DEVELOPMENT OF A HIERARCHICAL RIVERINE CLASSIFICATION SYSTEM AND ASSESSMENTS TO HELP DEFINE CONSERVATION TARGETS AND POTENTIAL REFERENCE SITES

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Outline

• Conceptual underpinning
• Classification hierarchy
  – Ecological Drainage Units
  – Aquatic Ecological Systems
  – Valley Segment Types
• Conservation Assessments (look for the ‘best’)
  – Planning Areas
  – Assessment Units
  – Stressor Index
  – Targets
• Example: identification of focus areas (potential reference sites) for the Meramec Ecological Drainage Unit
Why do we need a hierarchical classification of riverine ecosystems?

• Organize data and thoughts and communicate information (all classifications)
• Ecosystems consist of their abiotic and biotic components
  – Account for natural abiotic variation to facilitate stratification (compare apples to apples)
  – Account for biological variation based on evolutionary processes due to
    • stream system connectivity
    • hard species dispersal barriers
Federal Water Pollution Control Act (as amended, Nov. 27, 2002)

“Section 101: The objective of this act is to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.”
Need for Hierarchical Classification: Although Metrics Should Have Broad Application

**Typical IBI Metrics**

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
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<tbody>
<tr>
<td>Species richness and composition</td>
<td>Total number of fish species</td>
</tr>
<tr>
<td></td>
<td>Number of darter species</td>
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<tr>
<td></td>
<td>Number of sunfish species</td>
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<tr>
<td></td>
<td>Number of cyprinid species</td>
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<tr>
<td></td>
<td>Number of intolerant species</td>
</tr>
<tr>
<td></td>
<td>Proportion of individuals as green sunfish</td>
</tr>
<tr>
<td>Trophic composition</td>
<td>Proportion of individuals as omnivores</td>
</tr>
<tr>
<td></td>
<td>Proportion of individuals as insectivores</td>
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<tr>
<td></td>
<td>Proportion of individuals as piscivores</td>
</tr>
<tr>
<td>Fish abundance and condition</td>
<td>Number of individuals in sample</td>
</tr>
<tr>
<td></td>
<td>Proportion of individuals as hybrids</td>
</tr>
<tr>
<td></td>
<td>Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies</td>
</tr>
</tbody>
</table>
For Biodiversity Conservation
Species Composition and Population Isolation are of Critical Importance
Classification Hierarchy

Level 4
Subregions

Zone: Nearctic zoogeographic zone
Subzone: Arctic/Atlantic Drainages
Region: Mississippi Drainage
Subregion: Ozark Plateau
Ecological Drainage Unit: Ozark Plateau/Meramec Drainage
Aquatic Ecological System: Upper Meramec/Dry Fork, Oak/Woodland Plain, sandstone dominated, low gradient and spring density stream complex
Valley Segment Type: Warm, perennial, creek with a relatively high gradient, flowing through sandstone, and connecting to another creek
“A little inaccuracy sometimes saves a ton of explanation.”

~H. H. Munro~
Level 4: Aquatic Subregions

- Largely correspond to ecoregions, which account for differences in aquatic assemblages resulting from geographic abiotic variation in ecosystem structure/function (e.g., flow, habitat)
Level 4: Aquatic Subregions
(Showing Drainage Enforcement)

Largely Correspond to:
- Omernik Level 2
- Bailey’s Ecological Provinces
- Pflieger’s Aquatic Faunal Regions

“Terrestrial Boundaries”
Maxwell’s Boundaries
Largely account for compositional differences in aquatic assemblages resulting from distinct evolutionary histories.
For Biodiversity Conservation
Species Composition and Population Isolation
are of Critical Importance

Species Counts

Huzzah: 97
West Fork Black: 42
Shared: 29
Aquatic Subregions & EDUs are NOT Homogenous
Level 6: Aquatic Ecological System Types

- Like Aquatic Subregions, AES-Types account for differences in aquatic assemblages resulting from geographic abiotic variation in structure/function (e.g., flow, habitat).

Note: No 2 EDU’s have the same combination or spatial arrangement of AES-types.

Like colors represent ecosystem units having similar structure and function (AES-Types).
Aquatic Ecological Systems and Types
For the Ozark/Meramec EDU

- Defined by multivariate cluster analysis of geology, soil, landform, and groundwater variables
Level 7: Valley Segment Types

- Valley segments stratify a continuous stream network into distinct hydrogeomorphic patches
- Also account for differences in aquatic assemblages resulting from geographic abiotic variation in structure and function

Individual Variables

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Stream Size</th>
<th>Flow</th>
<th>Gradient</th>
<th>Geology</th>
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</thead>
</table>

Unique Valley Segment Types
Deciphering VST Codes

Valley Segment Type Codes and Descriptions

- 212230021 = Valley Segment Type Code
- 2 = Warm
- 1 = Headwaters
- 2 = Intermittent flow
- 2 = Flowing through dolomite/limestone
- 3 = Relatively high gradient
- 0 = Valley wall interaction (N/A)
- 0 = Flows into another headwater
- 2 = Flowing within own valley
- 1 = Primary channel
Classification Hierarchy Provides Landscape Ecological Context

Level 4
Subregions

Level 5
Ecological Drainage Units

Level 6
Aquatic Ecological System Types

Level 7
Valley Segment Types

Zone:
Nearctic zoogeographic zone

Subzone:
Arctic/Atlantic Drainages

Region:
Mississippi Drainage

Subregion:
Ozark Plateau

Ecological Drainage Unit:
Ozark Plateau/Meramec Drainage

Aquatic Ecological System:
Upper Meramec/Dry Fork, Oak/Woodland Plain, sandstone dominated, low gradient and spring density stream complex

Valley Segment Type:
Warm, perennial, creek with a relatively high gradient, flowing through sandstone, and connecting to another creek
Defining the Biotic Community: Spatially-linked 1,000’s of Collection Records to Valley Segment Coverage
Constructed Models Separately for Each Species (decision tree analysis of variables attached to VST’s)

- 571 total models constructed for 315 different species
Individual Models were Merged into a Single Database

**Ozarks: 27 Species**
- Ozark minnow
- bigeye chub
- black bullhead
- blackspotted topminnow
- bleeding shiner
- bluegill
- bluntnose minnow
- brook silverside
- central stoneroller
- common carp
- creek chub
- creek chub sucker
- golden redhorse
- golden shiner
- green sunfish
- greenside darter
- largescale stoneroller
- logperch
- longear sunfish
- northern hog sucker
- northern shad
- plains topminnow
- rainbow darter
- slender madtom
- smallmouth bass

**Plains: 10 Species**
- bigmouth shiner
- black bullhead
- bluegill
- bluntnose minnow
- central stoneroller
- creek chub
- green sunfish
- suckermouth minnow
- white sucker
- yellow bullhead
Conservation Assessment

• Identify Planning Regions and Assessment Units
• Select Conservation Targets
  – Abiotic
    • Aquatic Ecological System Types
    • Valley Segment Types
  – Biotic
    • Endemics
    • Species of Special concern
    • Characteristic species
      – Ecologically important species (top predators, major prey species)
      – Geographically distinct populations
• Assess quality & select focus areas
Planning Region & Assessment Unit

- Planning Region: generate separate conservation plans for each Ecological Drainage Unit (EDU)

- Assessment Unit: Select priority Aquatic Ecological Systems (AES’s) and Valley Segment Type (VST) complexes
Biotic Conservation Targets

- Represent all endemic species, species of special concern, and characteristic species for each EDU

### Scientific Common
- Acipenser fulvescens lake sturgeon
- Anodonta suborbiculata flat floater
- Arcidens confragosus rock pocketbook
- Cycleptus elongatus blue sucker
- Cyprinella lutrensis red shiner
- Fundulus zebrinus plains killifish
- Hiodon alosoides golye
- Hybognathus argyritis western silvery minnow
- Hybognathus hankinsoni brassy minnow
- Hybognathus placitus plains minnow
- Luxilus cornutus common shiner
- Macrhybopsis gelida sturgeon chub
- Macrhybopsis hyostoma shoal chub
- Macrhybopsis meeki sicklefin chub
- Macrhybopsis storrierana silver chub
- Notropis buchanani ghost shiner
- Notropis dorsalis bigmouth shiner
- Notropis topeka Topeka shiner
- Orconectes immunis papershell crayfish
- Pimephales promelas fathead minnow
- Platygobio gracilis fathead chub
- Polyodon spathula paddlefish
- Procambarus gracilis grassland crayfish
- Scaphirhynchus albus pallid sturgeon

- Endemics
- Species of special concern
- Characteristic species

Number of Target Species
Abiotic Targets: AES Types

Distinct types:
Each one warrants conservation

Redundant types:
One individual AES warrants conservation

Pieces of a Puzzle
Abiotic Targets: Dominant VST’s

- Representation of dominant VST’s (by stream size)
- Within a single AES
- Should address issue of connectivity

Stream Size Classes
- Headwater
- Creek
- Small River

Dominant Valley Segment Types by Size Class
For Huzzah River AES
Assessing Quality at the AES Level: Human Stressors

Percent Urban
Percent Cropland
Lead Mine Density
Riparian Forest

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Final Human Stressor Index List
(metrics relatively uncorrelated; r-square<0.5)

• % Urban
• % Agriculture
• Density of Road/Stream crossings
• Population change
• Degree of fragmentation/hydrologic alteration
• Density of small impoundments
• Density of coal mines
• Density of lead mines
• Density of industrial discharges
• Density of Confined Animal Feeding Operations
• Number of Exotic Species
Human Stressor Index (not simply cumulative but disjunctive & cumulative)

First number reflects:
Highest magnitude of individual stressor

Last two numbers reflect:
Degree of cumulative impacts
Selecting AES’s: human interaction required

Human Stressor Index -

Ability to Achieve Connectivity among - Dominant VST’s

Target Species Richness

Public Lands
Selecting Priority VST Complexes
Selection Criteria and Important Data Layers

**Criteria:**
- Connectivity
- Stressors
- Public Ownership

**Stressors:**
- Point sources
- Dams (small impoundments)
- Cafos
- Agricultural non-point sources
- 303d listed streams
- Gravel mines
- Other mines
- Roads
- Exotic species
- Hazardous material generators
- Industrial Facility Discharges

**Landcover:**
- Urban
- Row and Close-Grown Crops
- Grassland
- Forest and Woodland
- Swamp and Marsh
- Open Water
- No Data

**Dominant Stream Types:**
- Headwater Creek
- Small River

**Focus Area**
Conservation Focus Areas and Potential Reference Sites for the Meramec Drainage

Full network: 10,684 km
Focus Area network: Only 300 km
Focus area represents 2.8% of entire network
Linking Biomonitoring with Biodiversity Conservation

- Linking biomonitoring and biodiversity conservation efforts is critical to conserving our nation’s natural resources and without integrating such efforts we will likely not achieve the goals of either Hughes and Noss 1992; Moyle 1994; Davis and Simon 1995; Karr 1995
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