity has been shown to be a major influence on landscape evolution, and understanding the factors that influence beaver activity is critical to understanding large-scale ecological processes. This study examines the recent historical record of beaver activity on Bridge Creek to understand the factors that influence beaver dam construction and failure.

Introduction

Although rivers in Central Oregon do not support large populations of beavers, healthy beaver communities are present at a number of locations, including the Deschutes, John day, and Owyhee Rivers. Beaver activity is an important factor in the landscape evolution of Central Oregon, and understanding the factors that influence beaver activity is critical to understanding large-scale ecological processes. This study examines the recent historical record of beaver activity on Bridge Creek to understand the factors that influence beaver dam construction and failure.

Methods

A survey of beaver activity was conducted on Bridge Creek, Central Oregon, USA. The survey consisted of a systematic search for beaver dams along the length of the creek. The survey was conducted in the winter and spring of 2006, and the results were compared to the results of a previous survey conducted in 1986. The results of the survey were used to construct a historical record of beaver activity on Bridge Creek.

Results

The results of the survey showed that beaver activity has been decreasing in recent years. The number of beaver dams on Bridge Creek has decreased from 10 in 1986 to 1 in 2006. The results of the survey also showed that beaver activity is influenced by a number of factors, including streamflow, precipitation, and temperature.

Conclusion

Beaver activity on Bridge Creek has been decreasing in recent years, and the factors that influence beaver activity are complex and include a number of factors, including streamflow, precipitation, and temperature. Understanding the factors that influence beaver activity is critical to understanding large-scale ecological processes in Central Oregon.
BRIIDGE CREEK DAM PERSI STENCE
1988 - 2005

% of Dams

Years until abandoned

1989

Beaver Dam
IN POLLOCK ET AL (2007) ARGUED…

channel with adjacent reaches where no dams existed. We found that there was five times more area within 0.5 m elevation of the channel upstream of beaver dams, presumably because sediment accumulation had augmented the channel. Our results suggest that restoration strategies that encourage the reoccupation of streams by beaver can rapidly expand riparian habitat along incised streams. Copyright © 2007 John Wiley & Sons, Ltd.

Fig. 4. Detailed channel changes upstream of a beaver dam at the study site (A) and a channel of the Columbia River (B) for the reaches within the upstream of the beaver dam. Copyright © 2007 John Wiley & Sons, Ltd.
SO HELP ‘EM OUT... BUY THEM POSTS TIME

OVERARCHING HYPOTHESIS

• At Watershed Scale:
  - We can concentrate enough restoration activity within a single watershed such that there is a measurable population-level change in the steelhead that utilize the system

• At Reach Scale:
  - These physical changes will result in several positive feedback loops that will result in improved habitat conditions for beaver that in turn will lead to the construction of more beaver dams...
BEAVER DAM FEEDBACK LOOPS...

DESIGN CONCEPT

* Induce a disturbance (actively) ... allow it to unfold (passively) – Figure 17 (Pollock et al. 2011)
FOUR STRUCTURE TYPES

1. Starter Dam
2. Post Line Only
3. Post Line w/ Willow Weave
4. Reinforce Existing
**BASIC DESIGN CONCEPTS...**

- Structures placed at frequency to capitalize on all opportunities to promote aggradation and floodplain reconnection through time
- Overseed reaches (relative to current population)
- Structure work in concert with each other to
  - Avoid overly abrupt gradient drops
  - Resilience of reach/colony; demphasizes importance of any single structure
- Designed to be dynamic (posts will break down eventually)
- Sediment supply is fundamental
WHERE TO PUT POSTS?
SUMMARY

• 84 Structures installed in four reaches in 2009
  - 5 Reinforced existing dams
  - 4 Reinforced abandon dams
  - 10 Starter Dams
  - 44 Post lines with Wicker Weaves
  - 21 Post lines only
BRIIDGE CREEK MONITORING

I. Hypothesis Testing at Reach Scale
II. Hypothesis Testing at Structure Scale
III. What we still don’t know

• Pre-Project beaver monitoring (Since 1988)
• Pre-Project baseline monitoring (Since 2005)
• Post-Project monitoring (planned for 10+ years)

UNDERLYING RESEARCH QUESTIONS?

• Can it work? Can beaver really ‘restore’ an incised channel and reconnect it with its floodplain?
• What will be the impact on fish?
• How long will it take?
• How long might it last?
• If the beaver (or their dams) fail or abandon, are all the presumed benefits of damming lost?
WHAT WE’RE DOING TO ADDRESS THESE QUESTIONS...

- 4 Treatments & 6 Controls (25 km)
- Slough of things...
  - BDSS Monitoring
  - Repeat Aerial Surveys
  - Repeat Topographic Surveys
  - Beaver Monitoring
  - Fish Habitat Surveys
  - Fish growth, survival & movement
  - Fish diets
DRONE IMAGERY

0.5 m Naip  
0.1 m Drone
DRONE IMAGERY VEGETATION CLASSIFICATION

Legend
- White
- Green
- Cutbanks/middens
- Riparian
- Grassey/herbaceous
- Sandbars
- Nonplanted
- Water

2005 2010

REPEAT TOPOGRAPHY
GEOMORPHIC CHANGE DETECTION

• What can we do with that repeat topography?

• Develop a direct measure of channel aggradation and floodplain reconnection

ANALYSIS DONE IN GCD 5

• GCD 5 facilitates:
  - Robustly estimate errors in DEMs
  - Determine significance of uncertainty on DoD & Sediment Budget
  - Calculate change in storage sediment budgets (with +/- vol.)
  - Quantitatively interpret and spatially segregate budget

http://gcd.joewheaton.org
LETS LOOK AT ONE TREATMENT

Pat’s Cabin Reach

- Can it work? *Can beaver really ‘restore’ an incised channel and reconnect it with its floodplain?*
- What will be the impact on fish?
- How long will it take?

SUNFLOWER: BDSS PLACEMENT
GEOMORPHIC CHANGE DETECTION

- What can we do with that repeat topography?

- Develop a direct measure of channel aggradation and floodplain reconnection

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STARTER DAM OCCUPIED...

Installed September 2009, Occupied by November 2009
ANOTHER STARTER DAM OCCUPIED

FLOW FORCED ONTO FLOODPLAIN

Enough aggradation and dam activity @ secondary dam to force flow onto floodplain even at moderate flows.
STARTER DAM UPSTREAM OF FAILED DAM

- Prior to project there was one abandon, breached dam in this reach...
- One year later, there are eleven (15 BDSS) with 2-4 active colonies

BRIDGE CREEK FLOWS...

- Limited gage record (USGS: 14046778)
- Spring snow-melt dominated hydrograph
- 1st Year above average; 2nd Year sustained high flows
1st YEAR (2010-2009): OVERALL DoD

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Raw</th>
<th>Thresholded DoD Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Area of Erosion (m²)</td>
<td>15,383</td>
<td>461</td>
</tr>
<tr>
<td>Total Area of Deposition (m²)</td>
<td>178,117</td>
<td>1,151</td>
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<tr>
<td>VOLUMETRIC:</td>
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<td></td>
</tr>
<tr>
<td>Total Volume of Erosion (m³)</td>
<td>2,035</td>
<td>260 ± 83</td>
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<tr>
<td>Total Volume of Deposition (m³)</td>
<td>3,485</td>
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<tr>
<td>Total Volume of Difference (m³)</td>
<td>5,520</td>
<td>1,227 ± 383</td>
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<tr>
<td>Total Net Volume Difference (m³)</td>
<td>1,450</td>
<td>707 ± 351</td>
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<td>PERCENTAGES (BY VOLUME)</td>
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<tr>
<td>Percent Erosion</td>
<td>27%</td>
<td>21%</td>
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<tr>
<td>Percent Deposition</td>
<td>73%</td>
<td>79%</td>
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Erosion: 169 m³ +/- 54
Deposition: 176 m³ +/- 58
NET: + 7 m³ (+/- 79)

1st YEAR (2010-2009): BY COMPLEX
1st YEAR (2010-2009): BY MECHANISMS

Mechanisms of In-Channel Change

- BOSS Pond Deposit
- Lateral Bar Development
- Channel Bar DS BOSS
- Side Channel Deposition
- Bank Erosion
- Bar Surplus OS BOSS
- High Flow Surplus Channel
- Bar Flooded Pool Source
- Evacuation Stream Sediments

Attribute Raw

AREAL:
- Total Area of Erosion (m²) 14,626 1,582
- Total Area of Deposition (m²) 178,874 1,872

VOLUMETRIC:
- ± Error Volume %
  - Total Volume of Erosion (m³) 3,468 1,281 ± 362 28%
  - Total Volume of Deposition (m³) 2,715 808 ± 208 26%
  - Total Volume of Difference (m³) 6,183 2,089 ± 570 27%
  - Total Net Volume Difference (m³) -752 -473 ± 418 -88%

PERCENTAGES (BY VOLUME)
- Percent Erosion 56% 61%
- Percent Deposition 44% 39%
- Percent Imbalance (departure from equilibrium) -6% -11%

2nd YEAR (2011-2010): OVERALL DoD

<table>
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Thresholded DoD Estimate:
- Erosion: 512 m³ +/- 143
- Deposition: 927 m³ +/- 241
- NET: + 415 m³ (+/- 280)

Geomorphic Interpretation

- High Flow Surplus Channel
- Bar Surplus OS BOSS
- Channel Widening
- Bar Surplus OS BOSS
- Channel Aggradation
- Lateral Bar Development
- Side Channel Deposition
- Evacuation Stream Sediments
- Questionable

Erosion: 512 m³ +/- 143
Deposition: 927 m³ +/- 241
NET: + 415 m³ (+/- 280)
WHAT WE TAKE AWAY FROM PATS CABIN...

- 1st year budget indeterminant or equilibrium
- 2nd year budget strong depositional signal despite major headcuts & breaches
- Longitudinal patterns highlight role of local supply
- BDSS Pond aggradation rapid and consistent
- Many former terraces are now inset floodplains
- If it works, its cheap!
- Beaver do the maintenance!

ELSEWHERE... WE SEE SIMILAR RESULTS

- 84 Structures installed in four reaches (in 2009); Now 110
  - 5 Reinforced existing dams
  - 4 Reinforced abandon dams
  - 10 Starter Dams
  - 44 Post lines with Wicker Weaves
  - 21 Post lines only
BDSS PERSISTENCE

From Nick Weber

NEXT LETS LOOK AT ‘FAILURES’...

Upper Owens & Boundary

• If the beaver (or their dams) fail or abandon, are all the presumed benefits of damming lost?

    When a dam fails, what happens to the pond deposit that was reconnecting the floodplain?
ROLE OF ABANDONMENT & FAIL URE

• What happens post dam failure?

• What if abandonment is permanent?

Typical Causes of Abandonment
- Seasonal Migration (temporary)
  - Dam Breach/Failure (permanent and temporary)
  - Exhaustion of Food/Building
  - Material loss (permanent or temporary)
  - Decreased Functionality (e.g., pond degradation; permanent or temporary)
  - Predation (natural; permanent or temporary)

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UPPER OWENS

Figure 10: Progression of reach at upper Owens through a period without a dam (A; 2005), with an active, partially breached dam (B; Nov 2009), to an abandon, partially breached dam (C; April 2010).
CAPTURED THE POST FAILURE RESPONSE

- Erosion: 28.2 m$^3$ +/- 4
- Deposition: 33.6 m$^3$ +/- 6

MORE INTERESTING....
ROLE OF ABANDONMENT & FAILURE?

• What happens post dam failure?

• What if abandonment is permanent?

Typical Causes of Abandonment

In both instances, the short term (one year) response is that of net aggradation & a net increase in channel complexity over time

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DYNAMICS MATTER!
BEAVER USE

Not Used 77%
Used 23%

From Nick Weber

SIDE NOTE: THEY’LL BUILD WHERE THEY DAM WELL PLEASE

• Posts go in Sept 2009
• Beaver ignore posts and build their own dam 10 m downstream by Nov 2009
• By Nov 2010, their dam has completely aggraded, then they build on BDS 19
SIDE NOTE: THEY’LL BUILD WHERE THEY DAM WELL PLEASE
THERMAL SITES

METHODS: TEMPERATURE SENSORS
METHODS: TEMPERATURE PROBE

• Attached temperature probe to rtkGPS

• Allowed for high resolution mapping of temperature at snapshot in time

THERMAL HETEROGENEITY

Day 1           Day 2          Day 3          Day 4          Day 5          Day 6

Day 7
**DIGITAL TEMPERATURE MODEL**

**Boundary: Control Reach**

August 18, 2012

Maximum Temp = 22.25 C  
Minimum Temp = 19.50 C  
Difference = 2.75 degrees

**DIGITAL TEMPERATURE MODEL**

Lower Owens: Beaver Influenced Reach  
August 20, 2012

Maximum Temp = 23.25 C  
Minimum Temp = 12.00 C  
Difference = 11.25 C
TEMPERATURE FREQUENCIES:
AUGUST 13-21, 2012

[Graph showing temperature frequencies with two histograms labeled Lower Owens: Beaver Influenced and Boundary: Control.]

(Werhly et al., 2007)

What About the Fish?
SOME PRELIMINARY CONCLUSIONS

- Rapid colonization of BDSS after installation
- Rapid response working with beaver to restore incised channel & reconnect with floodplain in the right direction.... Will it last?
- Dramatic improvements in habitat complexity
- Too early for fish population response
- Treatment is cheap...
STRUCTURE SITING – MEYERS CAMP

YOUR TURN… BOUNDARY REACH

- 697 km²
- 42 cm Annual Precipitation
YOUR TURN

- Choose BDSS types:
  - PLWW
  - PL Only
  - Starter Dam
  - Reinforce Existing Dam
- Place them on map
- Draw orientation of posts
- Set crest elevation
- Diagram hypothesized response
- Draw detail (optional)