Process-based principles for restoring dynamic river ecosystems

Tim Beechie, George Pess, Michael Pollock, Phil Roni
NOAA Fisheries, Seattle
Why process restoration?

- Organisms are adapted to local habitat conditions
- Habitats are dynamic in space and time
Why process restoration?

- Piece-meal targets
  - US Endangered Species Act
  - US Clean Water Act

- Fragmented actions
  - Difficult to address causes
  - Difficult to restore ‘enough’
Process-based restoration

- Restoration is often focused in the channel
Process-based restoration

- Process restoration focuses on causes of habitat change.
- Restoration is often focused in the channel.
Process-based principles

1. Address causes of ecosystem change

2. Match scale of restoration with scale of physical and biological processes

3. Be explicit about expected outcomes

4. Be explicit about recovery time
Address causes of change

- Humans
- Landscape processes
- Habitat conditions
- Biota
Vegetation

Geology

Climate

Humans

Sediment supply
Signal inputs

Hydrologic regime

Organic matter inputs

Nutrient/chemical inputs

Light/heat inputs

Physical habitat characteristics

Water quality and primary productivity

Biological response
Address problems at the source

- Non-point sediment sources
  - Humid mountains
Address problems at the source

- Non-point sediment sources
  - Semi-arid interior
Address problems at the source

- Longitudinal connectivity
  - Integrity of flow and sediment regimes
- Vertical connectivity
  - Bed elevation, groundwater connections
- Lateral connectivity
  - Floodplain dynamics
Scale of restoration must match physical and biological process scales
Scales of process restoration

- Basin scale
  - Non-point processes

- Sediment supply
- Hydrologic processes
  - Urban
  - Rain-on-snow
- Water quality
- Riparian functions
- Floodplain dynamics
- Inaccessible habitat
  - Stream blockages
Scales of process restoration

- Reach scale
  - Localized effects

- Sediment supply
- Hydrologic processes
  - Urban
  - Rain-on-snow
- Water quality
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Scales of process restoration

- Sediment supply
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- Inaccessible habitat
  - Stream blockages

- Connectivity
  - Migration pathways
Match scale of biological processes

- Scale of salmon life cycle larger than that of most landscape processes
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Match scale of biological processes

- Interior Columbia salmon
Be explicit about expected outcomes

- Understand natural potential
- Describe target conditions clearly
Historical data: habitat change

<table>
<thead>
<tr>
<th>Wetland type</th>
<th>Decrease in area</th>
</tr>
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<tbody>
<tr>
<td>Riverine Tidal</td>
<td>-84%</td>
</tr>
<tr>
<td>Estuarine Forested Transition</td>
<td>-66%</td>
</tr>
<tr>
<td>Estuarine Emergent Marsh</td>
<td>-68%</td>
</tr>
<tr>
<td>Total</td>
<td>-72%</td>
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</table>

B. Collins 2000 (University of Washington) and
E. Beamer, unpublished (Skagit System Cooperative)
Historical data: riparian potential
**Reference sites: tributary pool area**

- Present-day habitat inventory
- Reference site data to estimate historic conditions

<table>
<thead>
<tr>
<th>Channel Slope</th>
<th>&lt;2%</th>
<th>2%-4%</th>
<th>&gt;4%</th>
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<tr>
<td><strong>Unlogged</strong></td>
<td>64</td>
<td>54</td>
<td>35</td>
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<td><strong>Agriculture</strong></td>
<td>47</td>
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Reference sites: channel pattern

- Straight
- Meandering
- Island Braided
- Braided

Increasing lateral migration rate
Reference sites: channel pattern

- Patch age distributions

[Diagram showing patch age distributions for different channel patterns: braided, island-braided, meandering, and straight. The diagram includes a legend for age classes (0-5, 5-25, 25-75, >75) and increasing age is indicated by a green arrow.]
Reference sites: channel pattern

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<th>Braided</th>
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<td>Median age of floodplain surfaces</td>
<td>65</td>
<td>48</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>Floodplain erosion return interval</td>
<td>89</td>
<td>60</td>
<td>33</td>
<td>8</td>
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Increasing migration rate
Reference sites: channel pattern

![Graph showing relationship between slope and discharge](image)

- **Slope (m/m)**
- **Discharge (m³/s⁻¹)**

Equations:
- \( S = 0.1Q^{-0.42} \)
- \( S = 0.05Q^{-0.61} \)

Legend:
- braided
- island-braided
- meandering
- straight

Images:
- Braided
- Island-braided
- Straight
Theoretical prediction

- Premise: basin topography and hydrology control channel morphology
- Simple mechanistic models
- Process-based framework
Be explicit about recovery time

- Some processes are slow to show results
  - Riparian restoration (10s – 100s of years)
  - Erosion controls (10s of years)

- Some processes yield nearly instant results
  - Restore migration pathways
  - Restore flow and sediment connectivity
Restoring incised streams

[Graph showing recovery time and bed elevation for different timescales]

110-200 yrs
Restoring riparian functions
Summary

- Avoids common pitfalls
  - Created habitats outside the range of natural potential
  - Structures overwhelmed by untreated system drivers
- Sustainable
  - Processes maintain habitat diversity
- Tempers expectations
Summary

1. Address causes of ecosystem change

2. Match scale of restoration with scale of physical and biological processes

3. Be explicit about expected outcomes

4. Be explicit about recovery time
- **Process restoration**

- **Examples of detailed steps for restoration planning**

- **Recovery time examples**