“Assessments for designing fish habitat programs and restoration”

Peter B Moyle
Center for Watershed Sciences
University of California, Davis
This talk

• Framing monitoring of aquatic systems in terms of reconciliation ecology

• Comparing diverse indices of stream ‘health’
  – Sierra Nevada meadows
  – Jucar River, Catalonia (Spain)
“Assessments for designing fish habitat programs and restoration”

Assessments for reconciled stream ecosystems
Reconciliation Ecology

“The science of inventing, establishing and maintaining new habitats to conserve species diversity in places where people live, work or play.”

Michael Rosenzweig

NOT RESTORATION.....
RECONCILED ECOSYSTEMS

- highly altered (novel)
- enhance native biodiversity
- contain alien species
- provide ecosystem services
- inhabited by humans

March 2007
Most (all?) streams in California are

NOVEL ECOSYSTEMS

• superficial resemblance to historic ecosystems
• Irreversibly altered
  – Dams, dikes, diversions
• Native & alien species
Major dams in California

3100 registered

Grantham and Moyle in progress
Fish species lost below major dams.

N = 28 spp
73% of extant fishes in decline

N = 122

- Reasonably Secure: 27%
- Listed: 23%
- Vulnerable: 28%
- Listing Recommended: 22%

Moyle, Quinones & Katz. 2011
Alien fishes = 50
Increases species richness. N = 172
PUTAH CREEK: A NOVEL, RECONCILED ECOSYSTEM
Putah Diversion Dam

PUTAH CREEK

95% OF WATER DIVERTED

100% CHANNELIZED

IN HIGHLY DEVELOPED WATERSHED

Putah South Canal
<table>
<thead>
<tr>
<th>Species group</th>
<th>Percent alien species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees (46)</td>
<td>35</td>
</tr>
<tr>
<td>Shrubs (39)</td>
<td>23</td>
</tr>
<tr>
<td>Herb. plants (198)</td>
<td>61</td>
</tr>
<tr>
<td>Butterflies (31)</td>
<td>25</td>
</tr>
<tr>
<td>Fish (35)</td>
<td>63</td>
</tr>
<tr>
<td>Amphibians (3)</td>
<td>33</td>
</tr>
<tr>
<td>Reptiles (10)</td>
<td>10</td>
</tr>
<tr>
<td>Birds (92 breeding)</td>
<td>3</td>
</tr>
<tr>
<td>Mammals (31)</td>
<td>11</td>
</tr>
</tbody>
</table>

Percent aliens of recorded species, Putah Creek, UCD
PUTAH CREEK IS A REFUGE FOR NATIVE FISHES

hitch

Tule perch

Sacramento pikeminnow

Rainbow trout

Sacramento sucker
RESULTS OF ADOPTING ‘NATURAL’ FLOW REGIME
KIERNAN ET AL. 2012 ECOLOGICAL APPLICATIONS

BEFORE
1991-1998
N= 7

AFTER
1998-2008
N= 10
WHAT DOES IT TAKE TO MANAGE PUTAH CREEK AS A RECONCILED ECOSYSTEM?

- BOLD VISION
- Flow regime
- Water Agency Cooperation
- Stream keeper
- Community involvement
- Landowner co-operation
- MONITORING
GOALS OF MONITORING

What do we want from aquatic ecosystems?

• Native species (PUTAH)
• Fisheries
• “Healthy” ecosystem
  – Self-sustaining
  – Reconciled?
• Ecosystem services
  – Aesthetics
  – Water quality
  – Recreation
What method so we use for monitoring?
Different methods give different answers

• Intensive, quantitative = research
  – Standard for comparison
  – Putah Creek (21 yrs annual)
  – Martis Creek (30 yrs annual)
  – Suisun Marsh (32 yrs, monthly)
  – Sagehen Creek (55 yrs, intermittent)

• Extensive surveys, semi-quantitative (indices)
  – Sierra Nevada Meadows
  – Jucar River, Spain
Indices of Biotic Integrity

• Developed by J. Karr, 1980s
• Compared existing fish fauna to presumed reference fauna
• 5-12 metrics per index
• Sites scores 20-100
• Rated: Poor, marginal, fair, good ‘integrity’
How does fish-based IBI compare to other indices as a monitoring tool?

- Developed to monitor water quality (EPA)
  - Eastern USA
  - Limited application in West
- Assumes that fish integrate many stressors
- Comparative studies
  - Sierra Nevada Meadow streams
  - Jucar River watershed, Spain
Study Regions
Sierra Nevada
167 sites

Jucar R Basin
114 sites
Meadow Streams: Project Goals

- Develop a standardized protocol for assessing condition of meadow streams
- Develop and compare multiple biotic indices
- Compare indices with prior vegetation surveys and EPA habitat assessment protocols
Index means and ranges

Box and Whisker Plot of Index Means and Ranges

Score (20-100)

Vegetation Index

Habitat index

Invertebrate IBI

Native Fish and Amphibian IBI

Fish-only IBI

Index means and ranges
Index Frequency Distributions

Fish-only IBI

Fish and Amphibian IBI

Invertebrate IBI

Habitat Index

Vegetation Index
## Pearson Correlations between Indices

<table>
<thead>
<tr>
<th>Pearson correlations</th>
<th>Fish-only IBI</th>
<th>Fish/Amphibian IBI</th>
<th>Invertebrate IBI</th>
<th>Habitat Index</th>
<th>Vegetation Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish-only IBI</strong></td>
<td>—</td>
<td>0.7135</td>
<td>-0.0249</td>
<td>-0.0456</td>
<td>-0.2123</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>—</td>
<td>0.0000</td>
<td>0.8518</td>
<td>0.7319</td>
<td>0.1064</td>
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<tr>
<td><strong>Fish/Amphibian IBI</strong></td>
<td>0.7135</td>
<td>—</td>
<td>-0.0253</td>
<td>-0.1890</td>
<td>-0.1503</td>
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<tr>
<td><strong>P-value</strong></td>
<td>0.0000</td>
<td>—</td>
<td>0.8494</td>
<td>0.1516</td>
<td>0.2559</td>
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<tr>
<td><strong>Invertebrate IBI</strong></td>
<td>-0.0249</td>
<td>-0.0253</td>
<td>—</td>
<td>0.3724</td>
<td>0.0790</td>
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<tr>
<td><strong>P-value</strong></td>
<td>0.8518</td>
<td>0.8494</td>
<td>—</td>
<td>0.0037</td>
<td>0.5522</td>
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<td><strong>Habitat Index</strong></td>
<td>-0.0456</td>
<td>-0.1890</td>
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<td>0.5522</td>
<td>0.00001</td>
<td>—</td>
</tr>
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</table>
Willow Creek, Plumas Co.
- Fish only: 60
- Native Fish/Amphib: 48
- Invertebrate: 80
- Habitat: 82
- Vegetation: 100

Cedar Creek, Lassen Co.
- Fish only: 60
- Native Fish/Amphib: 60
- Invertebrate: 40
- Habitat: 56
- Vegetation: 47
CONCLUSIONS
MOUNTAIN MEADOW STUDY

• DIFFERENT MONITORING TECHNIQUES GIVE DIFFERENT RESULTS
• USFS VEG. SURVEYS GIVE HIGHER SCORES THAN AQUATIC SURVEYS
• MEADOWS ON PUBLIC LAND MOSTLY OK
CONCLUSIONS II
MOUNTAIN MEADOW STUDY

• MEADOWS NEED A RECONCILIATION APPROACH TO MANAGEMENT
  • ALIEN SPECIES
    • Trout
    • Plants
  • GRAZING
  • FOREST ENCROACHMENT
  • HUMAN USE

• PERIODIC AQUATIC MONITORING NEEDED
Development and evaluation of a fish-based index to assess biological integrity of Mediterranean streams.

METRICS: JUCAR IBI

1. % FISH WITH ANOMALIES
2. SIZE (AGE) STRUCTURE OF POPULATION
3. ABUNDANCE OF NATIVE FISHES
4. # OF MISSING NATIVE SPECIES
5. % NATIVE FISHES IN CATCH

BASED ON MOYLE ET AL. 1996 “FISH IN GOOD CONDITION”
<table>
<thead>
<tr>
<th>Indices Compared to IBI-JUCAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluvial habitat index</td>
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<tr>
<td>IHF</td>
</tr>
<tr>
<td>EPA’s Rapid Bioassessment Protocols (Habitat)</td>
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<tr>
<td>HABITAT_EPA</td>
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<tr>
<td>Riparian Vegetation Quality Index</td>
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<tr>
<td>QBR</td>
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<tr>
<td>Specific Pollution Sensitivity Index (Diatom)</td>
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<tr>
<td>IPS</td>
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<tr>
<td>Diatom Biological Index</td>
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<tr>
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<tr>
<td>Iberian Biological Monitoring Working Party (Macroinvertebrate)</td>
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<td>IBMWP</td>
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<tr>
<td>European Fish Index</td>
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<tr>
<td>EFI+</td>
</tr>
</tbody>
</table>
EUROPEAN 2 STEP FISH INDEX

STEP 1: 12 ENVIRONMENTAL VARIABLES TO DETERMINE IF

CYPRINID STREAM

SALMONID STREAM
EUROPEAN 2 STEP FISH INDEX

STEP 2

IF A CYPRINID STREAM

METRIC 1- NUMBER OF RHEOPHILIC SPAWNING SPECIES

METRIC 2- DENSITY OF LITHOPHILIC SPAWNING SPECIES

IF A SALMONID STREAM

METRIC 1 –DENSITY OF FISH WITH POOR TOLERANCE OF LOW DO

METRIC 2- DENSITY OF 150+ MM FISH INTOLERANT OF HABITAT DEGRADATION
EFI VS. IBI

1. HIGHLY CORRELATED
2. EFI
   1. FOR COMPARING ALL EUROPEAN STREAMS
   2. WELL TESTED (not in Spain)
   3. GENERAL MEASURE OF STREAM HEALTH
      less useful at local level
3. IBI
   1. MORE USEFUL AT LOCAL LEVEL (INDICATES WHY)
   2. ALIEN SPECIES CONSIDERED
   3. BETTER FOR COMPARING LOW-DIVERSITY STREAMS
JUCAR: CONCLUSIONS

• MOST AQUATIC INDICES HIGHLY CORRELATED
  • Reflects long history of human use

• DIFFERENT SENSITIVITIES
OVERALL CONCLUSIONS

1. DON’T RELY ON ONE METHOD
   Fish+ bugs + habitat best

2. USE METHODS THAT ANSWER YOUR QUESTIONS

3. THINK IN TERMS OF RECONCILIATION ECOLOGY
THANK YOU