Downstream Hydrologic and Geomorphic Effects of Large Dams on American Rivers

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Research Questions

• What are the hydrologic differences between unregulated and regulated river reaches?

• What are the resulting geomorphic differences between unregulated and regulated river reaches?

• Why do these differences occur?
Overview

• Previous Research

• Basic Research Strategy and Data

• Methods for Hydrology and Geomorphology

• Results for Hydrology, Geomorphology, and Connections

• Conclusions
Previous Work in this Series

- 1999: census of dams
- 2001: dams and physical integrity
- 2002: SW willow flycatcher case study
- 2002 & 2003: dam removal
- 2005: scientific, social, economic context
- 2006: downstream effects of dams
## Hydrologic Indicators

<table>
<thead>
<tr>
<th>Max/Mean</th>
<th>Capacity/Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Max</td>
<td>Annual Range</td>
</tr>
<tr>
<td>1-Day Max</td>
<td>No. Reversals</td>
</tr>
<tr>
<td>30-Day Max</td>
<td>Up-Ramp Rate</td>
</tr>
<tr>
<td>Max Date</td>
<td>Down-Ramp Rate</td>
</tr>
<tr>
<td>Daily Mean</td>
<td>No. High Pulses</td>
</tr>
<tr>
<td>Annual Min</td>
<td>High Pulse Duration</td>
</tr>
<tr>
<td>1-Day Min</td>
<td>No. Low Pulses</td>
</tr>
<tr>
<td>30-Day Min</td>
<td>Low Pulse Duration</td>
</tr>
<tr>
<td>Min Date</td>
<td></td>
</tr>
</tbody>
</table>
Geomorphologic Indicators

Functional Surfaces

- Low Flow Channel
- High Flow Channel
- Low Bars
- High Bars
- Islands
- Active Flood Plains
- Inactive Flood Plains
- Engineered Surfaces
Unit Active Area

\[ A_u = \frac{A_a}{L} / A_d \]
Complexity Index

\[ C_i = \frac{f}{L_c} \]
Hydrologic Differences: Unregulated vs. Regulated

In Regulated reaches ....

- Annual maximum discharge \(-67\%\) *
- 1-day maximum discharge \(-71\%\) *
- 30-day maximum discharge \(-25\%\) *
- Annual max / Annual mean \(-60\%\) *
• Annual minimum discharge -33 % *
• 1-day minimum discharge -13 %
• 30-day minimum discharge +52 % *
• Annual min / Annual mean -29 % *
• Annual range of daily flows -60 % *
• Number of reversals   +34 %  *

• Daily up-ramp rate   -60 %  *

• Daily down-ramp rate   -19 %  

• Duration of high pulses   +71 %  *

• Date of Max (unchanged) 

• Date of Min (Aug 13 – Sept 11)
<table>
<thead>
<tr>
<th>Region</th>
<th>Max/Mean</th>
<th>Cap/Yield</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>14.4</td>
<td>0.9</td>
<td>-58 %</td>
</tr>
<tr>
<td>Great Plains</td>
<td>21.4</td>
<td>2.8</td>
<td>-65 %</td>
</tr>
<tr>
<td>Ozarks</td>
<td>25.4</td>
<td>2.6</td>
<td>-56 %</td>
</tr>
<tr>
<td>Pacific NW</td>
<td>3.6</td>
<td>0.5</td>
<td>-19 %</td>
</tr>
<tr>
<td>Interior West</td>
<td>11.2</td>
<td>3.2</td>
<td>-67 %</td>
</tr>
<tr>
<td>California</td>
<td>15.8</td>
<td>1.9</td>
<td>-58 %</td>
</tr>
<tr>
<td>All Regions</td>
<td>16.1</td>
<td>1.9</td>
<td>-58 %</td>
</tr>
</tbody>
</table>
Geomorphologic Differences: Unregulated vs. Regulated

In Regulated reaches ....

- Low flow channel area: +32 % *
- High flow channel area: -77 % *
- Low bar area: -52 % *
• High bar area  
  +7 % *

• Island area  
  -75 % *

• Active flood-plain area  
  -79 % *

• Inactive flood-plain area  
  +363 % *

• Engineered area  
  +145 % *
<table>
<thead>
<tr>
<th>Regional Diff.</th>
<th>Active Area</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>-27 % *</td>
<td>-56 % *</td>
</tr>
<tr>
<td>Great Plains</td>
<td>-91 % *</td>
<td>-14 % *</td>
</tr>
<tr>
<td>Ozarks</td>
<td>-82 % *</td>
<td>-39 % *</td>
</tr>
<tr>
<td>Pacific NW</td>
<td>-43 % *</td>
<td>-16 % *</td>
</tr>
<tr>
<td>Interior West</td>
<td>-65 % *</td>
<td>-52 % *</td>
</tr>
<tr>
<td>California</td>
<td>-64 % *</td>
<td>-49 % *</td>
</tr>
<tr>
<td>All Regions</td>
<td>-72 %</td>
<td>-37 %</td>
</tr>
</tbody>
</table>
General Construct

Upstream components

Dam and Releases

Downstream components
Regulated Downstream Functional Surfaces

- Active Flood Plain Reduced
- Islands and Bars Reduced
- High Flow Channels Abandoned

- Decreased Active Area
- Decreased Complexity

Downstream Valley Configuration

Pre-Dam Functional Surfaces

Regulated Downstream Riparian Habitat

- Area of Riparian Zone Reduced
- Variety of Inundation Areas Reduced
- Variety of Landforms Reduced

- Shrunken Riparian Habitats
- Simplified Array of Habitat Patches

Downstream Pre-Dam Habitats
Platte River

1938

1998