Environmental Flow Science: Lessons Learned from Selected Environmental Flow Programs

NC Environmental Flow Science Advisory Board
November 15, 2011

Mary M. Davis, Ph.D.
Southern Instream Flow Network
“Hydrologic regimes are the master variables in aquatic ecosystems.” Poff et al. 1997
Southern Instream Flow Network

Purpose - To facilitate protective instream flow policies and practices in 15 southern states by providing science-based resources and opening lines of communication.

More information at: [www.southeastaquatics.net/programs/sifn/](http://www.southeastaquatics.net/programs/sifn/)
Presentation Overview

1. Review of science-based methods to determine IF needs

2. Methods used by select states to determine IF needs

3. IF resources for North Carolina
Science-based Methods to Determine Instream Flow Needs

- Instream Flow Incremental Method (IFIM)
- Ecologically Sustainable Water Management (ESWM)
- Ecological Limits of Hydrologic Alteration (ELOHA)
Instream Flow Incremental Method (IFIM)

Source: http://www.fort.usgs.gov/Products/Software/ifim/5phases.asp
IFIM Process: Site- and Project–specific Evaluations

Field Study

Habitat vs. Flow for each organism

Hydrologic Modeling

Physical Modeling

Habitat Modeling

- Time Series Analysis
- Flow Alternatives
- Recommendations

Requires time and $
IFIM Process:
Water management alternatives are the basis for a negotiated solution.
IFIM Essentials

• Well-established methodology developed in the 1980s and 1990s

• Applies (usually) species-specific models at site-specific level

• Based on *population responses to natural variation* in velocity, depth, cover, and area

• Negotiated instream flow solutions
Ecologically Sustainable Water Management (ESWM)

- Ecosystem Flow Requirements
- Human Needs
- Areas of Incompatibility
- Collaborative Dialogue
- Water Experiments
- Adaptive Management
Ecological Conceptual Model

Flow Components and Needs: Major Tributaries

Example: 01543500 Sinnemahoning Creek at Sinnemahoning, PA (685 sq mi)

Flow Component (Daily Exceedance Probability)
- High Flow Events ($Q_{10}$ to $Q_2$)
- Seasonal Flow ($Q_{52}$ to $Q_{10}$)
- Low Flow ($Q_{10}$ to $Q_{5}$)
- Minimum to $Q_{10}$

- High Flow-related needs
- Seasonal Flow needs
- Low Flow-related needs

**SPRING**
- Maintain channel morphology, island formation, and floodplain habitat

**SUMMER**
- Transport organic matter and fine sediment
- Promote vegetation growth
- Cues and direct immigration of juvenile American Eel
- Provide abundant food resources and nesting and feeding habitats for birds and mammals
- Support development and growth of all fishes, reptiles, and amphibians
- Maintain connectivity between habitats and refuges for resident and diadromous fishes
- Support mussel spawning, goshell release, and growth
- Promote macroinvertebrate growth
- Maintain water quality
- Maintain hyporheic habitat

- Cue diadromous fish emigration
- Support winter emergence of aquatic insects and maintain overwinter habitat for macroinvertebrates
- Support spring emergence of aquatic insects and maintain habitats for mating and egg laying
- Support resident fish spawning

- Maintain ice scour events and floodplain connectivity

- Maintain stable hibernation habitats for reptiles and amphibians, nesting habitats for mammals

**WINTER**
- Support winter emergence of aquatic insects and maintain overwinter habitat for macroinvertebrates
- Support spring emergence of aquatic insects and maintain habitats for mating and egg laying
- Support resident fish spawning

- Maintain ice scour events and floodplain connectivity

**FALL**
- Cue diadromous fish emigration
- Maintain stable hibernation habitats for reptiles and amphibians, nesting habitats for mammals

Source: Susquehanna River Commission 2011
Savannah River Ecosystem Flow Workshop Participants
## Ecosystem Flow Recommendations: Building Block Method

### Augusta Shoals on the Savannah River

### Floods

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Flow Pulses</strong></td>
<td></td>
</tr>
<tr>
<td>20,000-40,000 cfs;</td>
<td>2-3 days, 1/month</td>
</tr>
<tr>
<td></td>
<td>Jan &amp; Feb</td>
</tr>
<tr>
<td>&gt;16,000 cfs;</td>
<td>1-2 days, 1-2 pulse</td>
</tr>
<tr>
<td></td>
<td>• Herring passage over NSBLD</td>
</tr>
<tr>
<td></td>
<td>• Morone egg suspension</td>
</tr>
<tr>
<td><strong>Low Flows</strong></td>
<td></td>
</tr>
<tr>
<td>&gt;5,000 cfs;</td>
<td>• Sturgeon spawning</td>
</tr>
<tr>
<td>6,000-10,000 cfs, with</td>
<td>• Shad, striped bass, robust redhouse spawning and habitat</td>
</tr>
<tr>
<td>6,000 cfs as baseflow</td>
<td></td>
</tr>
<tr>
<td>4,000-6,000 cfs, 4,000 cfs</td>
<td>as baseflow</td>
</tr>
<tr>
<td></td>
<td>&gt;2,700,000 cfs; • Sturgeon spawning</td>
</tr>
<tr>
<td>4,000-5,000 cfs;</td>
<td>• Resident fish habitat</td>
</tr>
<tr>
<td></td>
<td>• Juvenile fish out-migration</td>
</tr>
<tr>
<td>20,000 cfs;</td>
<td>2-3 days, 1 pulse  • Sturgeon spawning</td>
</tr>
</tbody>
</table>

### Key

- **Wet Year**
- **Avg Year**
- **Dry Year**

### No flood flow recommendations provided for the Shoals
ESWM Essentials

• Developed in 1990s by The Nature Conservancy

• Applied at watershed level to improve flow regimes and restore ecological function

• Based on existing data and expert knowledge of ecological relationships with natural hydrologic regimes

• Integrates societal values with ecological needs
Ecological Limits of Hydrologic Alteration (ELOHA)

http://conserveonline.org/workspaces/eloha

(Poff et al. 2010)
Ecological Limits of Hydrologic Alteration (ELOHA)

http://conserveonline.org/workspaces/eloha

(Poff et al. 2010)
Calculation of Flow Alteration

Green River at Greendale, Utah
Magnitude of Small Floods

Output from The Nature Conservancy’s
Indicators of Hydrologic Alteration (IHA)
software
Flow-Ecology Relationships from Literature

Source: McManamay et al. 2011
Flow-Ecology Relationships from Existing Data

Source: Potomac River Commission Watershed Assessment 2011
Ecological Response to Flow Alteration

Michigan’s Screening Tool for Ground-Water Withdrawals

Proportion of initial fish population metric

Proportion of index flow removed

Acceptable resource impact

Adverse resource impact

Characteristic species

Thriving species

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Proportion of initial fish population metric

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Michigan’s Screening Tool for Ground-Water Withdrawals

Acceptable resource impact

Adverse resource impact

Characteristic species

Thriving species

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0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Proportion of initial fish population metric
ELOHA Essentials

• Newly established method (Poff et al. 2010)

• Uses existing data to develop flow-ecology relationships for classes of rivers

• Based on *ecological responses to flow alteration* of natural hydrologic regime

• Integrates societal values with ecological values
Presumptive Flow Standard for Environmental Flow Protection

(Richter et al. 2011)
1. Review of science-based methods to determine IF needs

2. Methods used by selected programs to determine IF needs

3. IF resources for North Carolina
Approaches for Determining IF Standards

• **Minimum flow threshold**
  – 7Q10 (e.g., AL, LA, MS)
  – Modified Tennant (e.g., AR, GA, SC)

• **Statistically based standards**
  (e.g., FL St Johns WMD, Potomac River Commission)

• **Percent of flow approaches**
  (e.g., FL SW Florida and Suwannee River WMDs, TN Presumptive WQ Standard)

Under development in SE: TX, NC, VA
IF Methods Used by Selected Programs

- Florida
- Michigan
- Potomac River Commission
- Texas, if time allows
FLORIDA - INSTREAM FLOW PROTECTION POLICY AND MANAGEMENT PROGRAMS

Slides courtesy of Marty Kelly, Director SWFWMD MFL Program
The **minimum flow** for a given watercourse shall be the limit at which further **withdrawals** would be **significantly harmful** to the water resources or ecology of the area.

A MFL is set by the Water Management Districts for each of their priority streams, rivers, lakes, and aquifers.

MFLs are used in
- water management allocation planning,
- surface and groundwater withdrawal permit conditions, and
- recovery plans.
SWFWMD Instream Flow Program

- Building Block Method
- PHABSim-style methodology
- Percent of Flow Reduction Approach
- ‘Significant Harm’ threshold = 15% reduction in available habitat for most conservative target

![Flow Chart](chart.png)
Physical Habitat Simulation System
Used for Blocks 1 and 2

- Depth
- Velocity
- Substrate
Long-Term Inundation Analysis
Used for Blocks 2 and 3

Floedplain
Exposed Roots
Snags
Low Flow Threshold - Wetted Perimeter
Used for All Blocks
Low Flow Threshold - Fish Passage
Used for All Blocks
Flow Prescription

Percent of Flow and Seasonality

of allowable cumulative withdrawals

LFT = 67 cfs
• Best Available Information
• Peer Review Process
### SWFWMD MFLs

**Range of Percent Allowable Withdrawals**  
*(Significant Harm Threshold < 15% habitat loss)*

<table>
<thead>
<tr>
<th>Block</th>
<th>Rivers</th>
<th>Hi</th>
<th>Lo</th>
<th>Hi</th>
<th>Lo</th>
<th>Hi</th>
<th>Lo</th>
<th>Hi</th>
<th>Lo</th>
<th>Hi</th>
<th>Lo</th>
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<tbody>
<tr>
<td></td>
<td>Upper Alafia</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>8</td>
<td>10</td>
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<td></td>
<td>Braden</td>
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<td></td>
<td>Myakka</td>
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<td></td>
<td>Peace</td>
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<tr>
<td></td>
<td>Hillsborough</td>
<td></td>
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<td></td>
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<tr>
<td>1 (April 20-June 24)</td>
<td></td>
<td>8</td>
<td>15</td>
<td>10</td>
<td>11</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>18</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>2 (Oct 28 – Apr 19)</td>
<td></td>
<td>8</td>
<td>13</td>
<td>10</td>
<td>19</td>
<td>7</td>
<td>16</td>
<td>8</td>
<td>13</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>3 (Jun 25 – Oct 27)</td>
<td></td>
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</table>

Source: [http://www.swfwmd.state.fl.us/projects/mfl/](http://www.swfwmd.state.fl.us/projects/mfl/)
SWFWMD MFL Essentials

• MFL set for each water body (i.e., no classification needed)

• Flow requirements based on most sensitive ecological response to flow alteration (i.e., fish, coarse woody debris, floodplains, organic soils, etc.)

• Estimate habitat loss based on cumulative depletion of the natural daily flow regime

• MFLs for medium size, coastal rivers show a small range of allowable depletions.
IF Methods Used by Programs

- Florida – using similar methods as NC; finding similar standards within river class
- Michigan
- Potomac River Commission
Environmental Flow Standards in Michigan

Slides courtesy of Paul Seelbach, USGS and Richard Bowman, TNC
Michigan River Classification Approach

Spatial framework

Well-established conceptual framework tested and implemented over past 15 years by TNC, USGS Regional Aquatic GAP, and a few states.

Reach attribution

Provides for multi-state coverage.

Coordination is good

MI fisheries classification

Zoogeographic Region (WWF)

Ecological Drainage Unit (EDU)

Aquatic Ecological System (AES)

Ecological Segment

NHD+ Reach
Key landscape and riverine attributes for every reach came from existing map-level data and state-level models. Examples: flow, temperature, slope, and elevation.
Spatial framework
Reach attribution
MI fisheries classification
Coordination is good

- Cold
- Cold transition
- Warm transition
- Warm

Fish abundance

- Cold fishes
- Warm fishes

Summer temperature
**11 river classes based on flow and temperature**

<table>
<thead>
<tr>
<th>Cold</th>
<th>Cold Trans</th>
<th>Warm Trans</th>
<th>Warm</th>
<th>Streams</th>
<th>Sm Rivers</th>
<th>Lg Rivers</th>
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</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Simple. Familiar. Fish values.

Incredibly powerful in policy development. “Map that changed the world.” Map is central to state water law. Is in minds and language of policy leaders and users.

Is useful to many other river management programs. Can drill into database for more details.
Statewide habitat suitability info: flow and temperature

Rank scores per normal distribution; 60+ species

Optimum Habitat

'4' represents 'best' conditions
'4' is ± 0.5 SD

'3' is ± 0.5 to 1.0 SD

'2' is ± 1.0 to 1.5 SD

'1' is ± 1.5 to 2.0 SD

'0' is ± > 2.0 SD
For representative sites per river type:

Considered initial “characteristic” species

Ran withdrawal simulations and followed scores

<table>
<thead>
<tr>
<th>Reference flows</th>
<th>River types</th>
<th>Degree flow alteration</th>
<th>Ecological response curves</th>
<th>Ecological targets</th>
<th>Enviro. flow targets</th>
<th>Implement program</th>
</tr>
</thead>
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</tbody>
</table>

### Percent flow reduction

<table>
<thead>
<tr>
<th>Species</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
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</thead>
<tbody>
<tr>
<td>common shiner</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>white sucker</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>longnose dace</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>rainbow darter</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Variation in fish assemblage response curves for each of 15 representative sites within one river type. The mean response (dark line) was used in the water management program, and policy safeguards were used in recognition of the degree of variation.
Summaries of simulations create early warning and total impact curves (for assemblage)
Some replacement of sensitive species

Adverse Resource Impact
Curves and target zones per each ecological river type. Geographies of biological response and social values.
Michigan’s Screening Tool for Ground-Water Withdrawals

<table>
<thead>
<tr>
<th></th>
<th>A/B</th>
<th>B/C</th>
<th>ARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold</td>
<td>14%</td>
<td>14%</td>
<td>20%</td>
</tr>
<tr>
<td>Trans</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Cool</td>
<td>6%</td>
<td>15%</td>
<td>25%</td>
</tr>
<tr>
<td>Warm</td>
<td>10%</td>
<td>18%</td>
<td>24%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>A/B</th>
<th>B/C</th>
<th>ARI</th>
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<tbody>
<tr>
<td>Stream</td>
<td>10.5%</td>
<td>10.5%</td>
<td>21%</td>
</tr>
<tr>
<td>Small River</td>
<td>15%</td>
<td>19%</td>
<td>25%</td>
</tr>
<tr>
<td>Large River</td>
<td>14%</td>
<td>19%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Allowable cumulative withdrawal (% median August)
Michigan Instream Flow Program

- River classification informed by fish assemblages
- *PHABSim*-style methodology
- *Percent of Flow Reduction Criteria*
IF Methods and Approaches Used by Advanced State Programs

• Florida – similar standards within river class
• Michigan – river classification informed by fish assemblages; similar standards within river class
• Potomac River Commission
Middle Potomac Watershed Assessment: Environmental Flows

- Follows ELOHA framework
- Multistate watershed
- www.potomacriver.org

Slides courtesy of Carlton Haywood, PRC
Ecological Limits of Hydrologic Alteration (ELOHA)

http://conserveonline.org/workspaces/eloha

(Poff et al. 2010)
Hydrologic Data

- Simulated daily flow time series for a current conditions scenario and for a baseline scenario
  - Current conditions:
    - 2000 land use
    - 2005 withdrawals, discharges, and impoundment volume
    - 1984-2005 hydrology
  - Baseline:
    - Land use modified to 78% forest, 0.35% impervious surface, other land uses adjusted proportionally,
    - Discharges and withdrawals set to zero.
    - No impoundments
- Flows simulated for 747 watersheds
Hydrologic Metrics

- Broad suite of flow metrics are calculated for each flow time series
  - Plus additional metrics commonly used.
  - 256 metrics total

- Selection process to reduce number of metrics
  1. Metrics with high variation between baseline and current scenarios
  2. Metrics with high variation among watersheds
  3. High model efficiency: Medians and inter-quartile range of flow metric for Simulated flows versus for Observed flows are similar
  4. Select only one of highly correlated groups
  5. Represent different aspects of flow regime
  6. Explainable relationship with biota
# Hydrologic Metrics

<table>
<thead>
<tr>
<th>Flow Range</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Frequency</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Mean high flow volume (MH21)</td>
<td>High Flow Duration (DH17)</td>
<td>High pulse count, High flow freq, Flood freq (FH9)</td>
<td>Skewness in annual max flow (MH19)</td>
</tr>
<tr>
<td>Mid</td>
<td>Median Q</td>
<td>Flood free season</td>
<td></td>
<td>Fall rate (RA3), Flashiness</td>
</tr>
<tr>
<td>Low</td>
<td>4b3, Seasonal Q85</td>
<td>Low pulse duration, Extreme low duration, Variability in low pulse duration (DL17)</td>
<td>Low pulse count, Extreme low freq.</td>
<td></td>
</tr>
</tbody>
</table>

*Seasonal flow metrics were evaluated but none of them met the initial screening criteria or were highly correlated with RA3. After further analysis some seasonal metrics may be included.*
Middle Potomac – Biological Data

1) Benthic macroinvertebrate data
   a) Only bio data set sufficiently rich for this basinwide, interstate, assessment
   b) Samples rarified to common basis and metrics calculated to family level for consistency

2) Collected in years 2000 – 2008

3) 1,313 samples at 869 locations for 747 watersheds
### Biotic Metrics

<table>
<thead>
<tr>
<th>Candidate Biometric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diversity</strong></td>
<td></td>
</tr>
<tr>
<td>Family-Level Taxa Richness</td>
<td>Number of taxonomic families</td>
</tr>
<tr>
<td>Shannon-Wiener Index</td>
<td>A common measure of taxonomic diversity</td>
</tr>
<tr>
<td><strong>Taxonomic Composition</strong></td>
<td></td>
</tr>
<tr>
<td>%EPT</td>
<td>% of individuals belonging to Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)</td>
</tr>
<tr>
<td>EPT Taxa</td>
<td>Number of EPT families</td>
</tr>
<tr>
<td>Gold’s Index</td>
<td>1 minus % of gastropods (snails), oligochaetes (worms), and Diptera (true flies) individuals; also indicates pollution.</td>
</tr>
<tr>
<td>%Chironomidae</td>
<td>% of individuals belonging to Chironomidae family of Diptera</td>
</tr>
<tr>
<td>Ephemeroptera Taxa</td>
<td>Number of Ephemeroptera families</td>
</tr>
</tbody>
</table>
Classification

Some biological metrics appear not to need classification.

Family-Level Taxa Richness

Watershed Size

Season

“Bioregion”
Classification

...while others may need classification

<table>
<thead>
<tr>
<th>%Shredders</th>
<th>%Net Caddisfly</th>
<th>%Chironomidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watershed Size</td>
<td>Season</td>
<td>“Bioregion”</td>
</tr>
</tbody>
</table>

- Box plots showing distribution of ecological indicators across different categories.
Flow-Ecology Relationships
Flow-Ecology Relationships
Flow-Ecology Relationships

High Flow Frequency vs BIBI

- Macrocinvertebrate community status deteriorates with increasing frequency of high flow events.
Flow-Ecology Relationships

- Mean daily fall rate (Q0.3) vs BIBI
- Median annual flow vs BIBI
- Flood Free Season vs BIBI
- Mean of Jul-Oct monthly Q85 flow vs BIBI

Flow alteration vs BIBI values

- Good
- Poor
- 90th percentile
- 60th percentile
- 30th percentile
IF Methods and Approaches Used by Advanced State Programs

- Florida – similar standards within river class
- Michigan – river classification informed by fish assemblages; similar standards within river class
- Potomac River Commission – demonstrated ecological impairment due to flow alteration in addition to other sources of stress
Presentation Overview

1. Review of science-based methods to determine IF needs

2. Methods used by select states to determine IF needs

3. IF resources for North Carolina and the SE region
Southern Instream Flow Network

Purpose - To facilitate protective instream flow policies and practices in 15 southern states by providing science-based resources and opening lines of communication.

More information at: www.southeastaquatics.net/programs/sifn/
Southern Instream Flow Research Agenda
www.southeastaquatics.net/programs/sifn

- **Problem:** The limited focus on research and funding for instream flows has resulted in a lack of science to support protective instream flow standards.

- **Objective:** to highlight research needs and coordinate sources of funding and research to address these needs.

- **Goal:** to ensure that instream flow research is focused on the needs of water resource managers for scientifically credible and protective state instream flow standards and practices.
Southern Instream Flow Research Agenda
Priority Research Topics

1. Develop a regional river classification system

2. Identify commonalities in ecosystem responses to flow alterations

3. Compile regional aquatic ecology data sets

4. Develop hypotheses for regional ecological responses to flow alteration

5. Perform field studies to test ecological responses to altered flow regimes
Integration of Instream Research Agenda Products
To Develop Flow-Ecology Relationships

- Ecological Condition Assessment
- Ecological Metric
- Hypothetical Flow-Ecology Relationships
- Aquatic Conservation Priority Areas
- Sources of Flow Alteration
- Quantify Flow Alteration
- Hydrologic Models
- River Classification

Research Priorities and Validation

Graph: Hydrologic Alteration vs. Ecological Condition

Legend:
- +: Ecological Condition
- -: Ecological Condition
- 0: Hydrologic Alteration

Flow-Ecology Relationships:
- Quantification
- Research Priorities and Validation
SE River Classification

- Utilizing existing classifications
- Hierarchical scales for geomorphology, hydrology, and biota
- Principals:
  John Faustini, USFWS and Chris Konrad, USGS
Preliminary SE Flow-Ecology Relationships

Anthropogenic Flow Alterations

Source: McManamay et al. 2011
Compile regional aquatic ecology data sets

Multistate Aquatic Resources Information System
www.marisdata.org

Integrating State Data into the National Fish Habitat Assessment

MARIS States (2010)
SARP Flow Alteration Assessment

Approach – Qualitatively assess sources, spatial distribution, and relative magnitude of hydrologic alteration from water consumption, impervious cover, and dams.
In conclusion:

Generally, instream flow science is progressing and is resulting in more protective policies and management practices.

From the case studies:

- River classification works well where there is a clear relationship with biota.
- ‘Flow-ecology’ relationships help guide selection of hydrologic and biotic metrics
- Demonstrated ecological impairment due to flow alteration provides a strong basis for instream flow criteria.

If we had more time:

- Scientific certainty should be balanced with policy development.
- Presumptive standards may provide a protective option until more studies can be completed.