Day 1. Palmer
Ecological Context of Restoration

1. Why do we restore rivers? *ecosystem services concept*
2. How are restoration **objectives** linked to services? Are they?
3. What are our **options** for restoration to provide services?
4. How does the ability to do this depend on **context**?

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**Ecosystem services of rivers**

- **purify water** - denitrification, contaminate uptake
- **store water** - groundwater recharge
- **contribute to climate control** - moderate temperatures
- **control floods, reduce erosion** - absorb storm 'energy'
- **provide habitat** - support diverse aquatic life
- **process & store carbon** - nutrient regeneration
From Roni et al. 2005

Every stream has a context that is linked to its position in the watershed, climatic region, land use, etc.

Northwest Branch watershed
Every stream reach has a context
...a template for ecological structure and function
that is fundamentally linked to its hydrology & geomorphology

Palmer, Intro lecture

2. Longitudinal dimension

The River Continuum Concept

Figure 9.10 The continuum concept divides a river into three sections: headwater streams, the middle river, and the lower reaches. Changes in the properties of shredders, grazers, collectors, and predators result in changes in energy flow and nutrient cycling in these sections. (Modified from Vannote et al. rights by permission.)
2. Lateral dimension

Floodplains
- regions of high biodiversity and production
- slow water, trap nutrient sediments, and reduce peak flows
- refugia

Lateral hyporheic zones
- dominated by interstitial fauna (meiofauna)
- refugia
- high nutrient turn-over

See Riparia Naiman et al. 2005 Especially Fig. 2.4 page 29

Riparian zone
- role of vegetation: interception; evaporation; concentration; selective uptake
- riparian trees- keystone species for river ecosystems
- critical habitat for long-range migration of terrestrial animals (e.g., neotropical birds)
- important biogeochemical transition zones

1. stems, branches, & leaves interact with overbank flow; 2. flow diversion by log jams; 3. change in the infiltration rate of flood waters and rainfall by litter; 4. increase of turbulence as a consequence of root exposure; 5. increase of substrate macro-porosity by roots; 6. increase of capillary fringe by fine roots; 7. stem flow; 8. condensation of atmospheric water and interceptions of dew by leaves.
3. Vertical dimension

Surface water-hyporheic –groundwater interactions create patch mosaic

- rapid chemical transformations as water enters & leaves HZ (often controlled by O2 availability)
- also influences thermal structure of streams
- influences denitrification and other biogeochemical processes
4. Temporal dimension

*Variability is the norm in rivers... balance of nature is the exception*

Flow regime is considered to be a “master variable” that influences a river’s ecosystems via multiple pathways.

FLOW REGIMES (sensu Poff)

Can predict functional groups expected at a site based on flow regime
1. Why do we restore rivers? *ecosystem services concept*

2. *How are restoration objectives linked to services?*

3. What are our options for restoration to provide services?

4. How does the ability to do this depend on context?

Are they?

**River Restoration Trends in the U.S.**

- Pacific Northwest
- Central US Large Rivers
- Upper Midwest
- Chesapeake Bay
- California
- Southwest
- Southeast

# of Restoration Projects per 1000 river km

- < 0.25
- 0.25 - 0.75
- 0.75 - 1.5
- 1.5 - 3
- 3 - 5
- 5 - 15
- 15 - 75
- 75 - 150
- > 150

(Bernhardt et al. 2005)
**13 Categories of Restoration Goals**

- Water quality improvement
- Riparian management
- In-stream habitat improvement
- Channel reconfiguration
- Bank stabilization
- Dam removal
- Floodplain reconnection
- Fish passage
- Stormwater management
- Instream species management
- Aesthetics/ recreation/ education
- Land acquisition
Why rivers are being restored: regional differences

Aesthetics/Recreation/Education
Bank Stabilization
Channel Reconfiguration
Dam Removal Retrofit
Fish Passage
Floodplain Reconnection
Flow Modification
Instream Habitat Improvement
Instream Species Management
Land Acquisition
Combined non-dominant
Other
Riparian Management
Stormwater Management
Water Quality Management

To facilitate visual comparison only the top five intent categories for each node are shown in each pie chart. All other “non-dominant” intents are summed as part of the “Combined Non-dominant” wedge.

Most common reasons for stream restoration

1. Water Quality Management

Options: riparian buffers, livestock exclusion, septic improvements, acid mine drainage remediation, wetland creation, etc.
2. Riparian Management

- riparian planting, fencing, removal of non-natives
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3. In-stream habitat improvement
Create riffles & pools, add wood, flow deflectors
In-stream Habitat Improvement

Activities implemented for:
- Rip rap
- Fencing
- Rock vanes
- Step pools
- Reveg
- Fish screens, ladders, sunken culverts

4. Fish Passage
fish screens, ladders, sunken culverts
5. Bank Stabilization

- rip-rap, gabions, root wads, Matting/live stakes, biologs

Activities implemented for Bank Stabilization:

- Rip rap
- Rock vanes
- Culverts
- Reveg
- Modeling
- Grading
- Revegetation-seedlings/saplings
- Revegetation-seeds
- Revegetation-shrubs
- Revegetation-live stakes
- Revegetation (unspecified)
- Agricultural BMPs
- Fencing
- Livestock exclusion
- Riparian buffer creation/maintenance
- Other
5. Flow modification
static or dynamic channel reconstruction,
removal of channel protection

6. Channel Re-configuration
static or dynamic channel reconstruction,
removal of channel protection
**In-stream species management:**
re-establishing native species, removing exotic aquatic species

- Grass carp
- Northern snakehead
- Potamogeton

**How much is being spent?**

Total expenditures 1996-2003 > $14 billion (ca. $1B per year)
Average cost per project $380,000
Are they successful?  
What is the outcome?

<table>
<thead>
<tr>
<th>NRRSS I</th>
<th>NRRSS II</th>
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<tbody>
<tr>
<td>Summary Database</td>
<td>Interviews</td>
</tr>
<tr>
<td>10%</td>
<td>60%</td>
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</tbody>
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% of Projects Monitored

Day 1. Palmer. Success In Restoration

**Stakeholder Success**
- Aesthetics
- Economic Benefits
- Recreation
- Education

**Ecological Success**
- Guiding image exists
- Ecological improvement
- Self-sustaining
- No lasting harm done
- Assessment completed

**Learning Success**
- Scientific contribution
- Management experience
- Improve methods

Palmer et al. (the NRRSS working group). 2005 J. Applied Ecology
1. A guiding image

A dynamic endpoint identified a priori and used to guide the restoration

- Describes the dynamic, healthy river that could exist at a site
- Pragmatic enough to recognize what is achievable
- Can be accomplished in a variety of ways

2. Conditions are enhanced

Measurable functional improvement

- Acknowledge it may take time
- Assessed using a range of indicators or of stressors that are cause of impairment
3. The river system is more self-sustaining
   * resilience is increased*

   - Most likely when focus is on restoration of dynamic processes (e.g., river-floodplain reconnection)
   - Indicated by minimal need for maintenance and repair;
   - Indicators stay within range of “reference” (or desired) conditions

4. No lasting harm
   * Implementing the project does not cause irreparable harm*

   - Activities should minimize physical disturbance and harm to native vegetation
   - Activities should avoid channel designs or hardening that could force river adjustments up- and downstream
5. Assessment is completed
some level of pre- and post-monitoring done and
information made available

- Priority for monitoring should reflect existing knowledge, potential harm, and cost
- Monitoring should not be of one 'mold' and may not be required on all projects

Ecological success criteria

Close with some quotes from interviewees....

"Be on site when concrete is being poured"

"No easy answers for having a natural community that is aesthetically pleasing to golfers who don't understand about community succession".

"Don't just take a book design and just apply it in all situations"

"I sympathize with the need for a watershed-based approach to restoration, but the timing and funding of the agencies, and need for mitigation credit, doesn't seem to allow it right now. There is a problem with doing restoration for the sake of mitigation, and the regulatory agencies need to solve it"

Verbatim answers from Project X interview:  (not an atypical response)

(Q2) What was the Intent of your project:
"Water Quality Management"

(Q37) What were the success Criteria?
"We wanted to be able to handle one inch of rainfall per hour"

(Q38) Was the project successful?
"Yes, completely"

(Q26) Was the project monitored?  "No"