Environmental Flow Science: Lessons Learned from Selected Environmental Flow Programs

Arkansas Environmental Flow
Science Advisory Board
March 27, 2013

Mary M. Davis, Ph.D.
Southern Instream Flow Network

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
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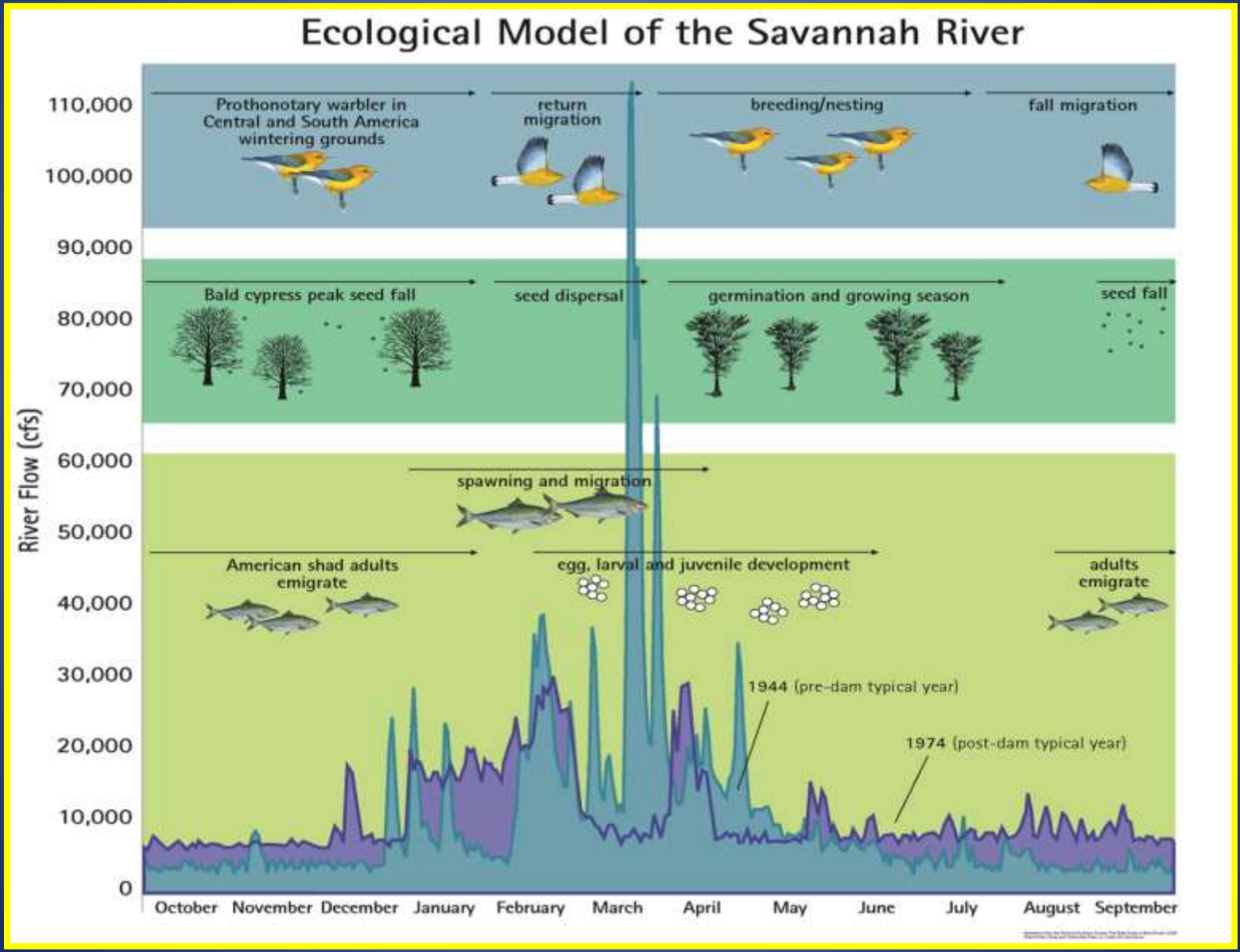
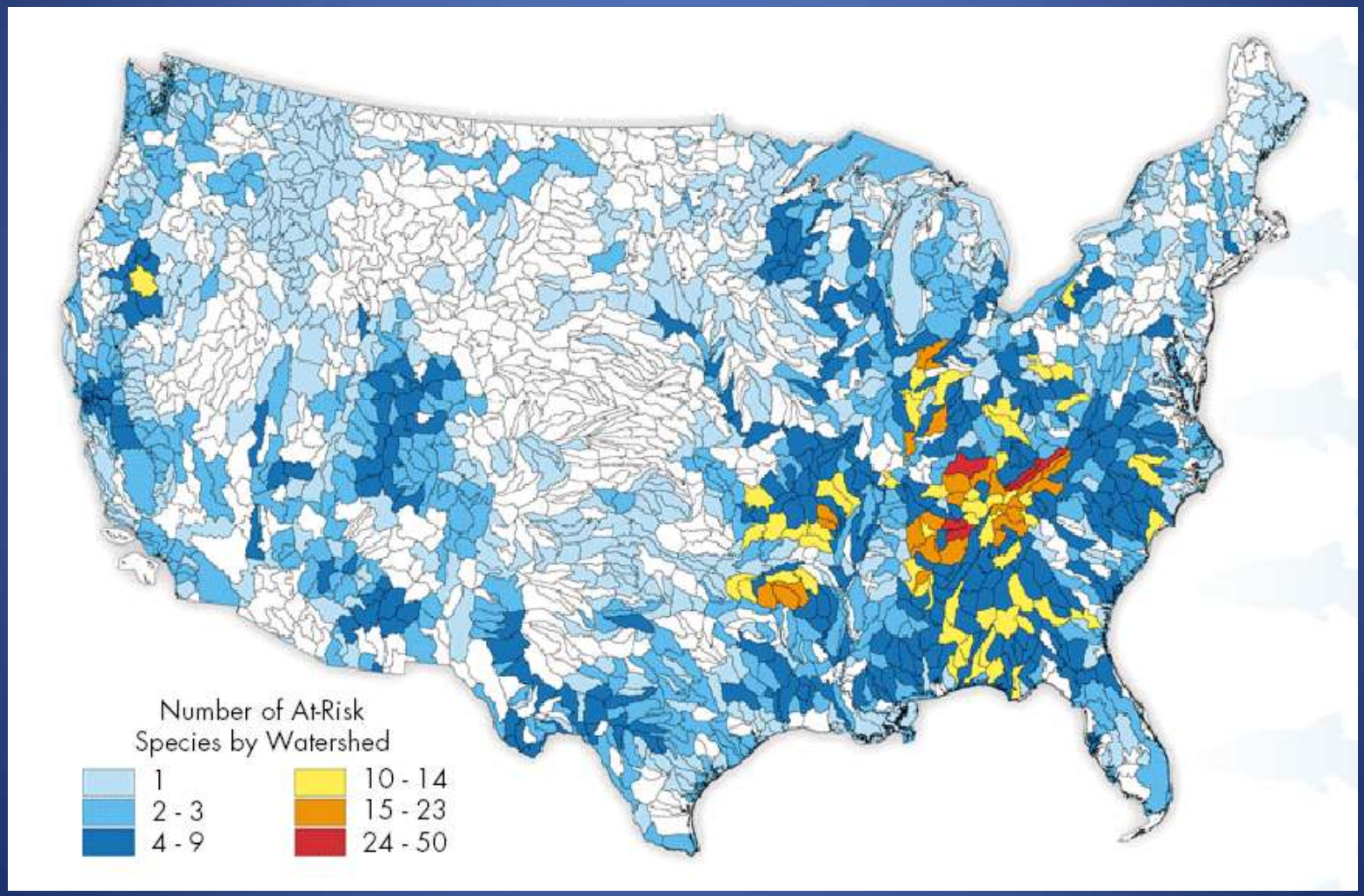
"Hydrologic regimes are the master variables in aquatic ecosystems." Poff et al. 1997



The South is a global hotspot for aquatic species richness.



Source: NatureServe

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.

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
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More information at:
www.southeastaquatics.net/programs/sifn/

Presentation Overview

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

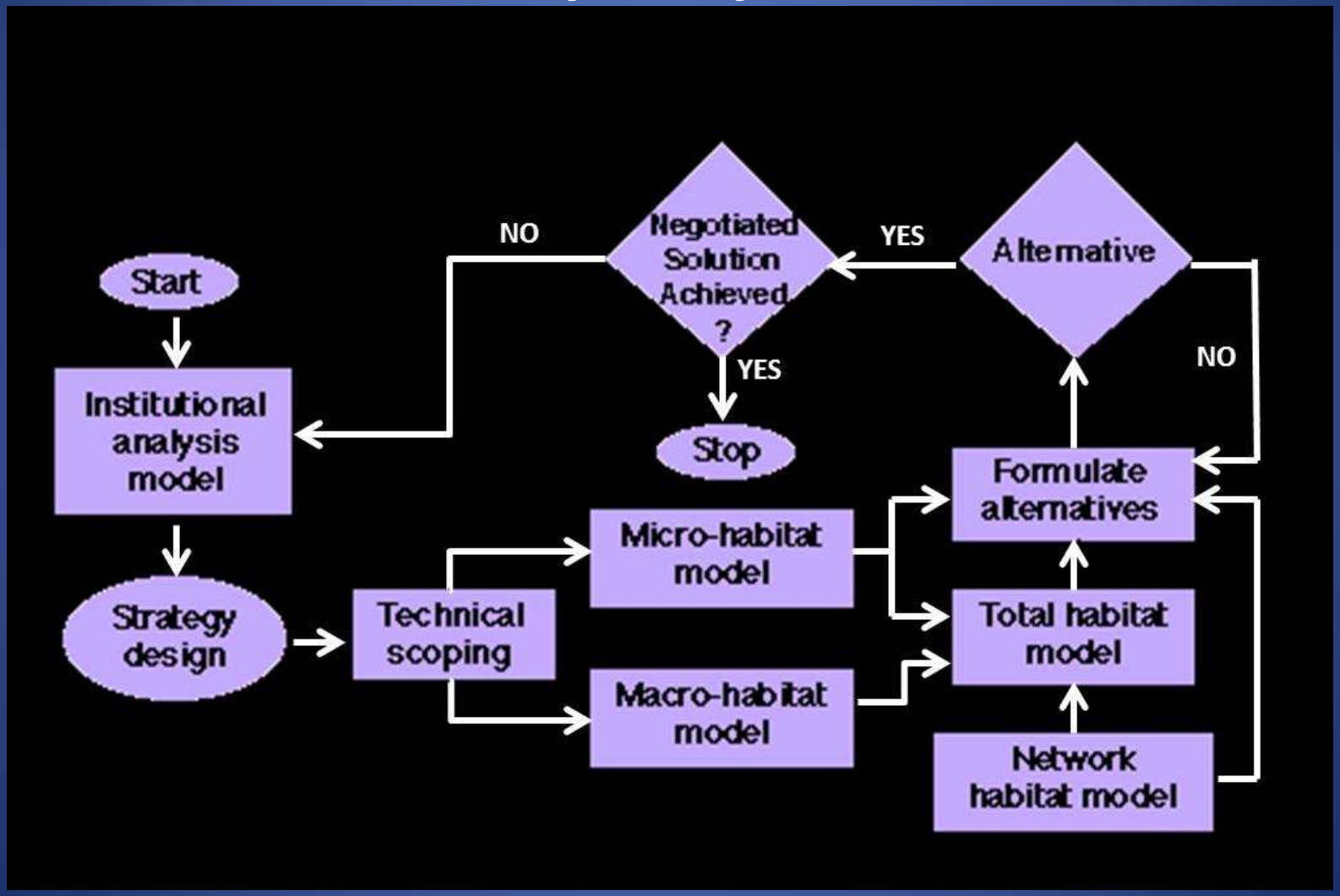
2. Methods used by select states to determine IF needs

3. IF resources for Arkansas

Science-based Methods to Determine Instream Flow Needs

- Instream Flow Incremental Method (IFIM)
- Ecologically Sustainable Water Management (ESWM)
- Ecological Limits of Hydrologic Alteration (ELOHA)
- Sustainable Boundary Approach for a Presumptive Instream Flow Standard

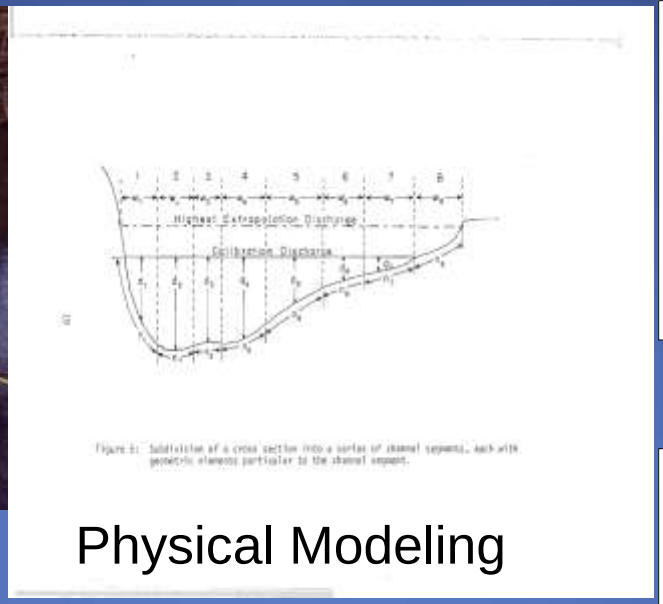
Instream Flow Incremental Method (IFIM)



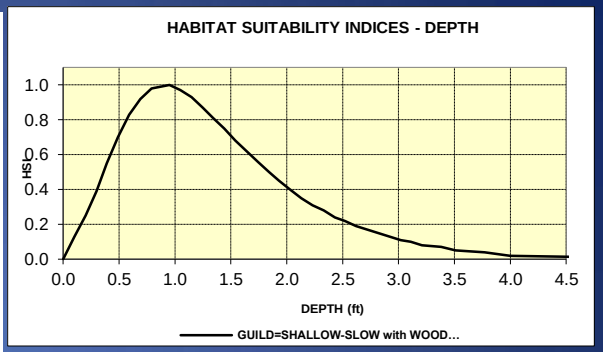
Source: http://www.fort.usgs.gov/Products/Software/ifim/5phases.asp

IFIM Process: Site- and Project–specific Evaluations

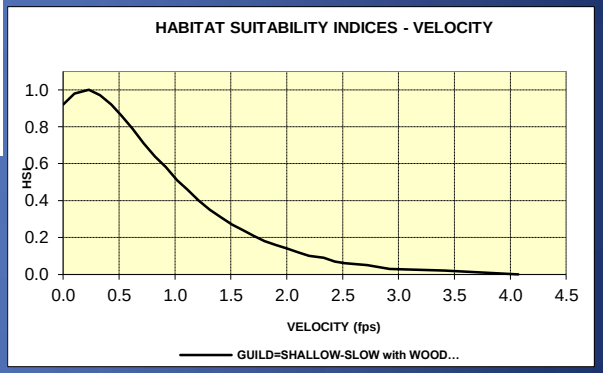
Field Study

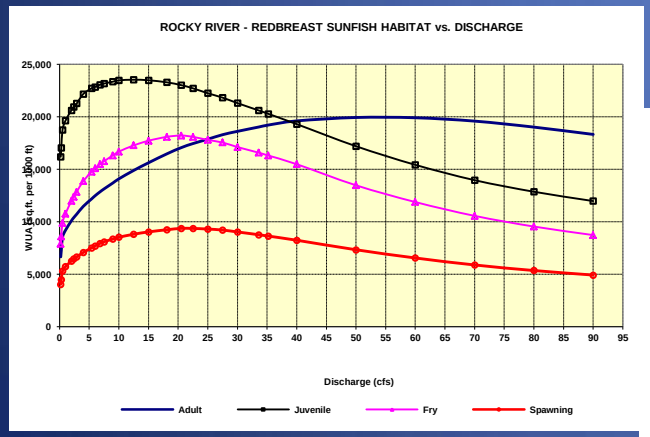


Physical Modeling

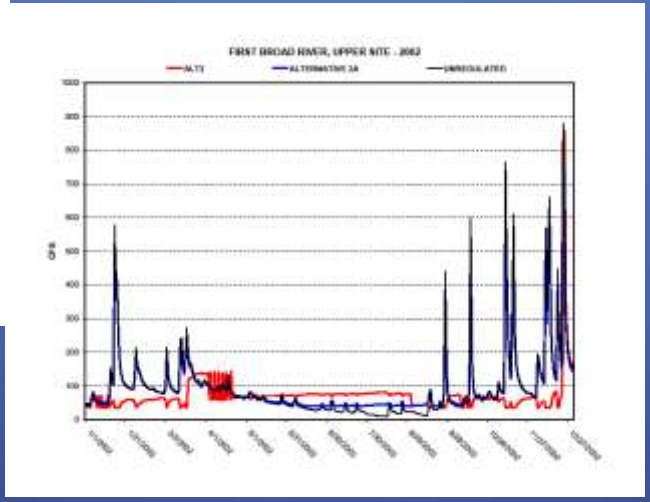


Habitat Modeling





Habitat vs. Flow
for each organism

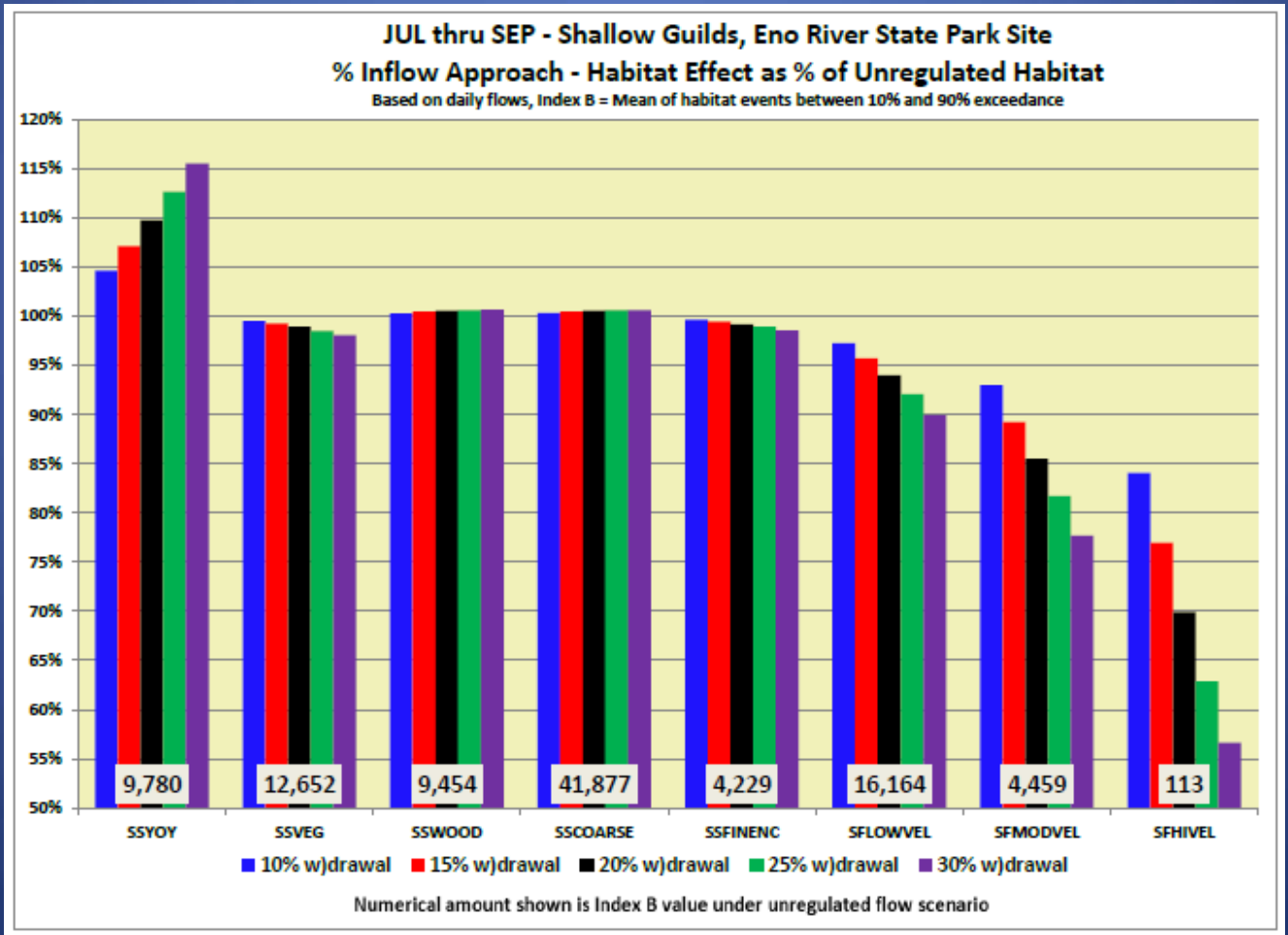


Hydrologic Modeling

- Time Series Analysis
- Flow Alternatives
- Recommendations

Requires time and $

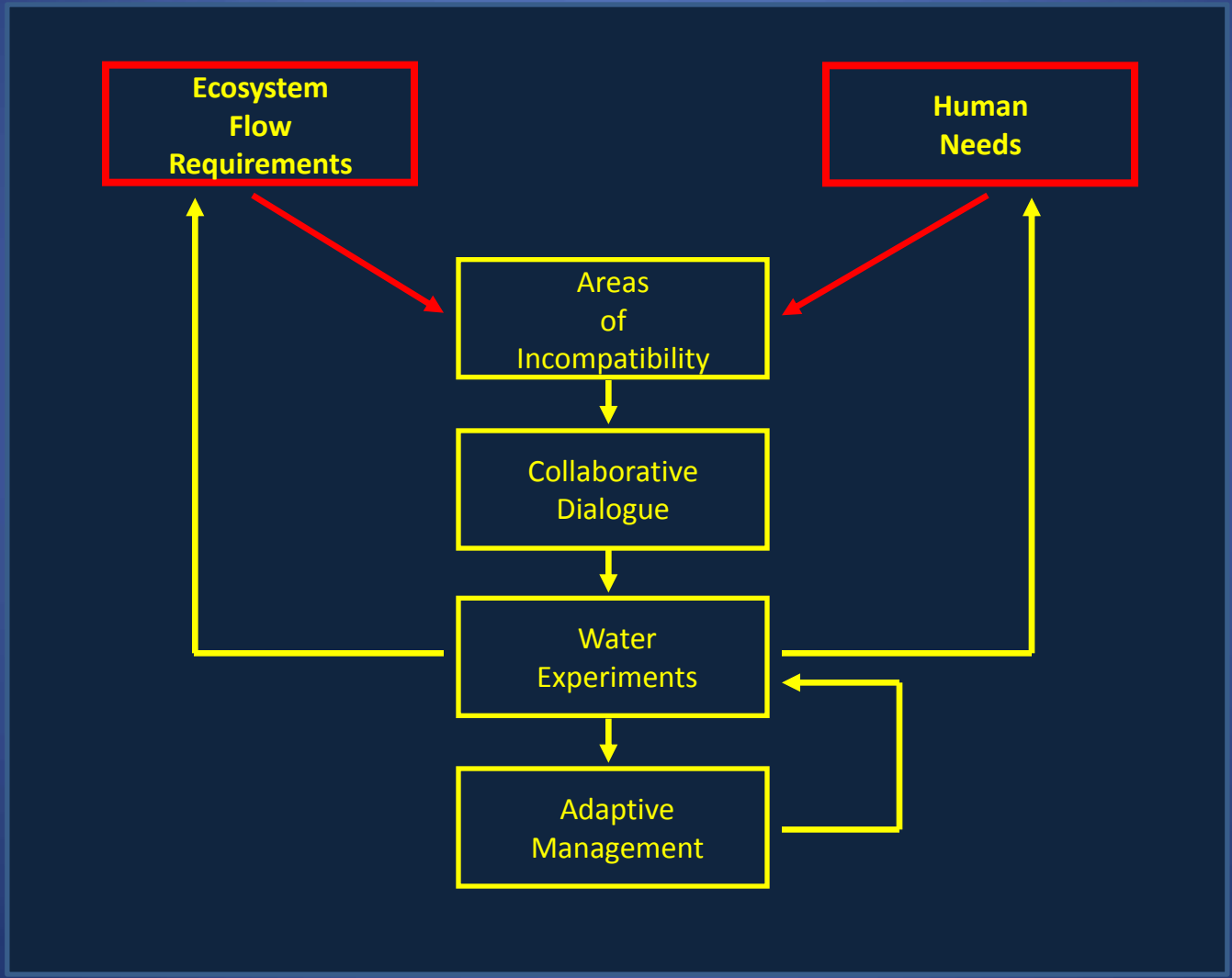
IFIM Process:
Water management alternatives are the basis for a negotiated solution.



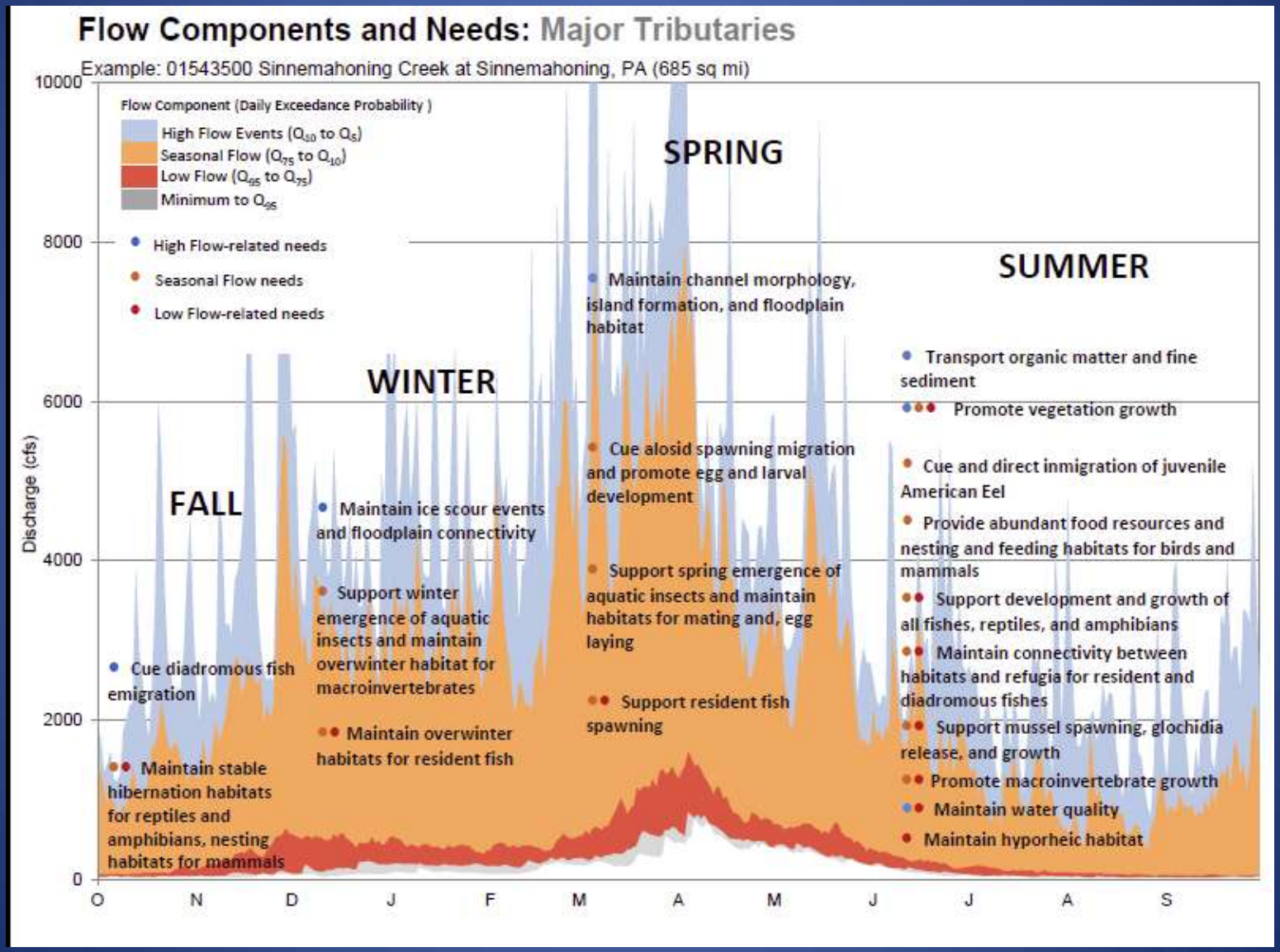
IFIM Essentials

- 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)



Ecological Conceptual Model



Source: Susquehanna River Commission 2011

Savannah River Ecosystem Flow Workshop Participants

Ecosystem Flow Recommendations: Building Block Method

Augusta Shoals on the Savannah River

Floods

No flood flow recommendations provided for the Shoals

High Flow Pulses

20,000-40,000 cfs;
2-3 days, 1/month | 14 days, 1/month
Jan & Feb | Mar & Apr

20,000-40,000 cfs; 2-3 days, 1/month

>16,000 cfs; 1-2 days, 1-2 pulse

- Herring passage over NSBLD
- Morone egg suspension

20,000 cfs;
2-3 days, 1 pulse
- Sturgeon spawning

Low Flows

>5,000 cfs;
- Sturgeon spawning

6,000-10,000 cfs, with 6,000 cfs as baseflow

6,000-10,000 cfs, with 6,000 cfs as baseflow

4,000-6,000 cfs, 4,000 cfs as baseflow

- Shad, striped bass, robust redhouse spawning and habitat

4,000-5,000 cfs;
- Sturgeon spawning

4,000-5,000 cfs;

4,000-5,000 cfs;

- Resident fish habitat
- Juvenile fish out-migration

>2,700,000 cfs

>2,700 cfs; • Juvenile Outmigration

>2,700 cfs | >2,000 cfs | >2,700 cfs

- protect spider lily from deer grazing

Key

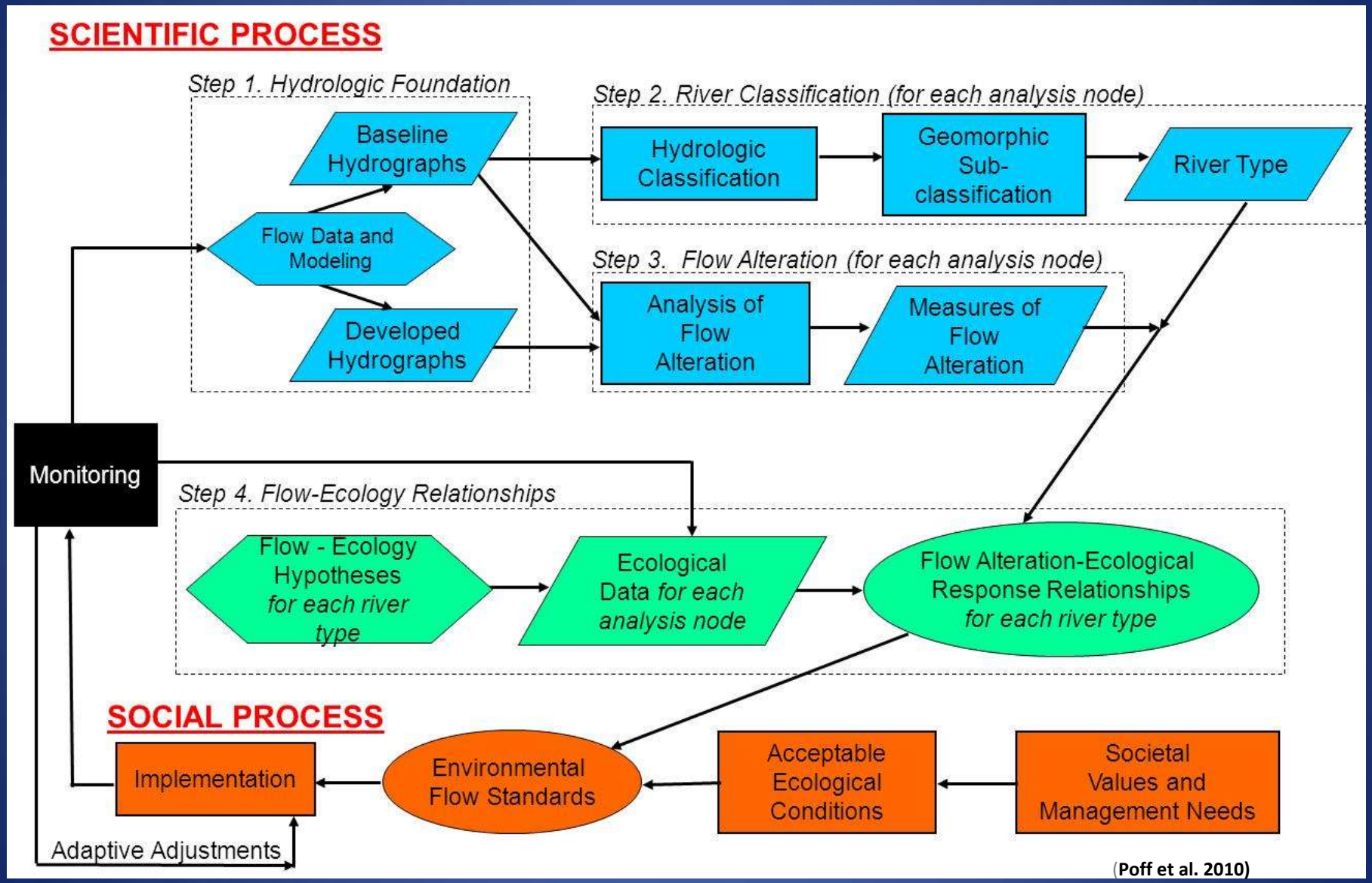
- Wet Year
- Avg Year
- Dry Year

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

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)



(Poff et al. 2010)

http://conserveonline.org/workspaces/eloha

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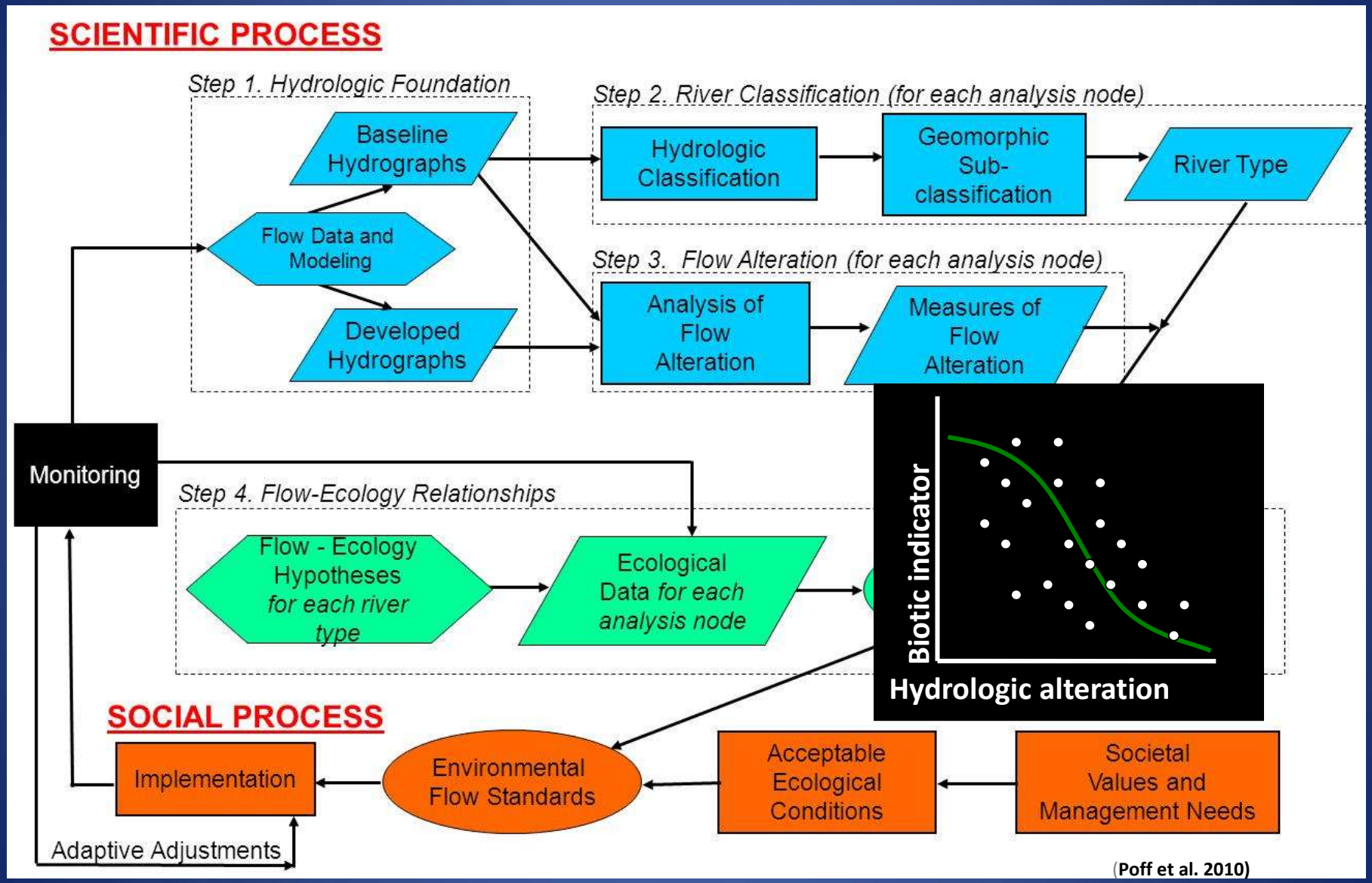

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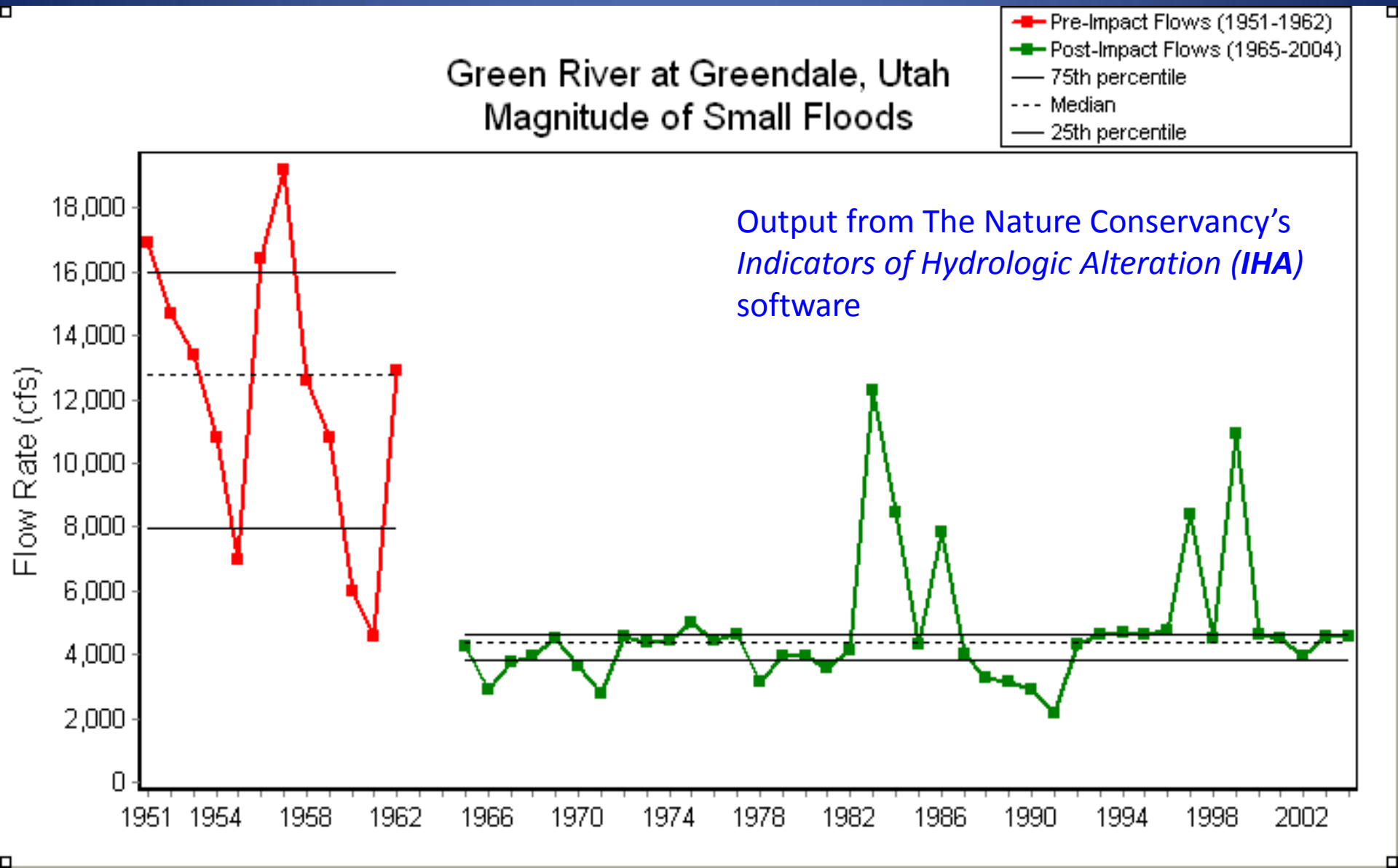
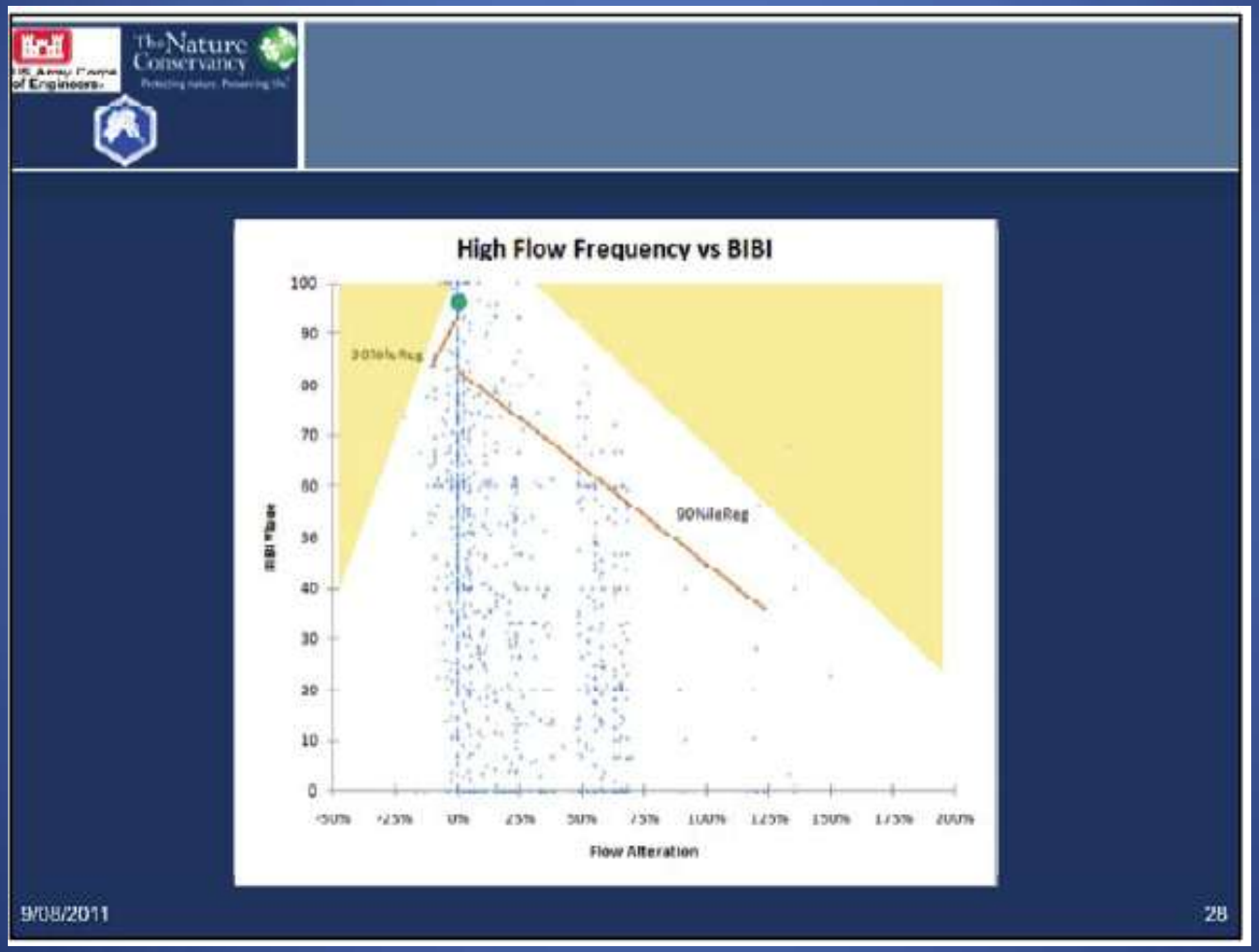
Calculation of Flow Alteration



Output from The Nature Conservancy's *Indicators of Hydrologic Alteration (**IHA**)* software

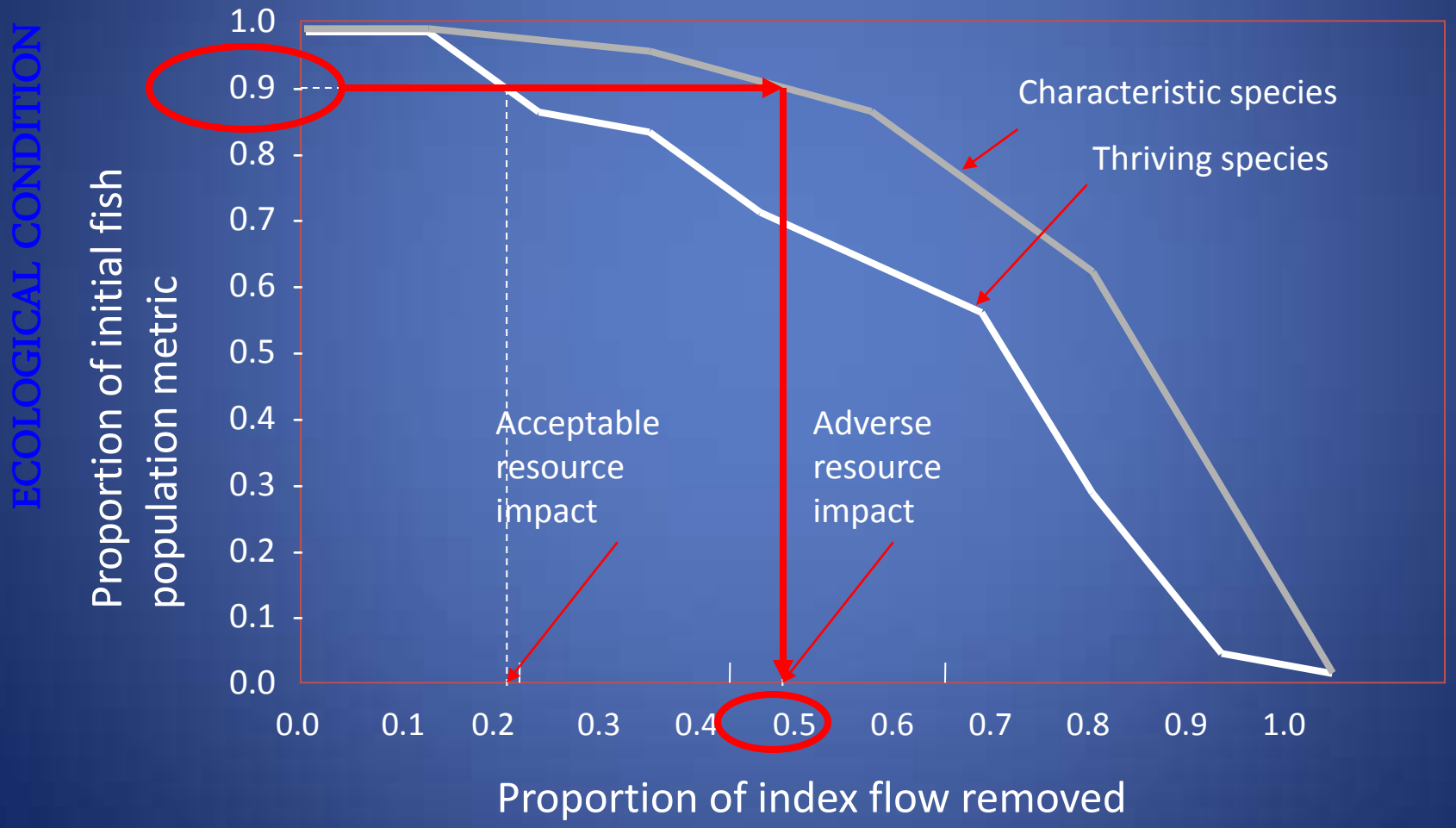
Flow-Ecology Relationships from Existing Data



Source: Potomac River Commission Watershed Assessment 2011

Ecological Response to Flow Alteration

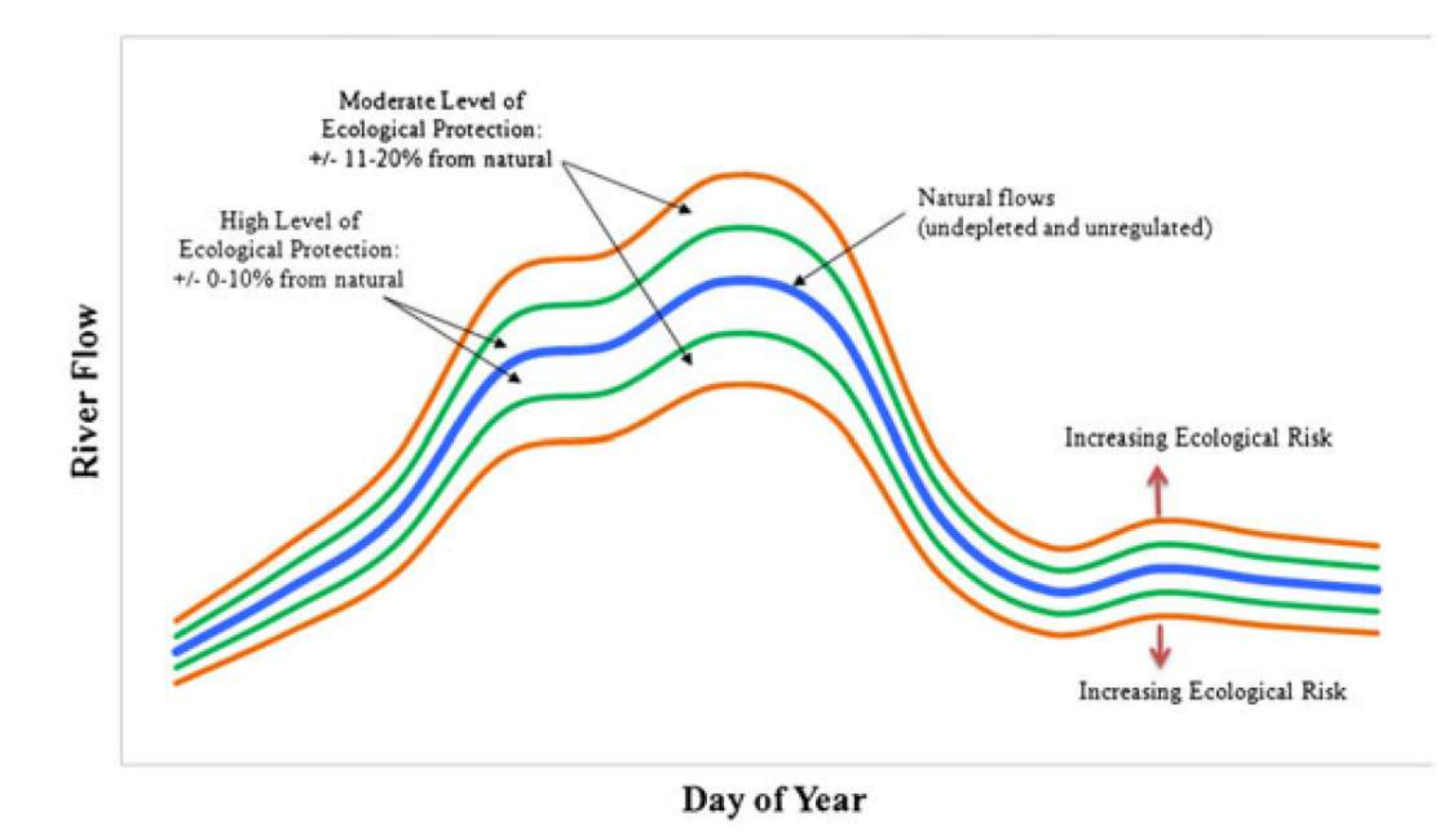
Michigan's Screening Tool for Ground-Water Withdrawals



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)

Presentation Overview

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 Specifying IF Standards

- 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)

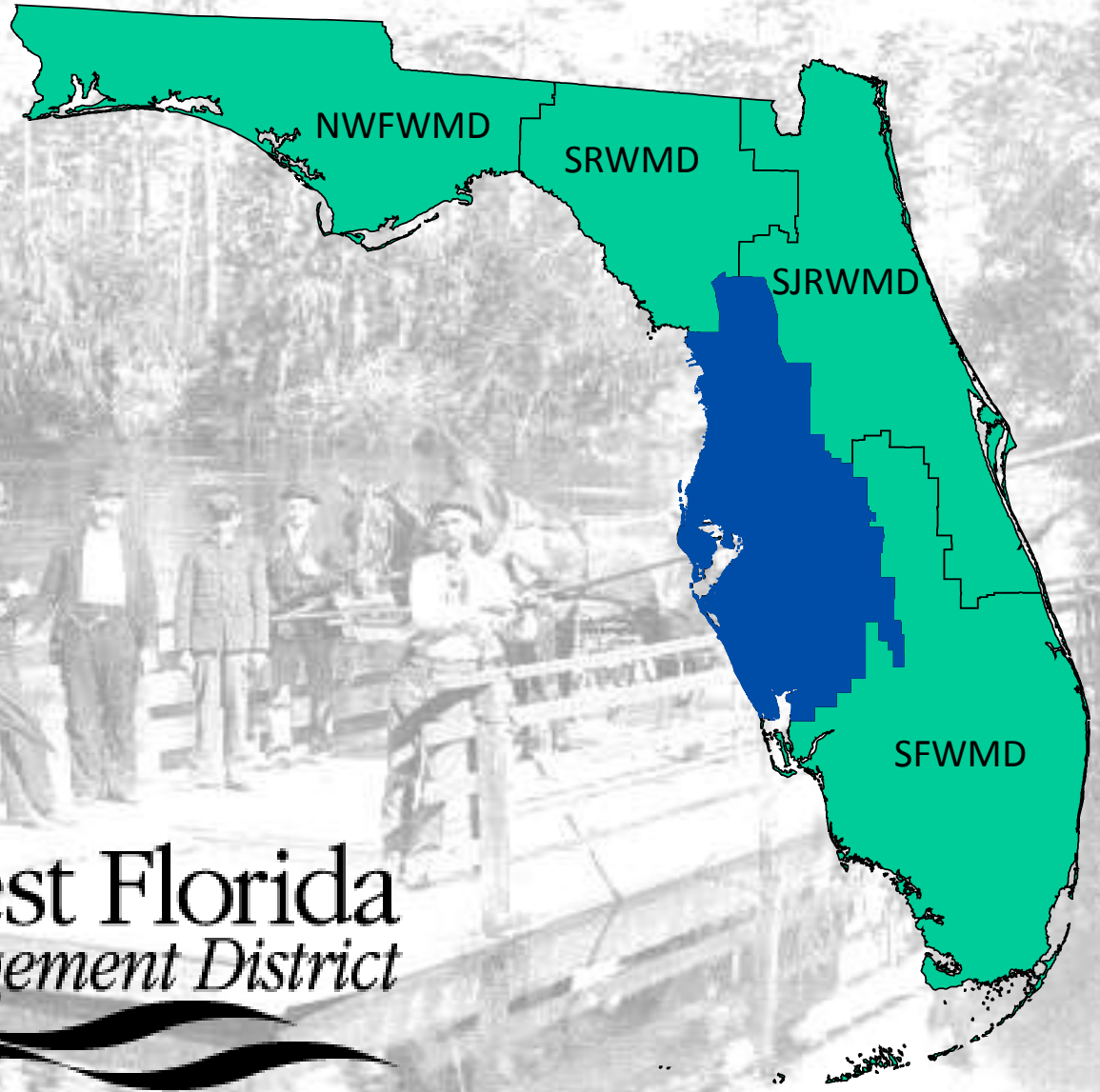
IF Methods Used by Selected Programs

- Florida
- Potomac River Commission

- Texas, if time allows

Florida – Instream Flow Protection Policy and Management Programs

Slides courtesy of
Marty Kelly, Director
SWFWMD MFL Program



Southwest Florida
Water Management District

http://www.swfwmd.state.fl.us/projects/mfl/

Minimum Flows and Levels

- Florida Statutes, Section 373.042 -

The ***minimum flow*** for a given watercourse shall be the limit at which further <u>withdrawals</u> would be <u>significantly harmful</u> to the water resources or ecology of the area

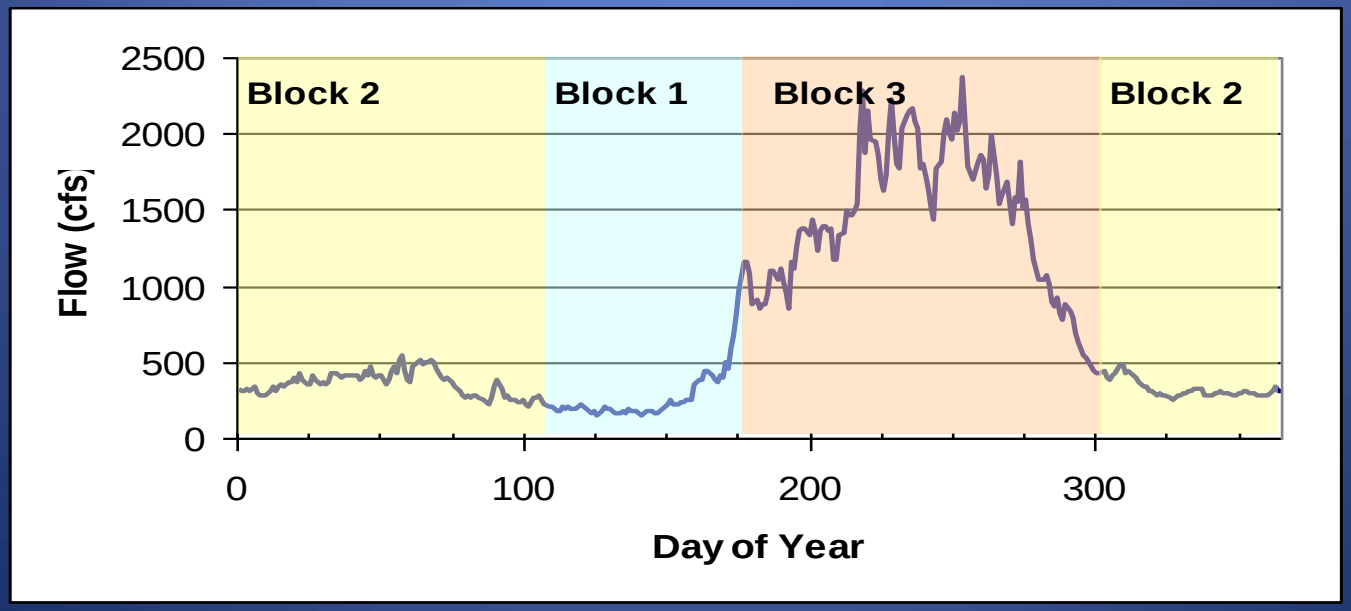
A MFL is set by the Water Management Districts for each of their priority streams, rivers, lakes, and aquifers.

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*



Physical Habitat Simulation System

Used for Blocks 1 and 2

- **Depth**
- **Velocity**
- **Substrate**

Long-Term Inundation Analysis

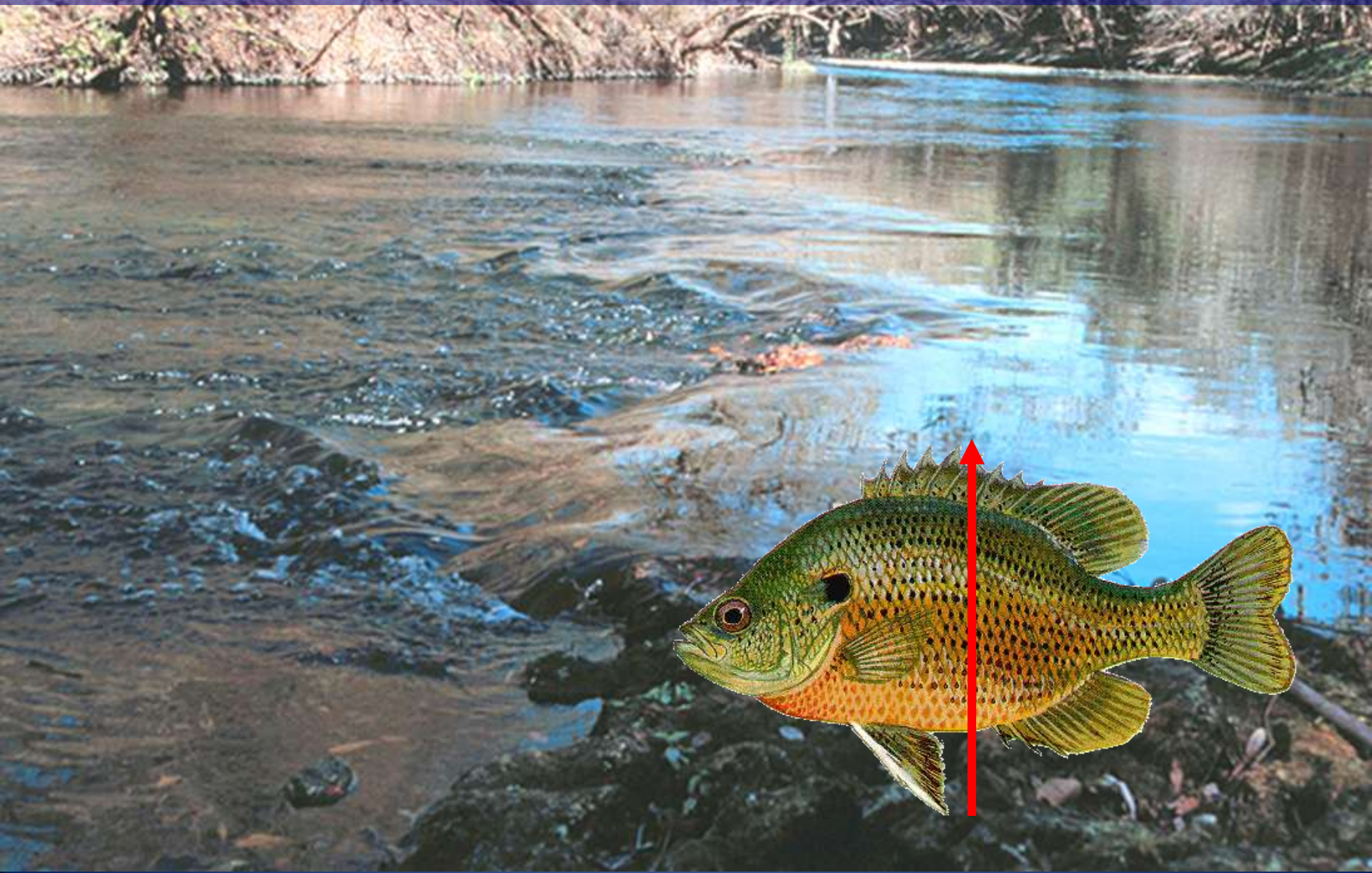
Used for Blocks 2 and 3

Low Flow Threshold - Wetted Perimeter

Used for All Blocks

Low Flow Threshold - Fish Passage

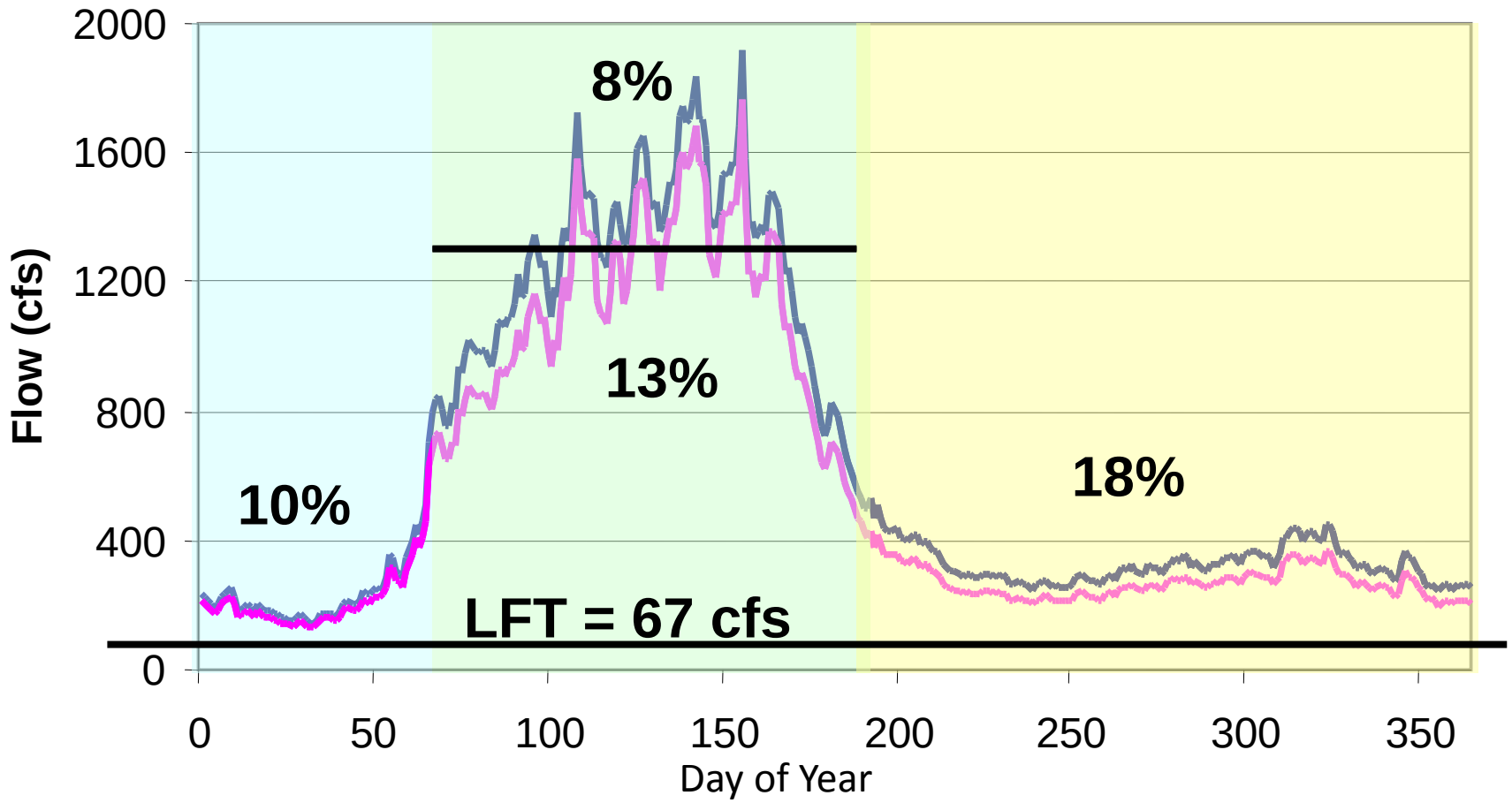
Used for All Blocks



Flow Prescription

Percent of Flow and Seasonality

of allowable cumulative withdrawals



- Best Available Information
- Peer Review Process

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

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

Source: http://www.swfwmd.state.fl.us/projects/mfl/

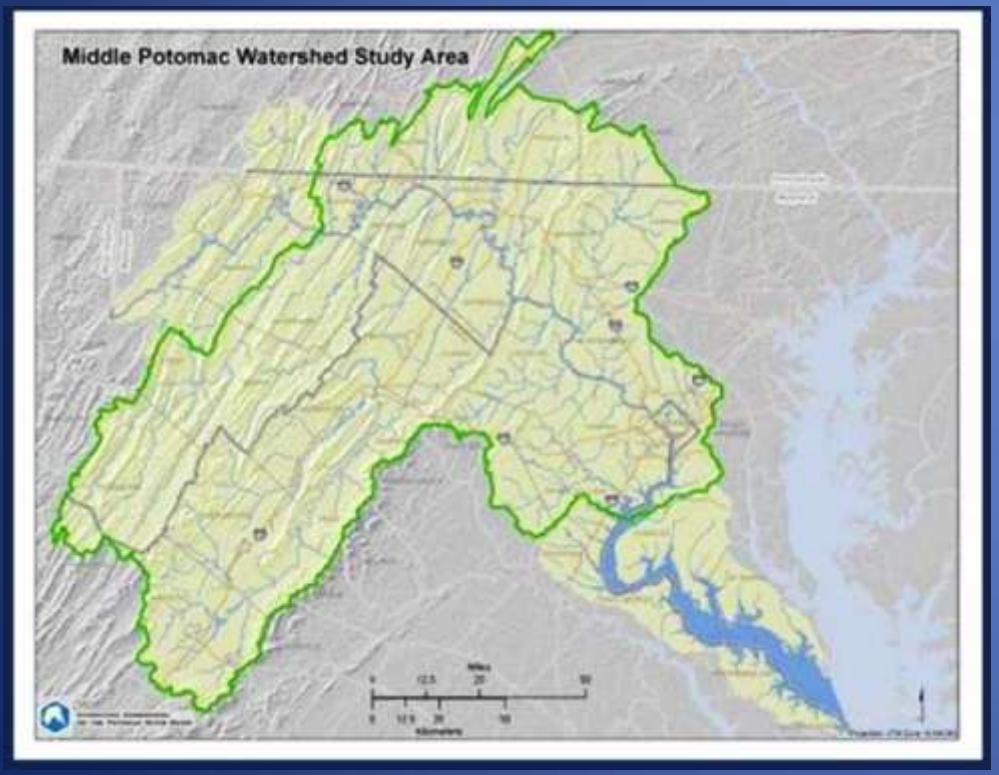
SWFWMD MFL Essentials

- 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 and Approaches Used by Advanced State Programs

- Florida – similar standards within river class
- Potomac River Commission

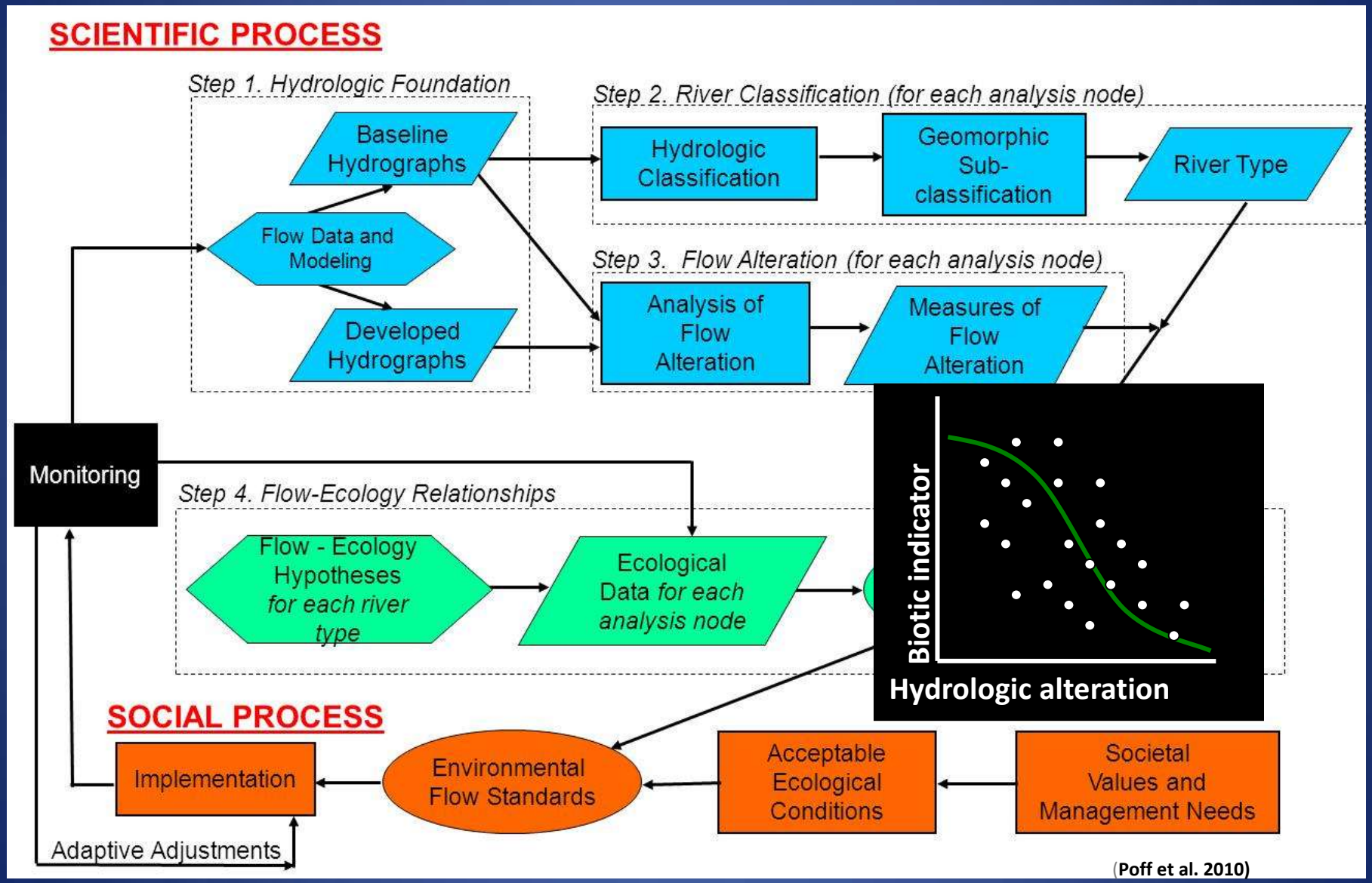
Middle Potomac Watershed Assessment: Environmental Flows



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

Slides courtesy of Carlton Haywood, PRC

Ecological Limits of Hydrologic Alteration (ELOHA)



(Poff et al. 2010)

http://conserveonline.org/workspaces/eloha

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
  - Hydrologic Integrity Tool (HIT). Henriksen et al (2006), *The Hydroecological Integrity Assessment Process*, USGS Open File Report 2006-1093.
  - Indicators of Hydrologic Alteration (IHA). The Nature Conservancy (2007), *Indicators of Hydrologic Alteration, Version 7 User's Manual*.
  - 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

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Hydrologic Metrics

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

*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.

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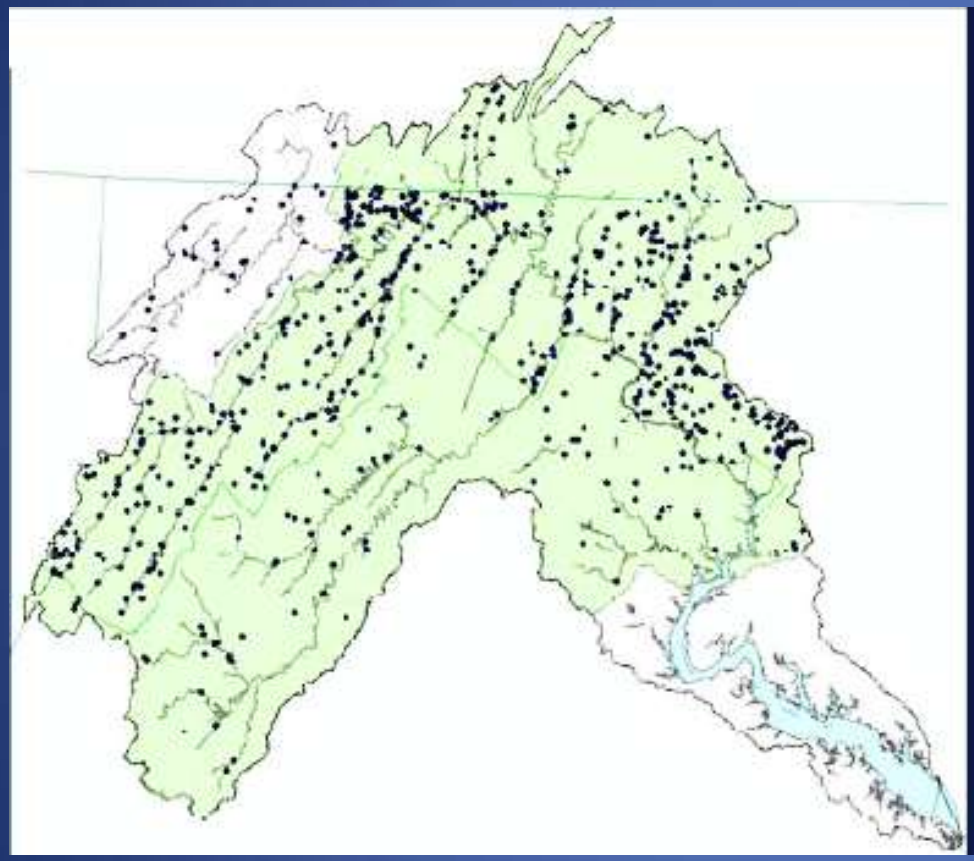
Middle Potomac – Biological Data



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

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Biotic Metrics

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

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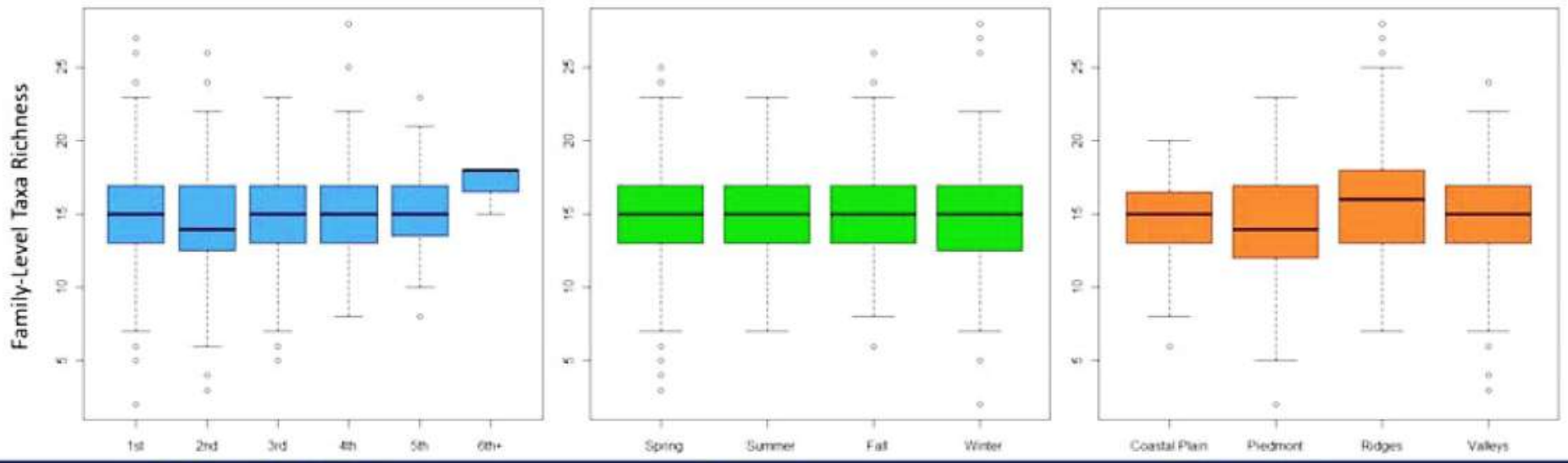
Classification

Some biological metrics appear not to need classification….

Family-Level Taxa Richness

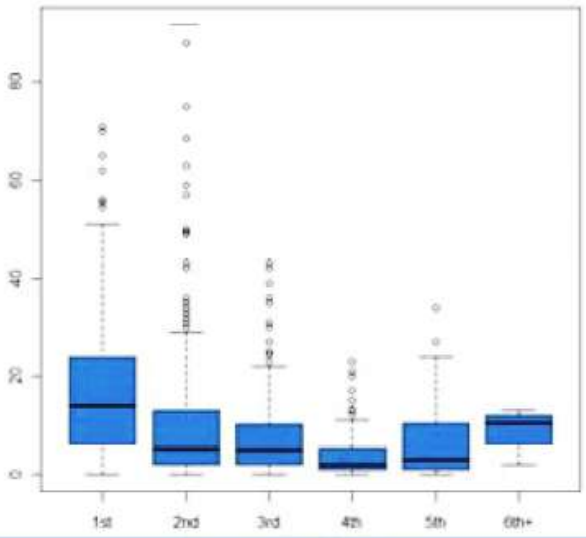


Watershed Size | Season | "Bioregion"

Classification

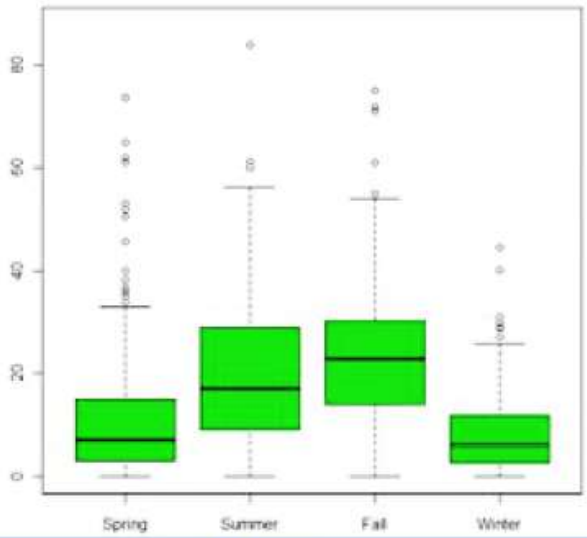
…while others may need classification

%Shredders



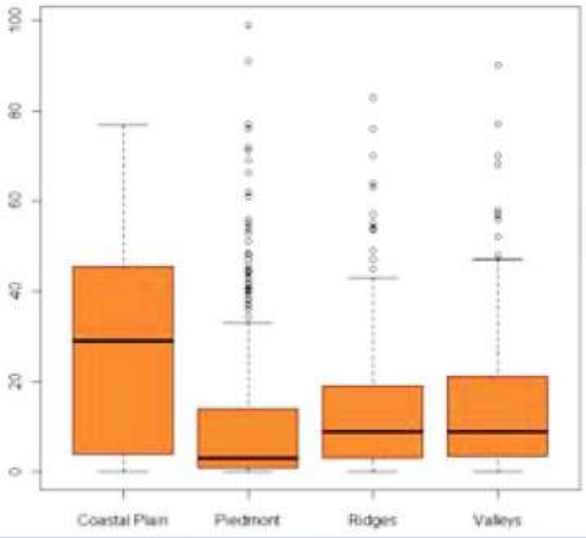
Watershed Size

%Net Caddisfly



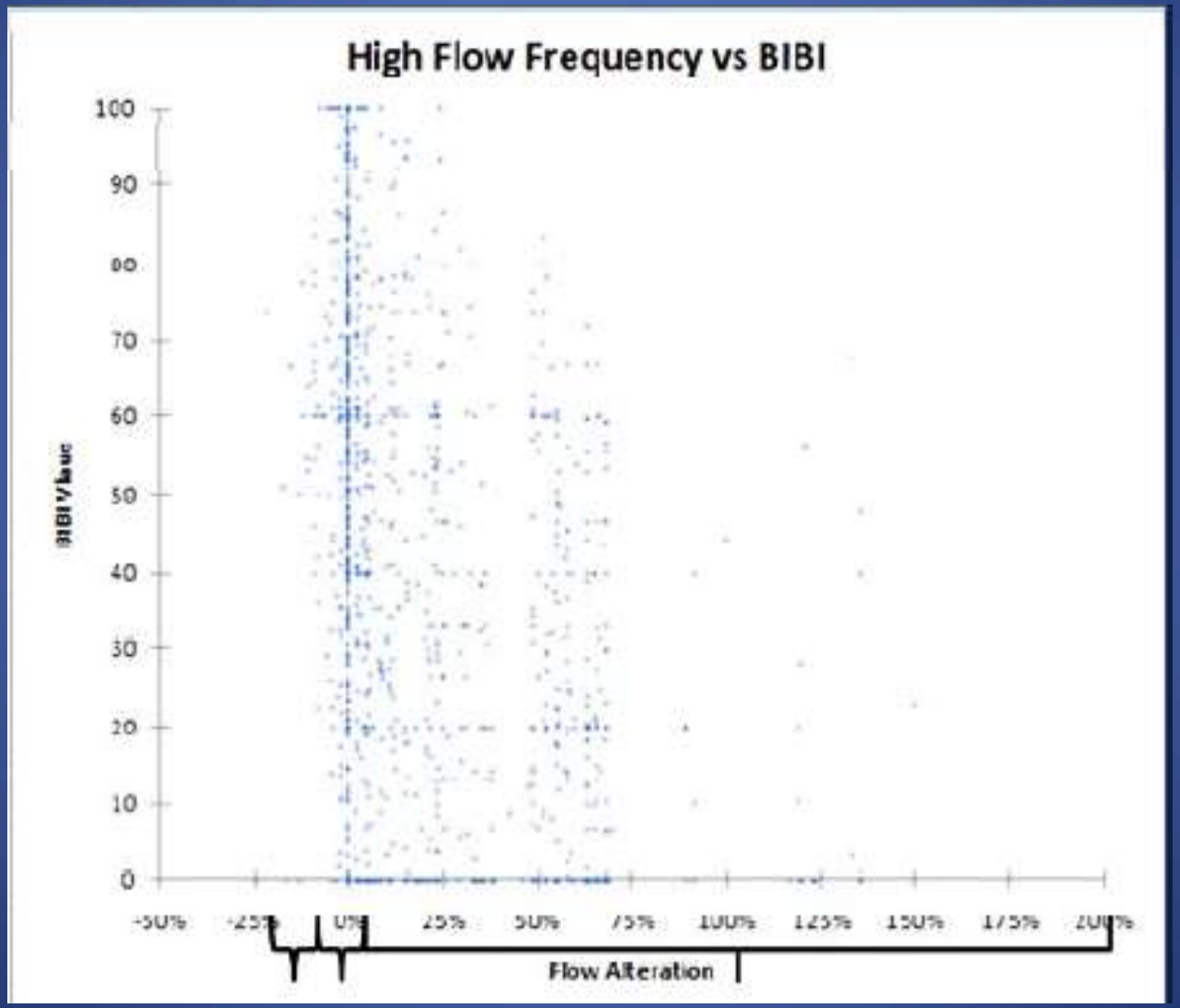
Season

%Chironomidae

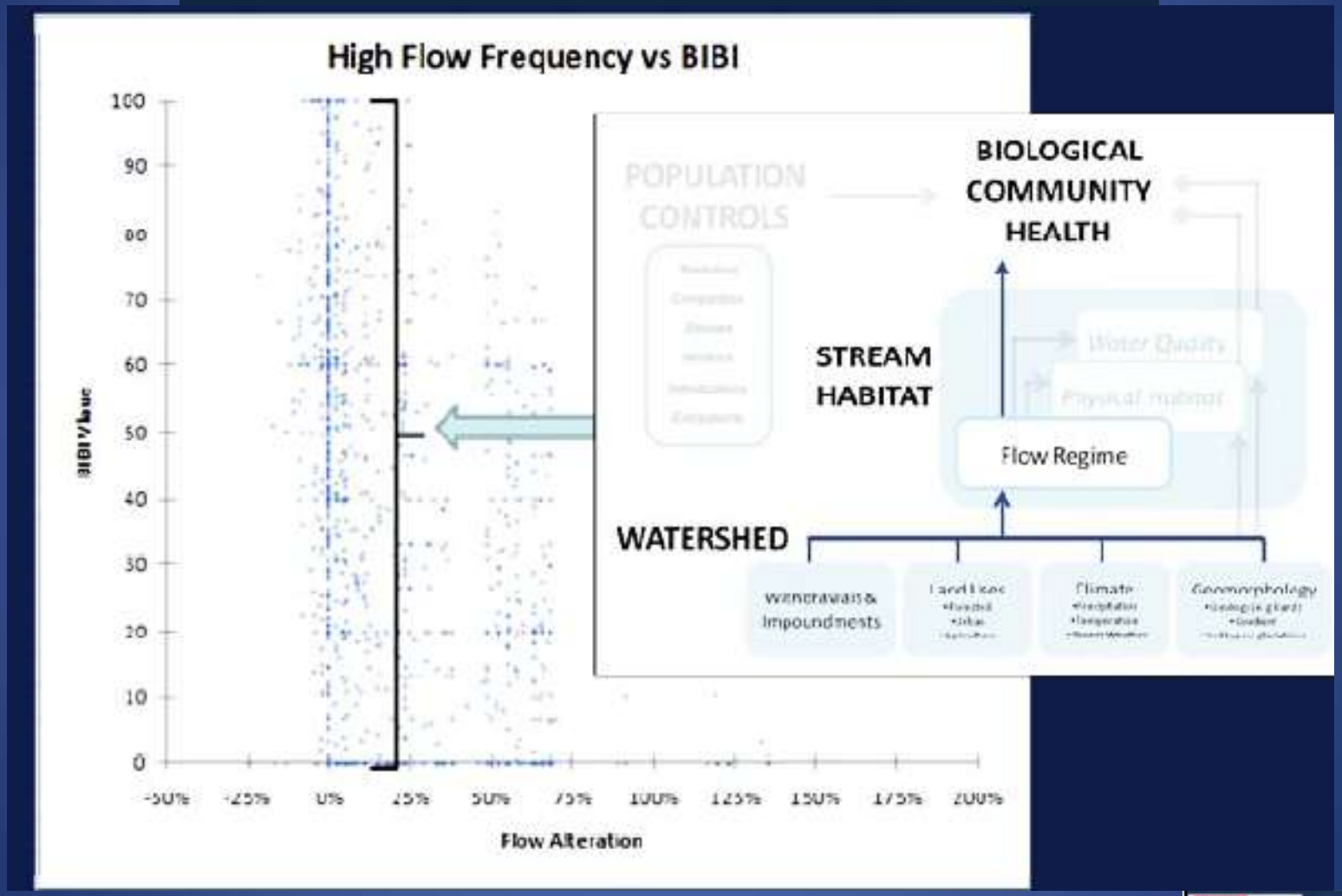


"Bioregion"

Flow-Ecology Relationships



Flow-Ecology Relationships



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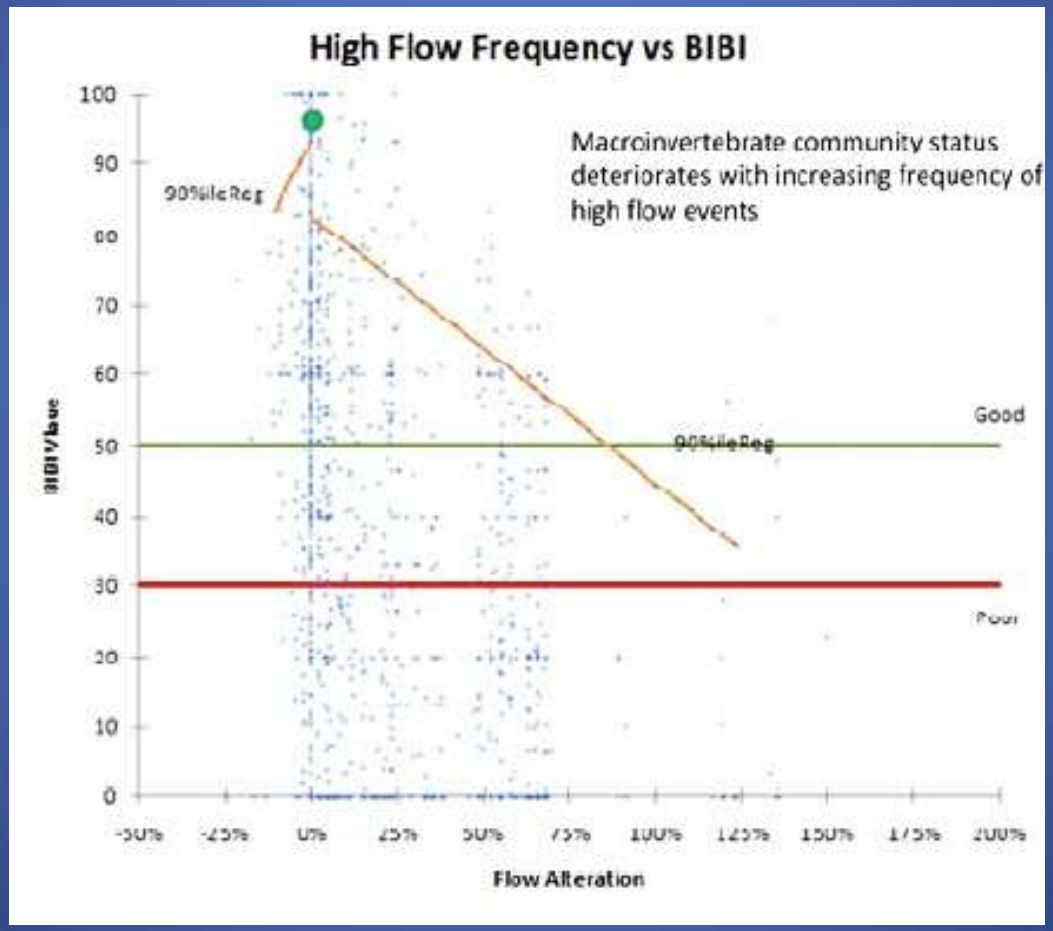
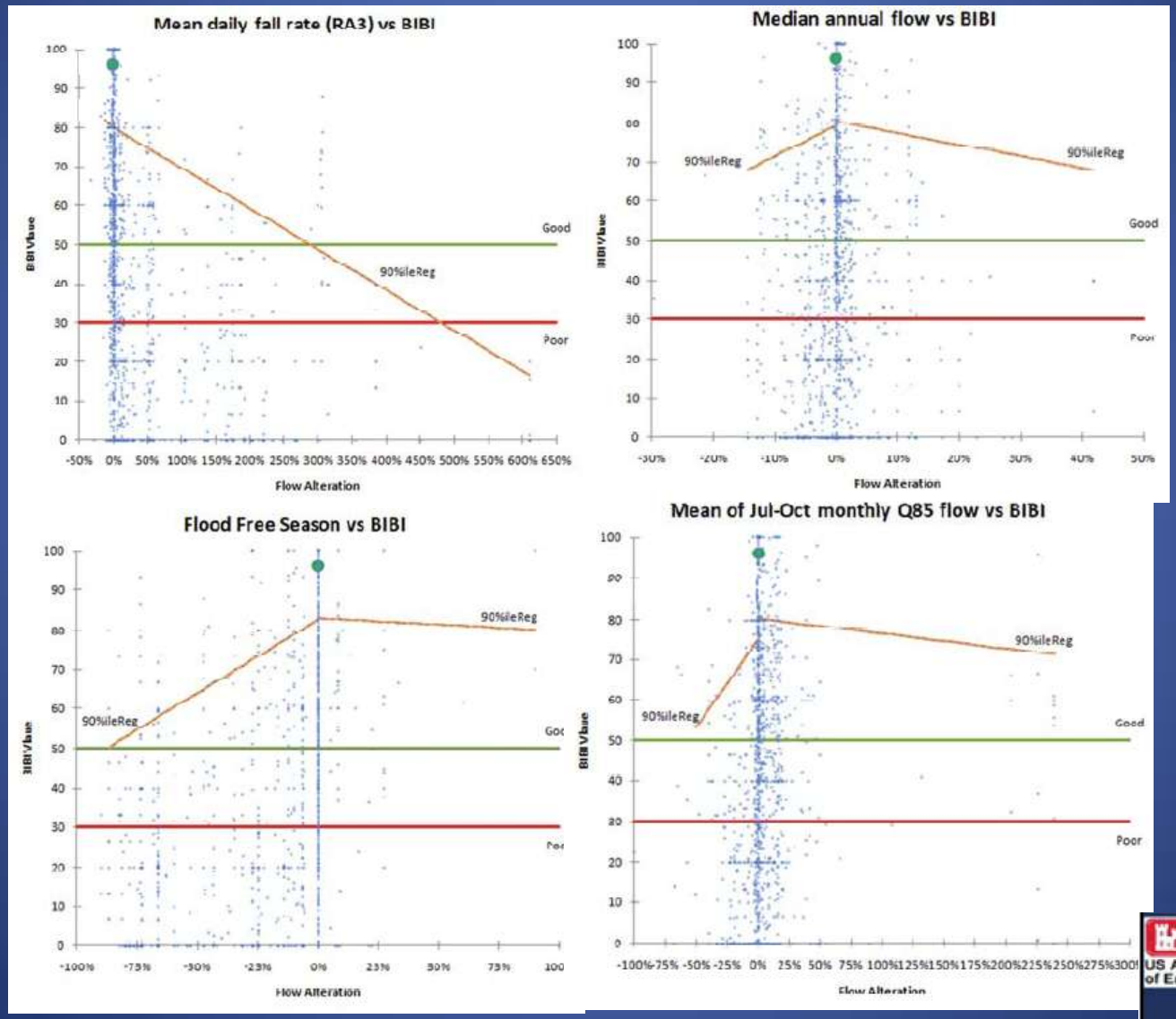


Flow-Ecology Relationships



IF Methods and Approaches Used by Advanced State Programs

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

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 Arkansas 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.

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
SARP

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.

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
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Southern Instream Flow Research Agenda

Priority Research Topics

1. River classification
2. Flow alteration assessment
3. Aquatic ecology data sets
4. Ecological responses to flow alteration hypotheses
5. Field studies to test F-E hypotheses

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
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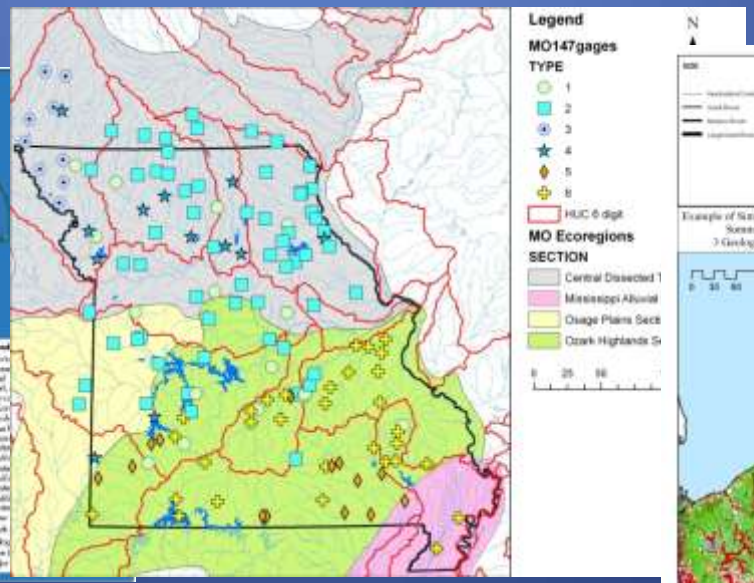
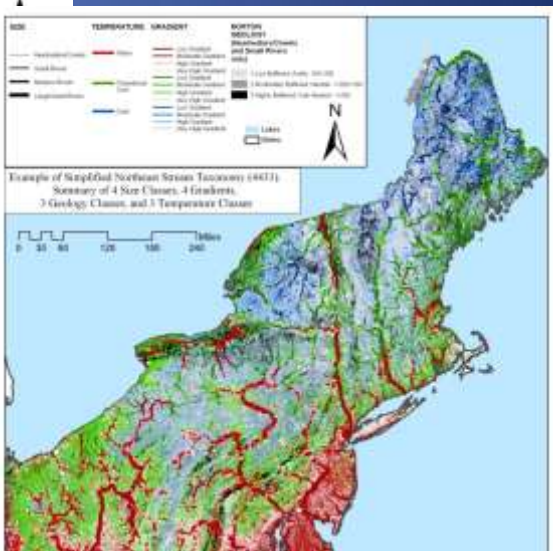
SE River Classification Framework

- **Specifications:**
  - Utilized existing classifications
  - NHD+ segment scale for 14 SE states
  - Expert-review process

- **Categories**
  - SE states: size, gradient, ecoregion, soils
  - Eastern: landform, temp, hydrology, geology





Compile regional aquatic ecology data sets

MARIS

Multistate Aquatic Resources Information System

www.marisdata.org

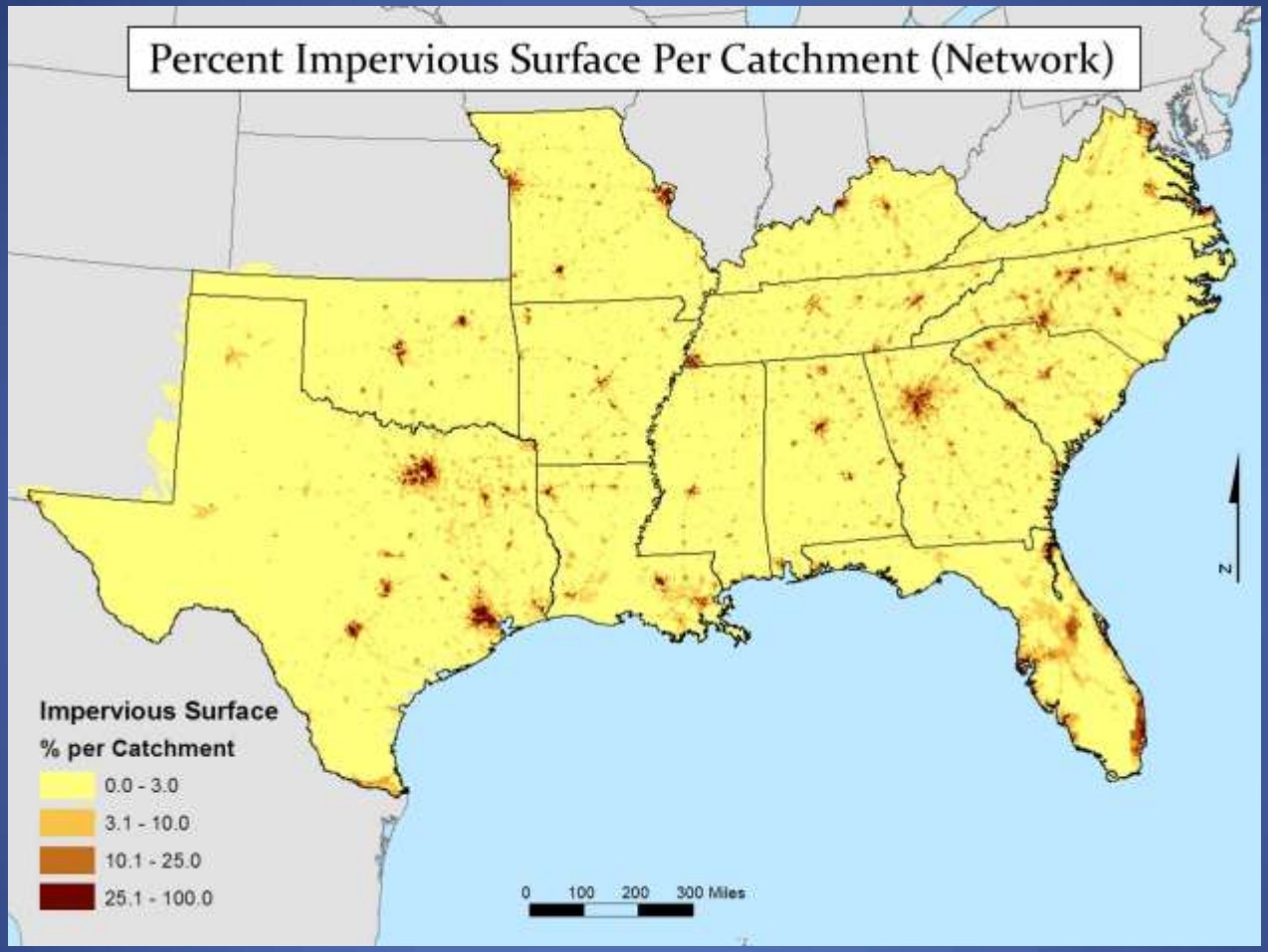
Integrating State Data into the National Fish Habitat Assessment

MARIS States (2010)

Compiled Flow-Ecology Literature

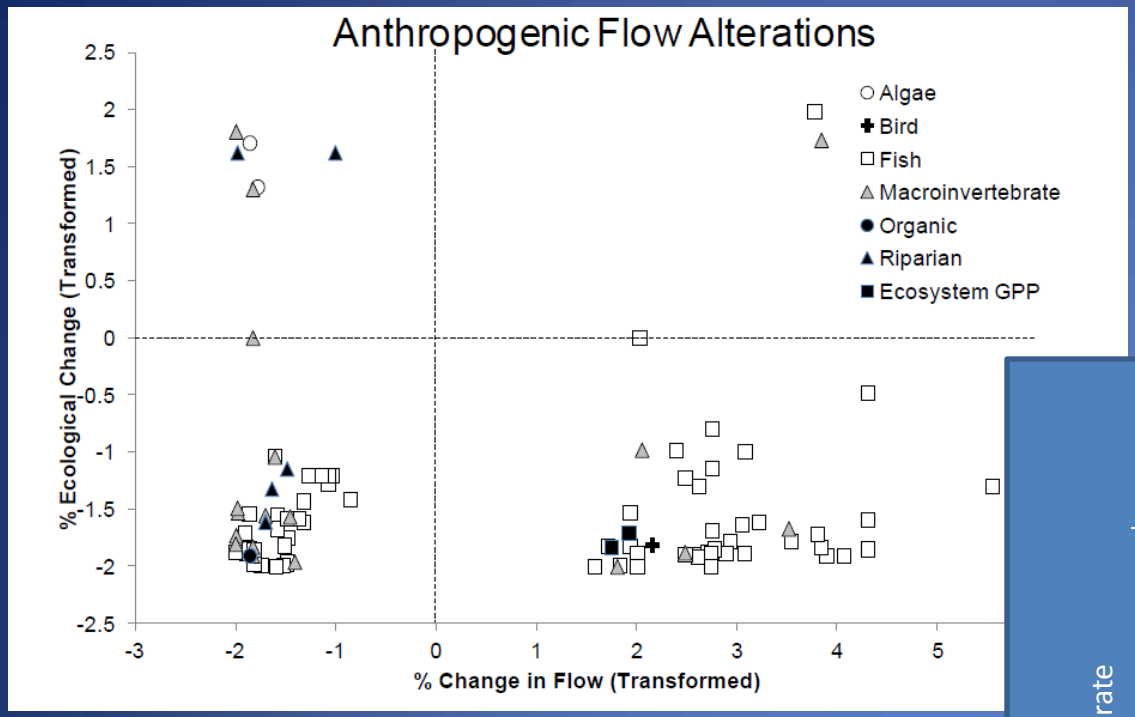
- Peer-reviewed and gray literature
- Maintained in publicly accessible Mendeley database
- Searchable by keywords, authors, titles
- Over 900 citations at present
- Updated regularly

SARP Flow Alteration Assessment

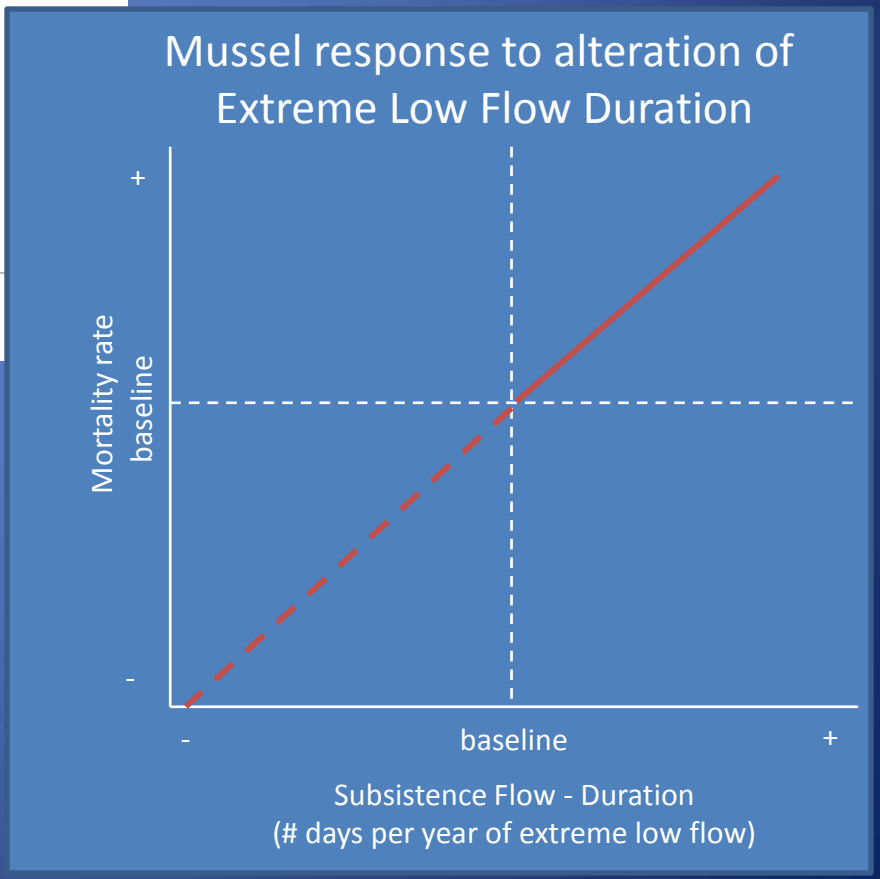


Approach – Qualitatively assess sources, spatial distribution, and relative magnitude of hydrologic alteration from water consumption, impervious cover, and dams.

Preliminary SE Flow-Ecology Relationships



Source: McManamay et al. 2011



Hydrologic Foundation

- Hydrologic process models
  - Baseline, current, and future flow conditions
  - Daily time step
  - River segment scale
  - Calibrated to ecologically significant flow parameters

- Guidance for ecological application of modeled flow
  - Unbiased error
  - Hydrologic ‘behavior’
  - Site specific vs region-wide use

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.**

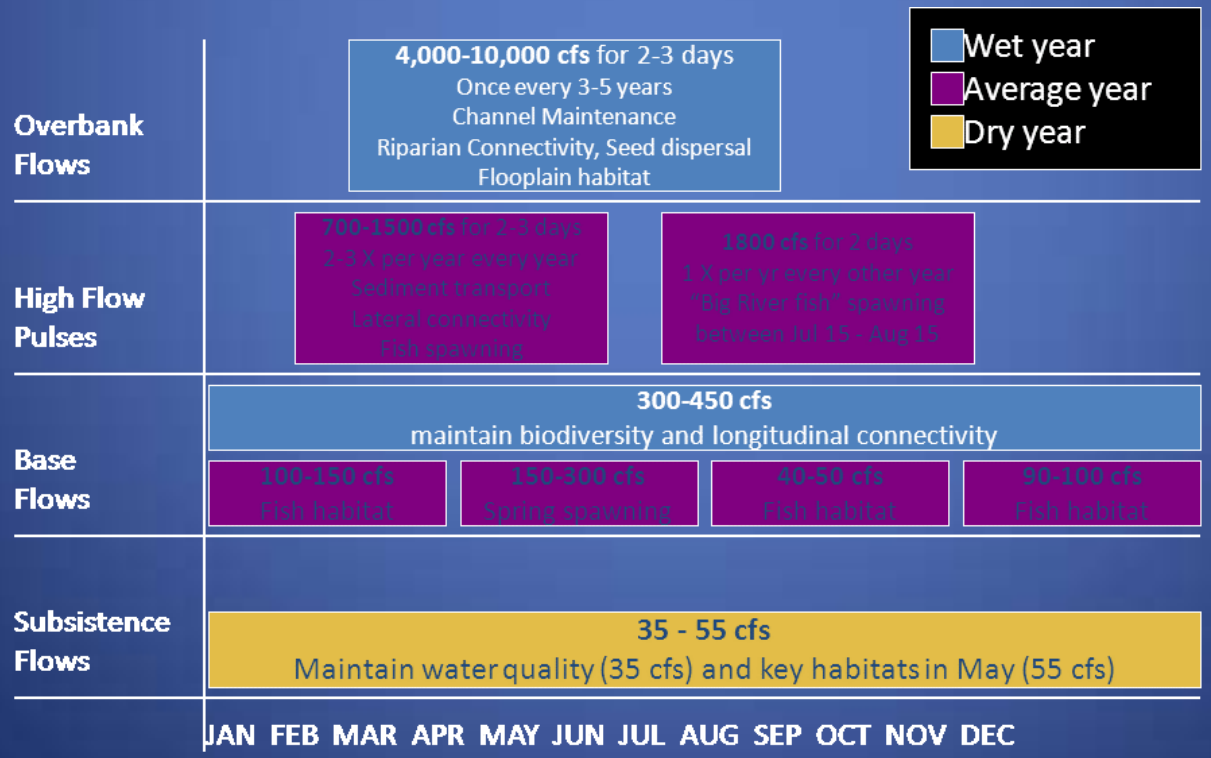
Environmental Flows Allocation Process in Texas

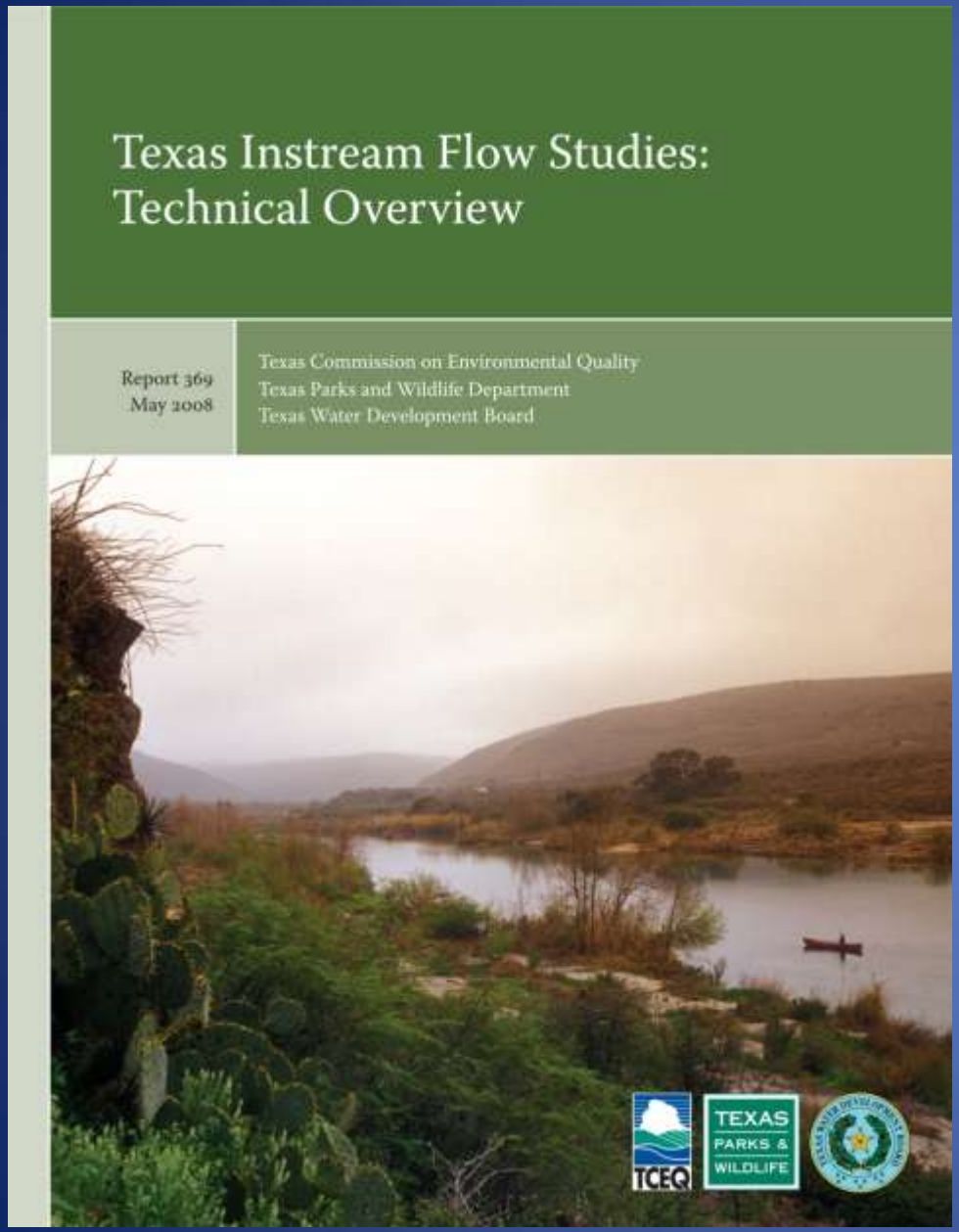
Slides Courtesy of
Kevin Mayes
Director, EF Program

TEXAS PARKS & WILDLIFE

Texas EF Program

- *Flow Regime* – Integration of Ecological Flow Components
- *IFIM-style methodology*
- *Statistically-based approach for recommendations*
- *Sound ecological management target*

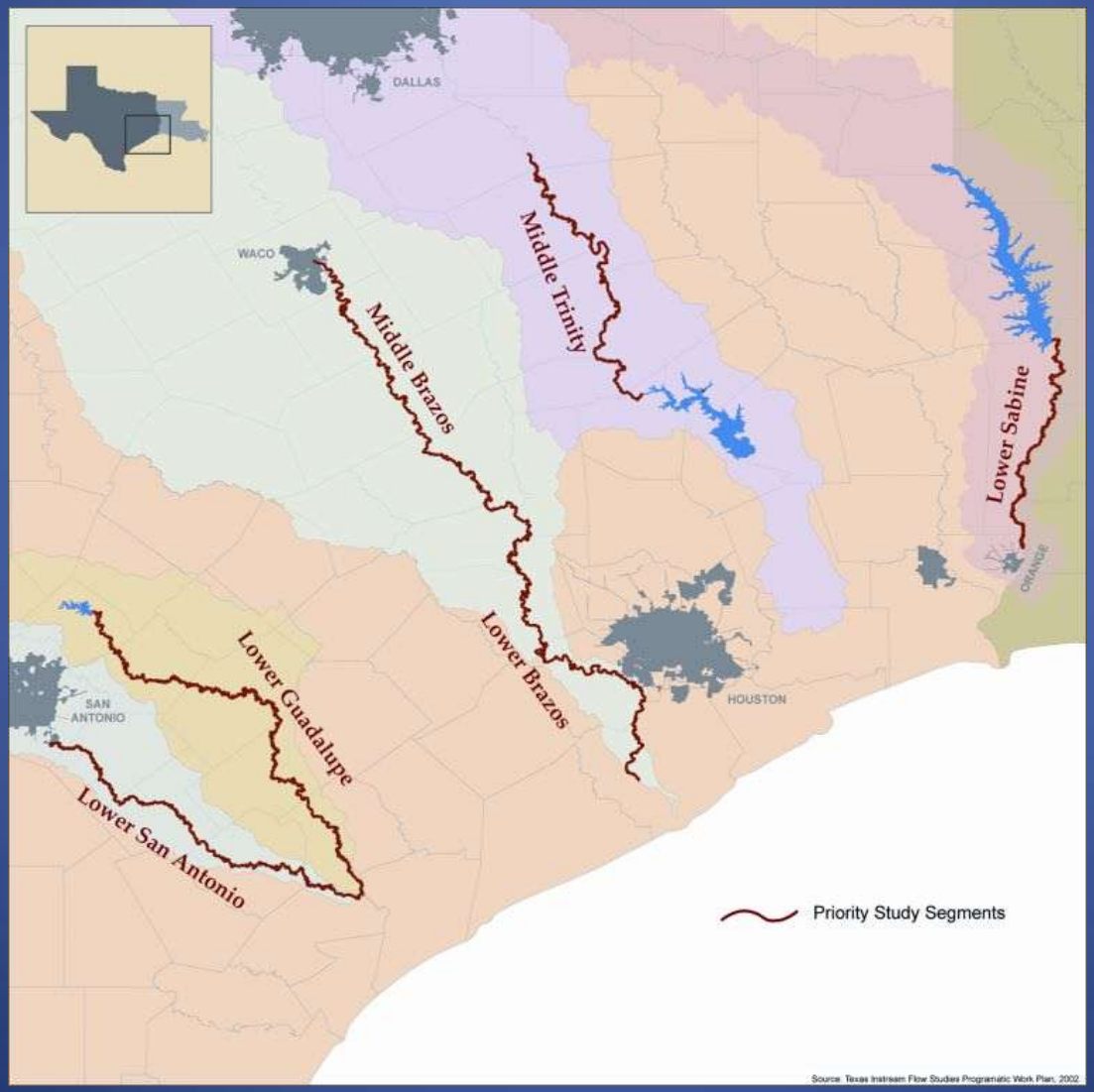




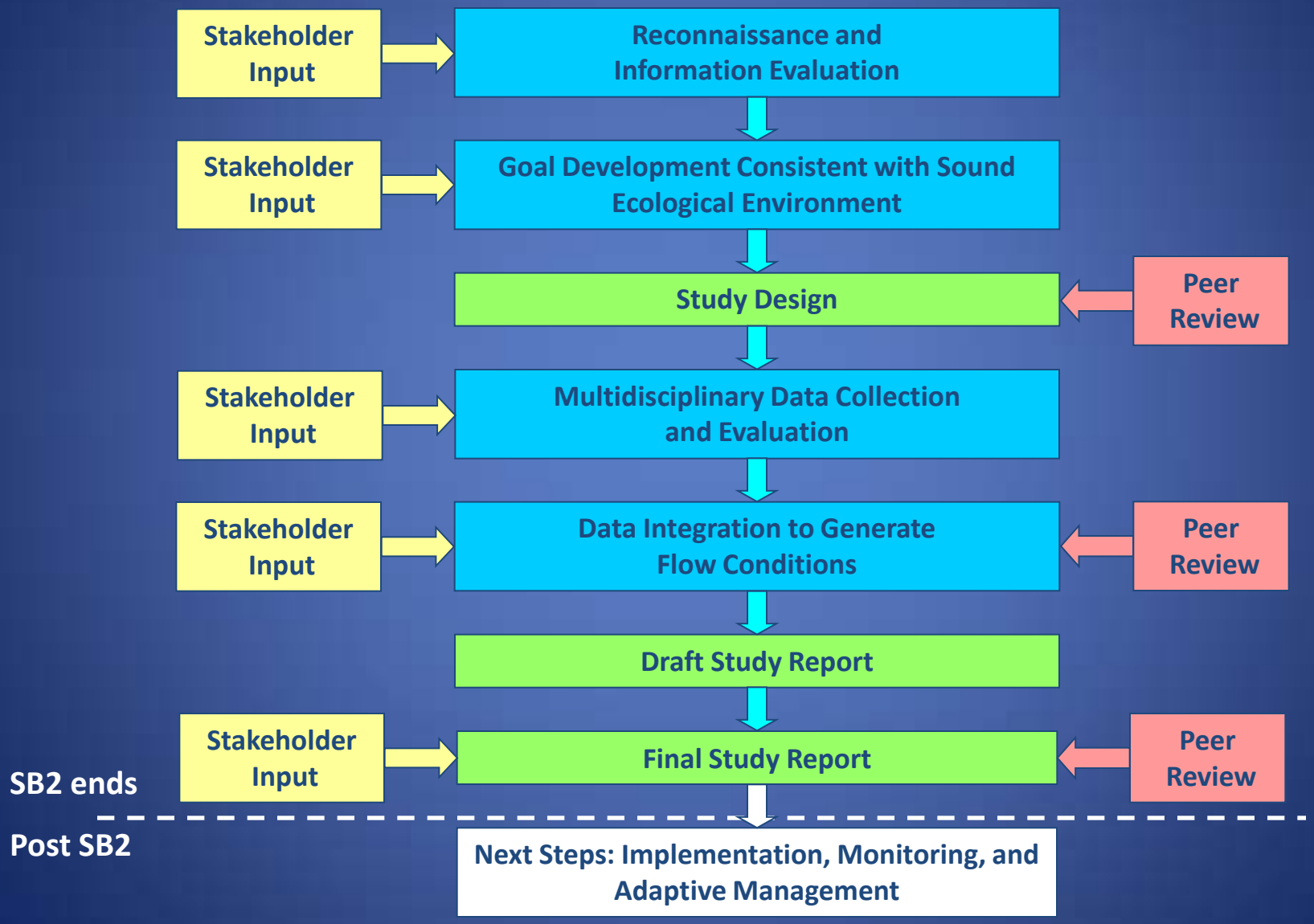
- Clear definitions and process
- Well-defined stakeholder/public involvement process
- Integration framework ties flow components and disciplines
- Approved by National Research Council

Texas Environmental Flow Program

Priority Study River Segments

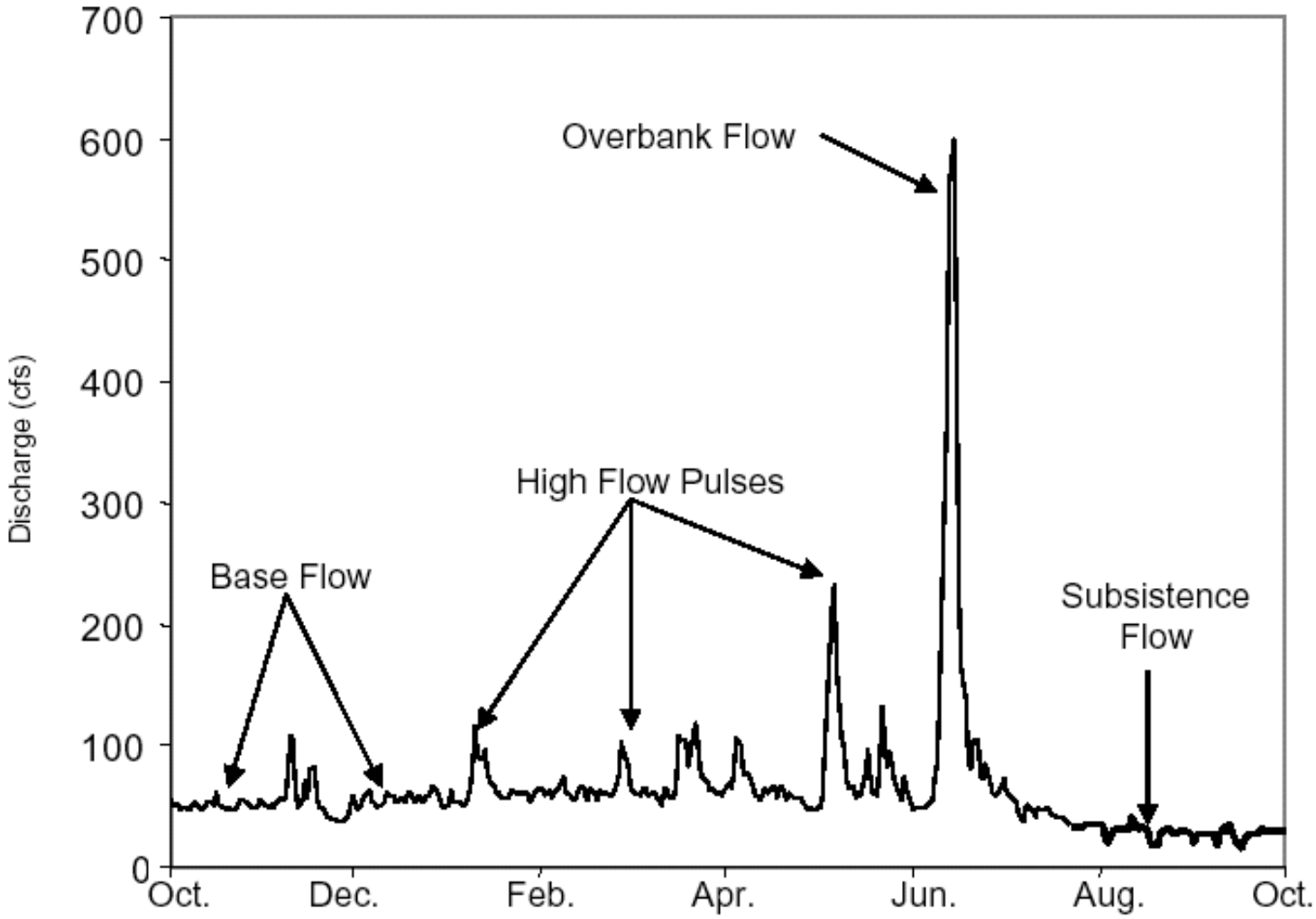


TIFP Process

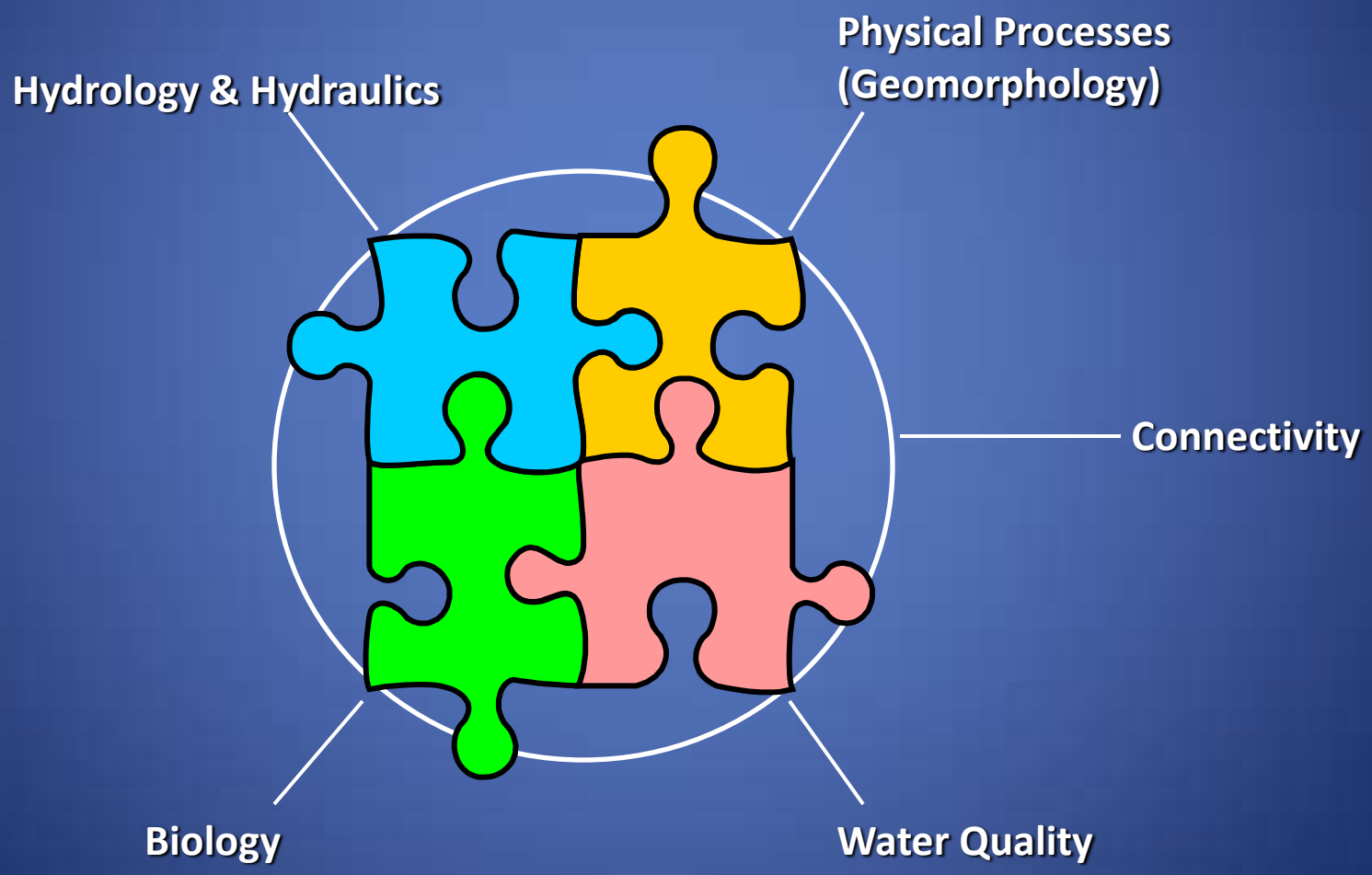


Instream Flow Components

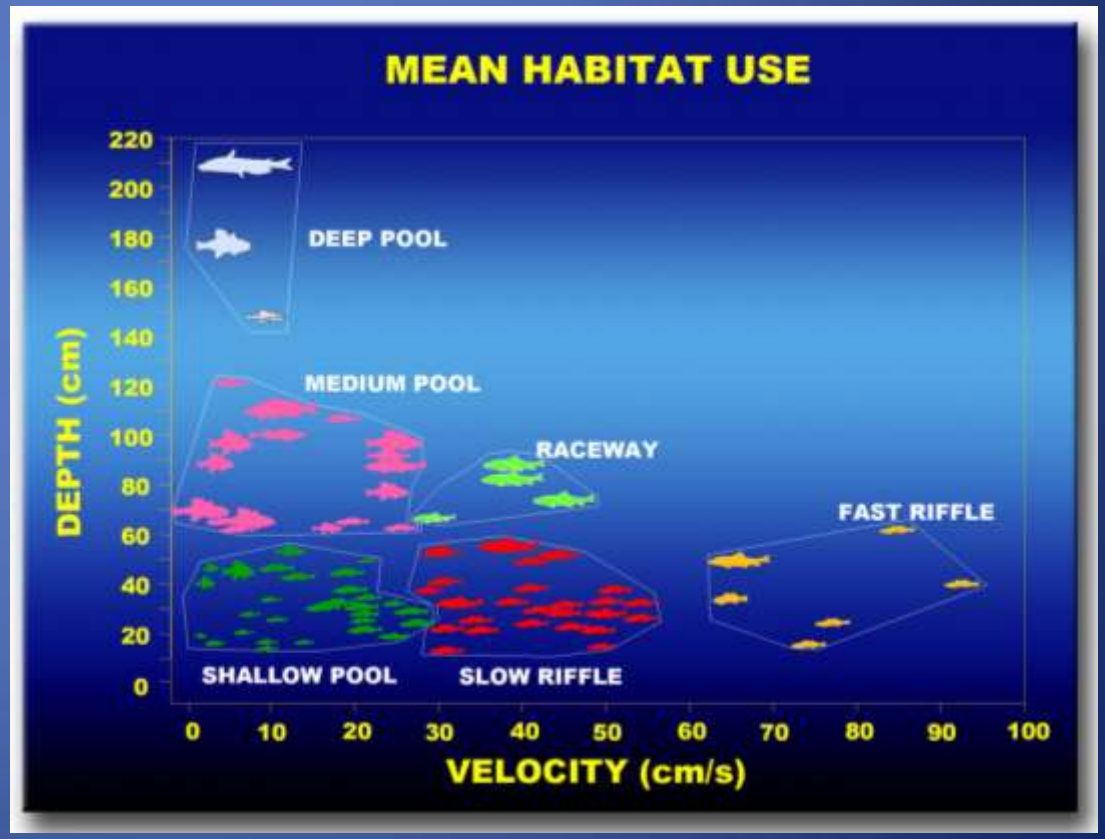
(National Research Council 2005)



Primary Disciplines



Key Species and/or Habitat Diversity



Hydrology-Based Environmental Flow Regime (HEFR) Basics

- Uses hydrologic data
- Computations are rapid
- Populates a flow regime matrix

(1) Select Flow Gage

↓

(2) Select Period of Record

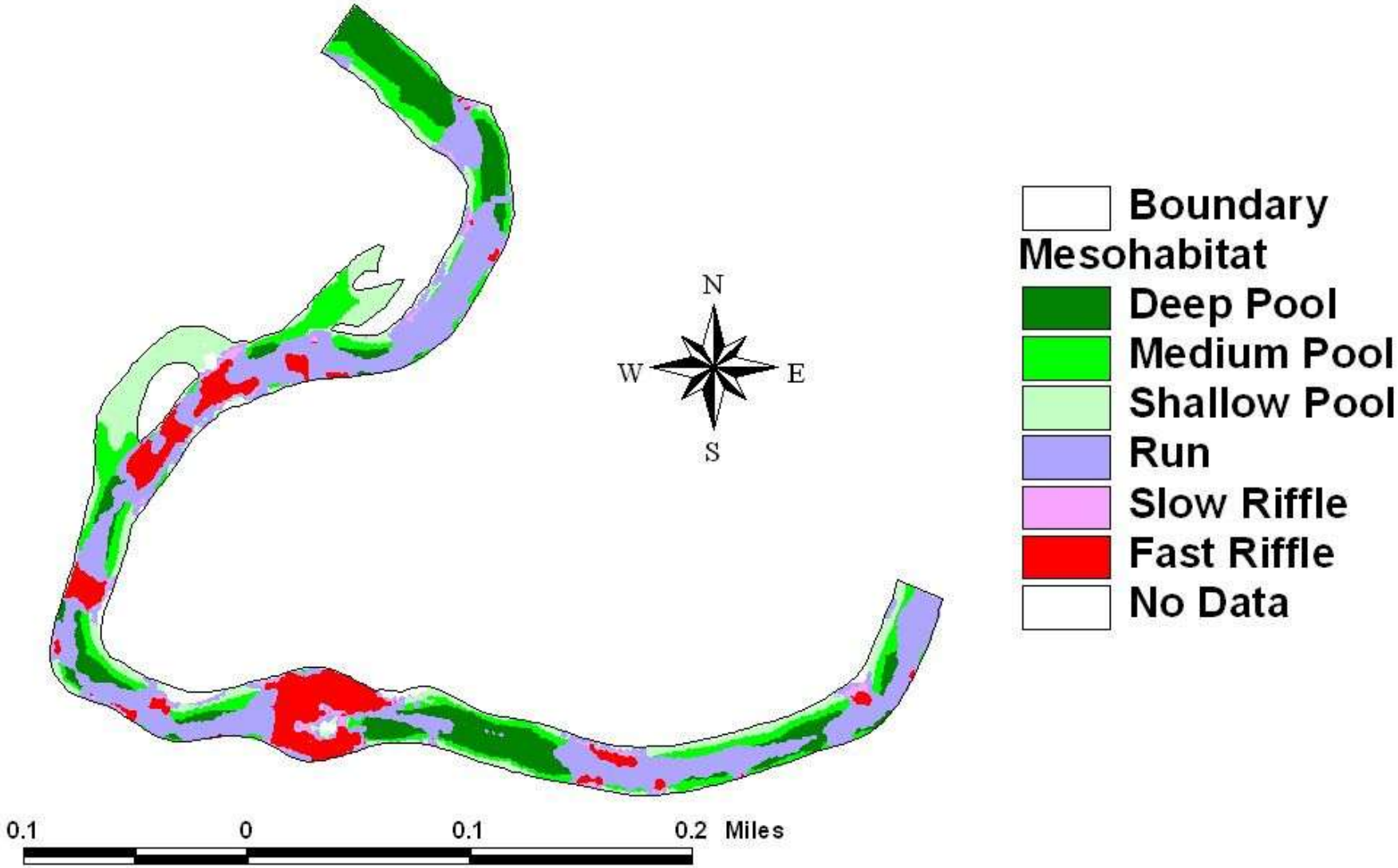
↓

(3) Separate (parse) Hydrograph into Flow Components

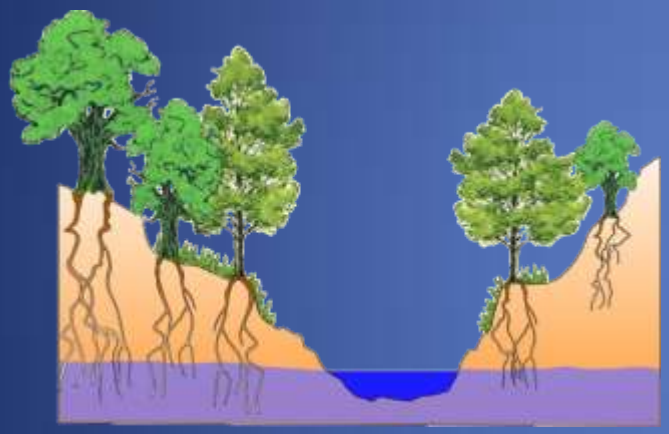
↓

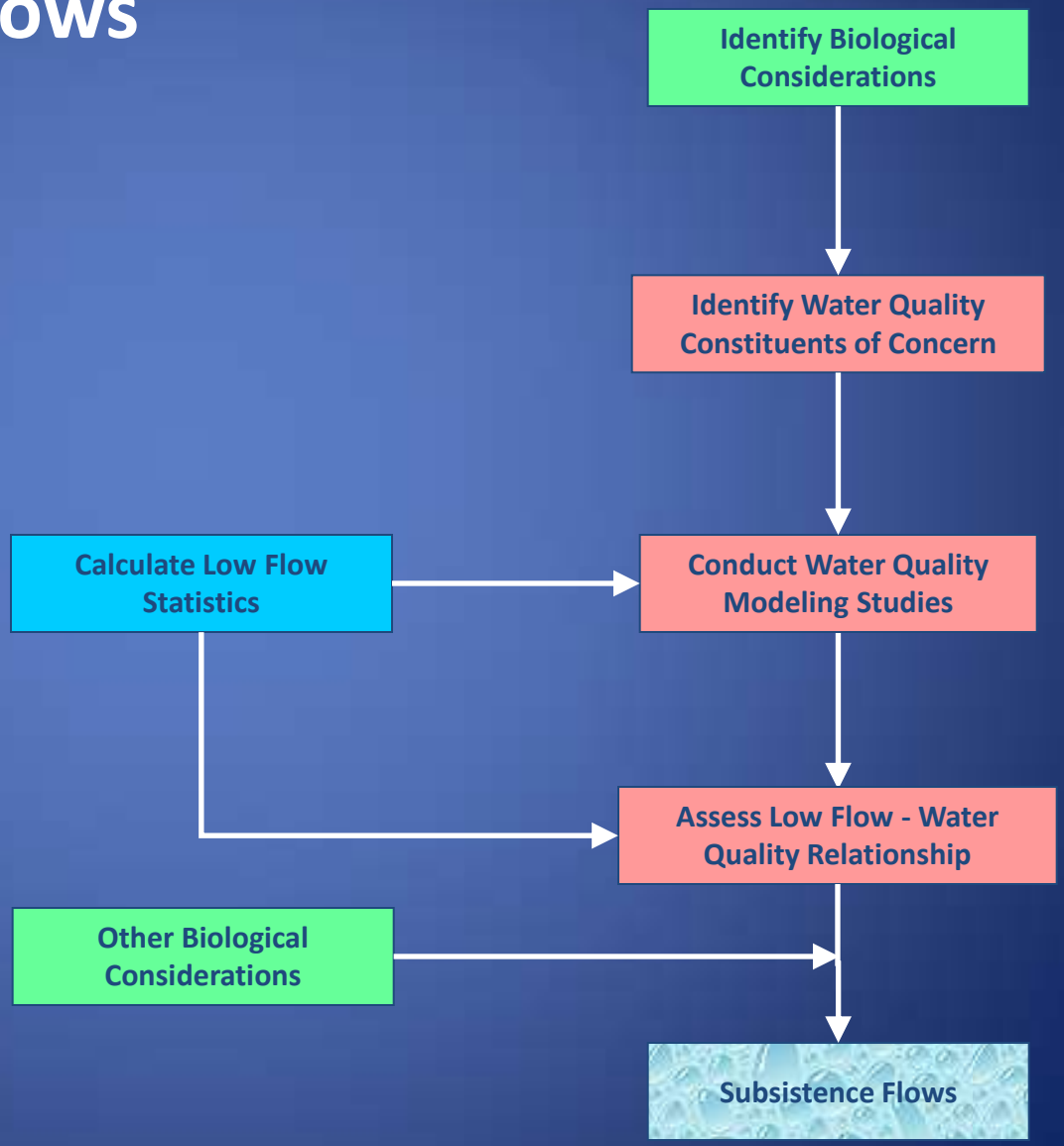
(4) Generate Statistical Summaries in Excel

Mesohabitat for Rainwater Ranch at Q=1000cfs



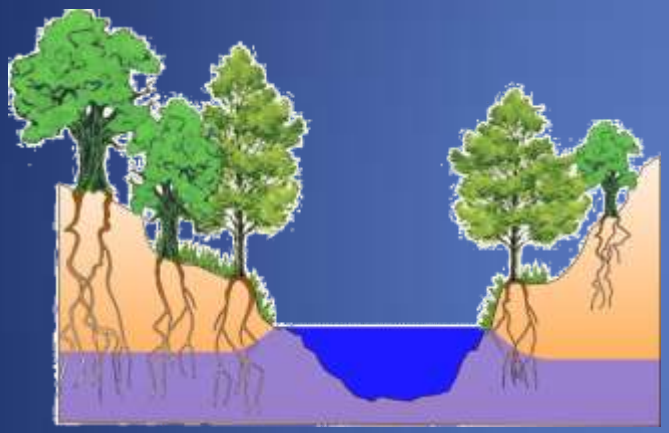
Subsistence Flows

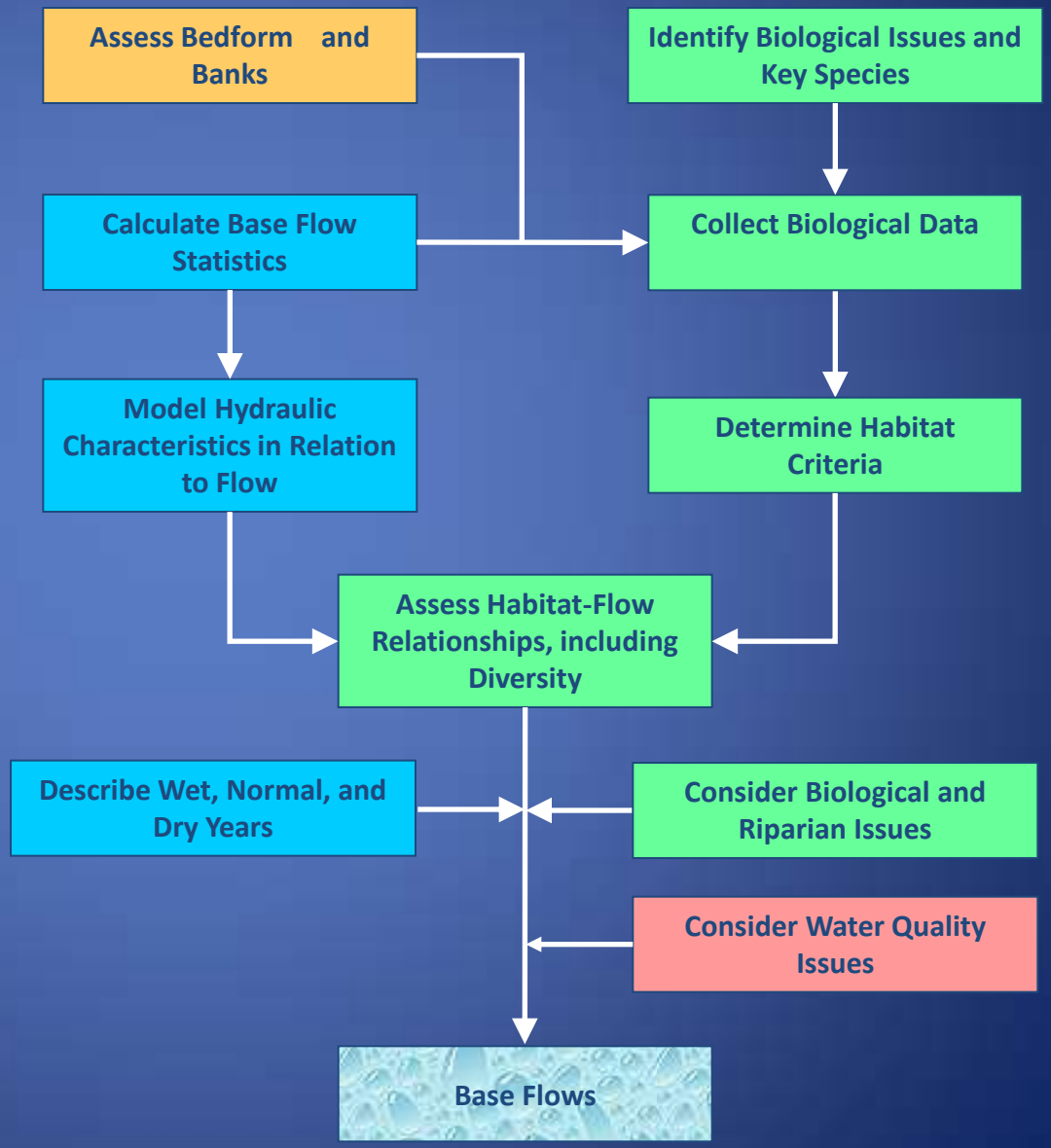




Primary Discipline
- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality

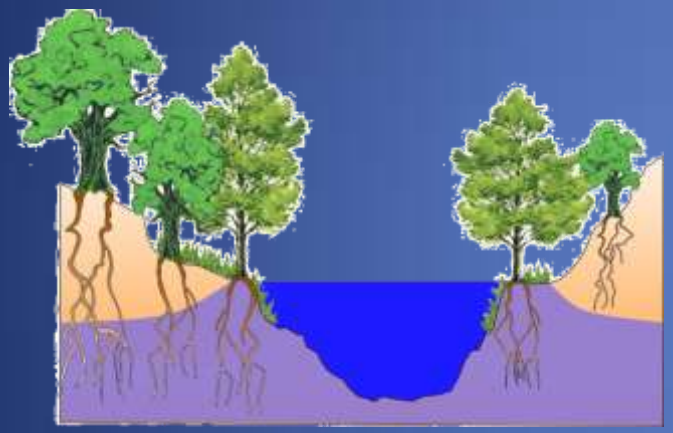
Base Flows

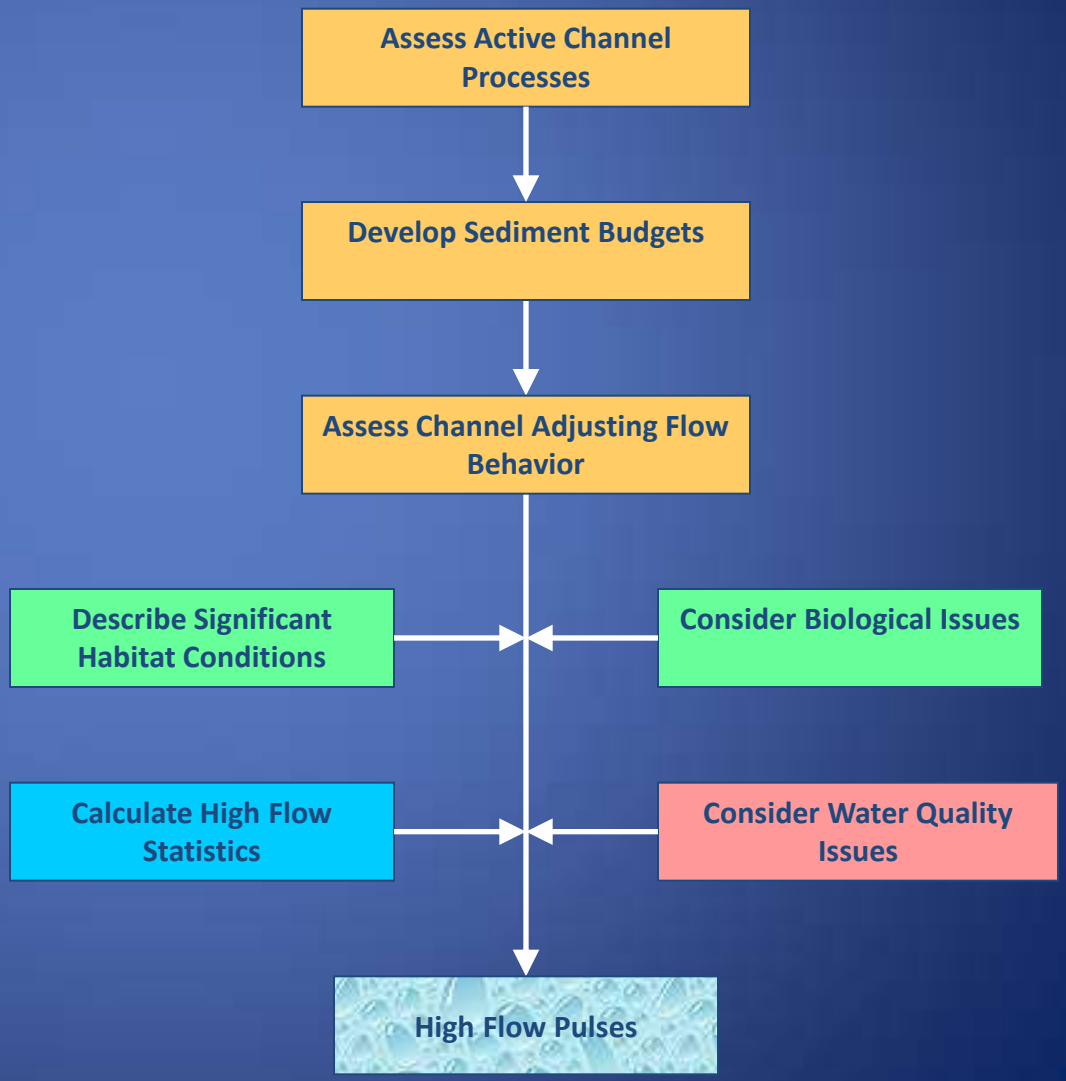




Primary Discipline
- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality

High Flow Pulses

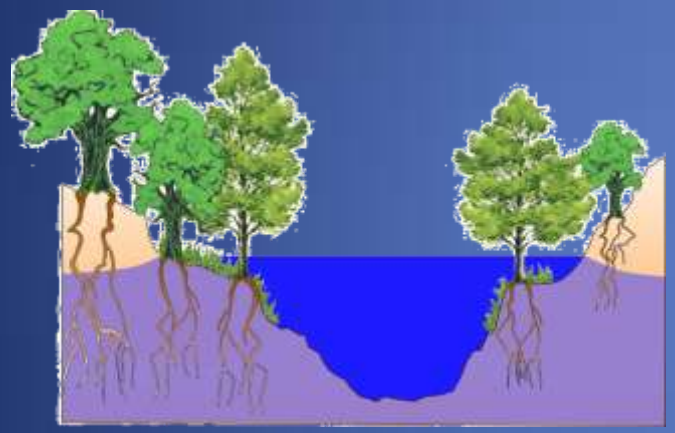


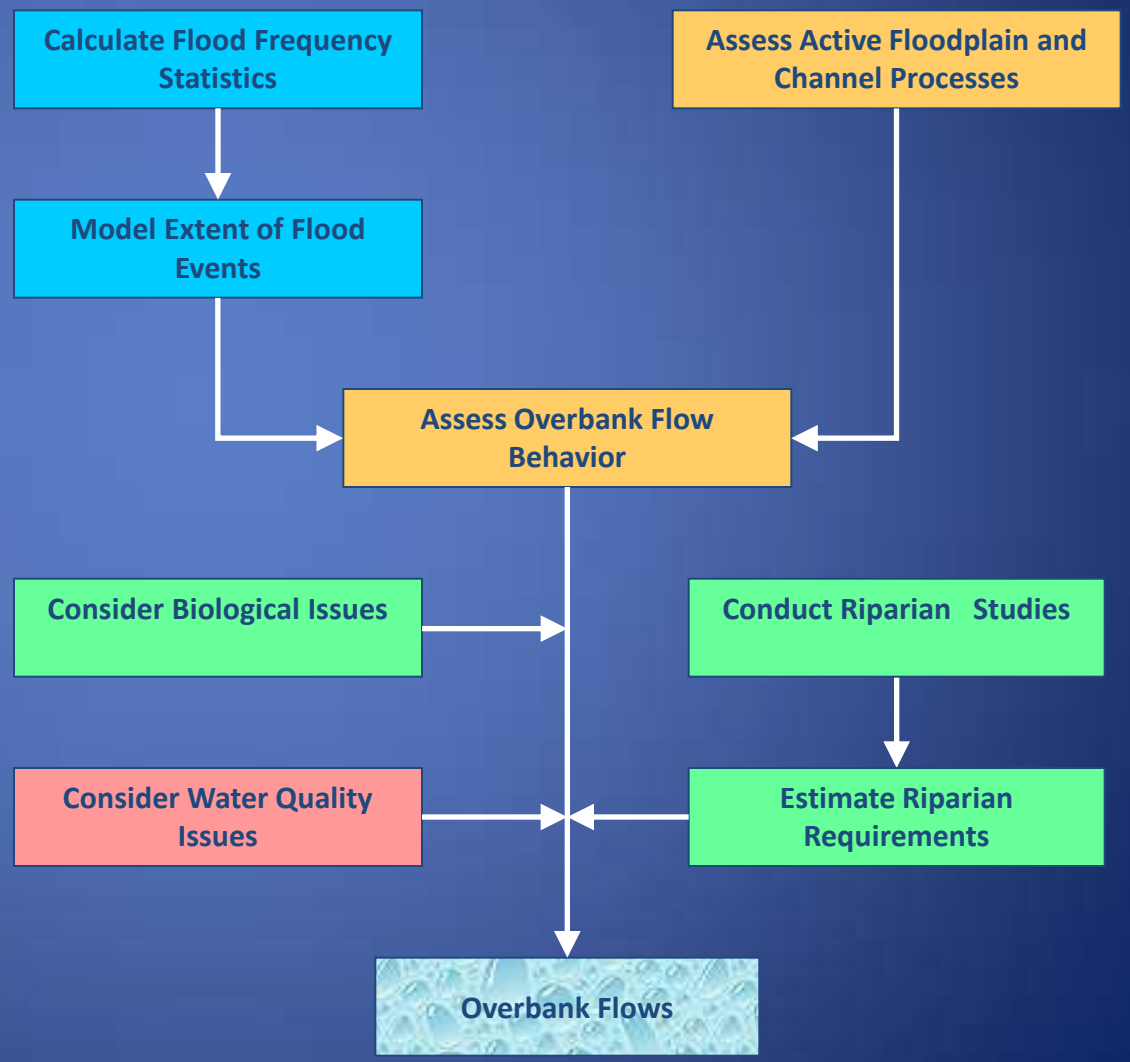


Primary Discipline

- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality

Overbank Flows

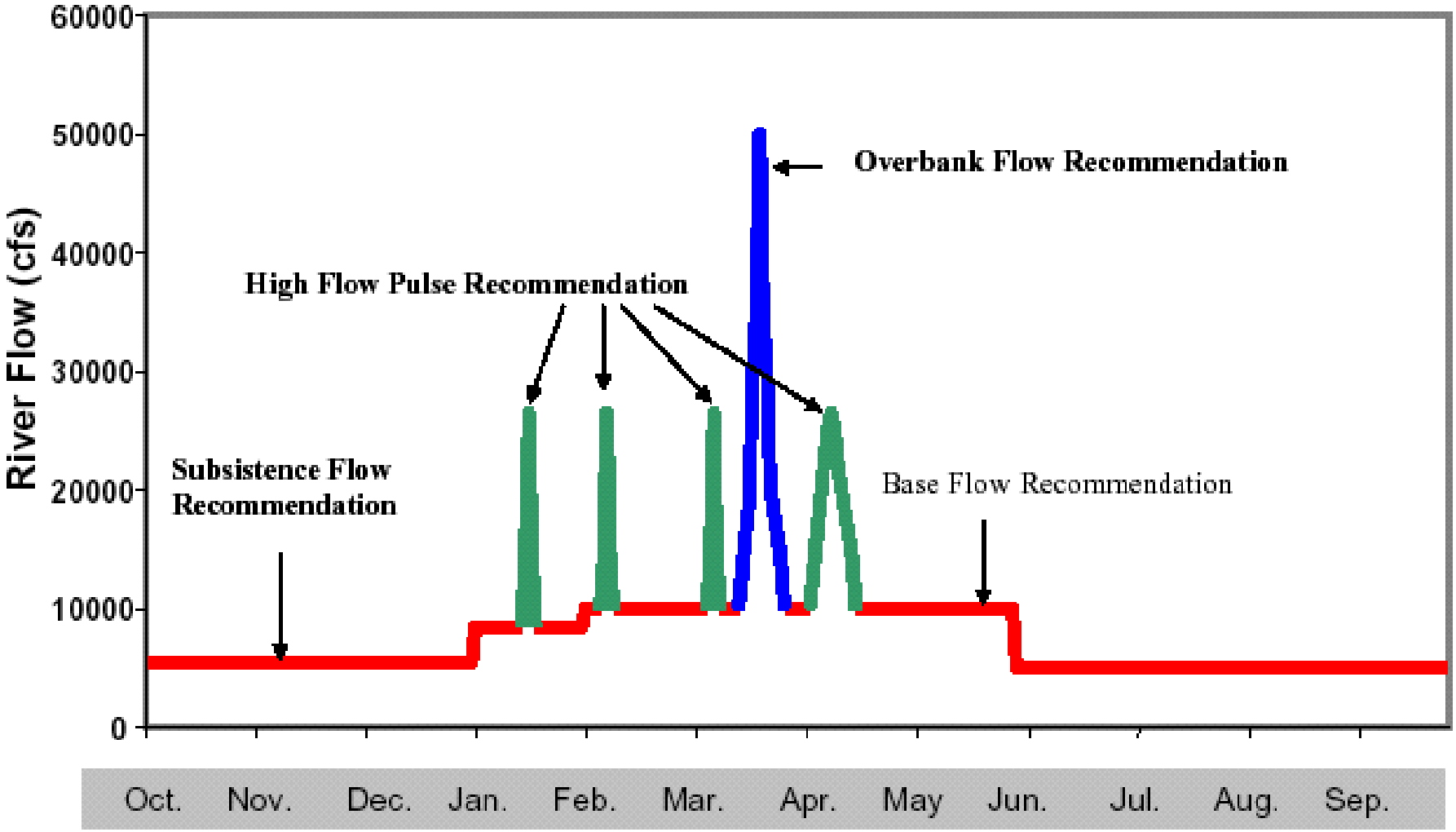




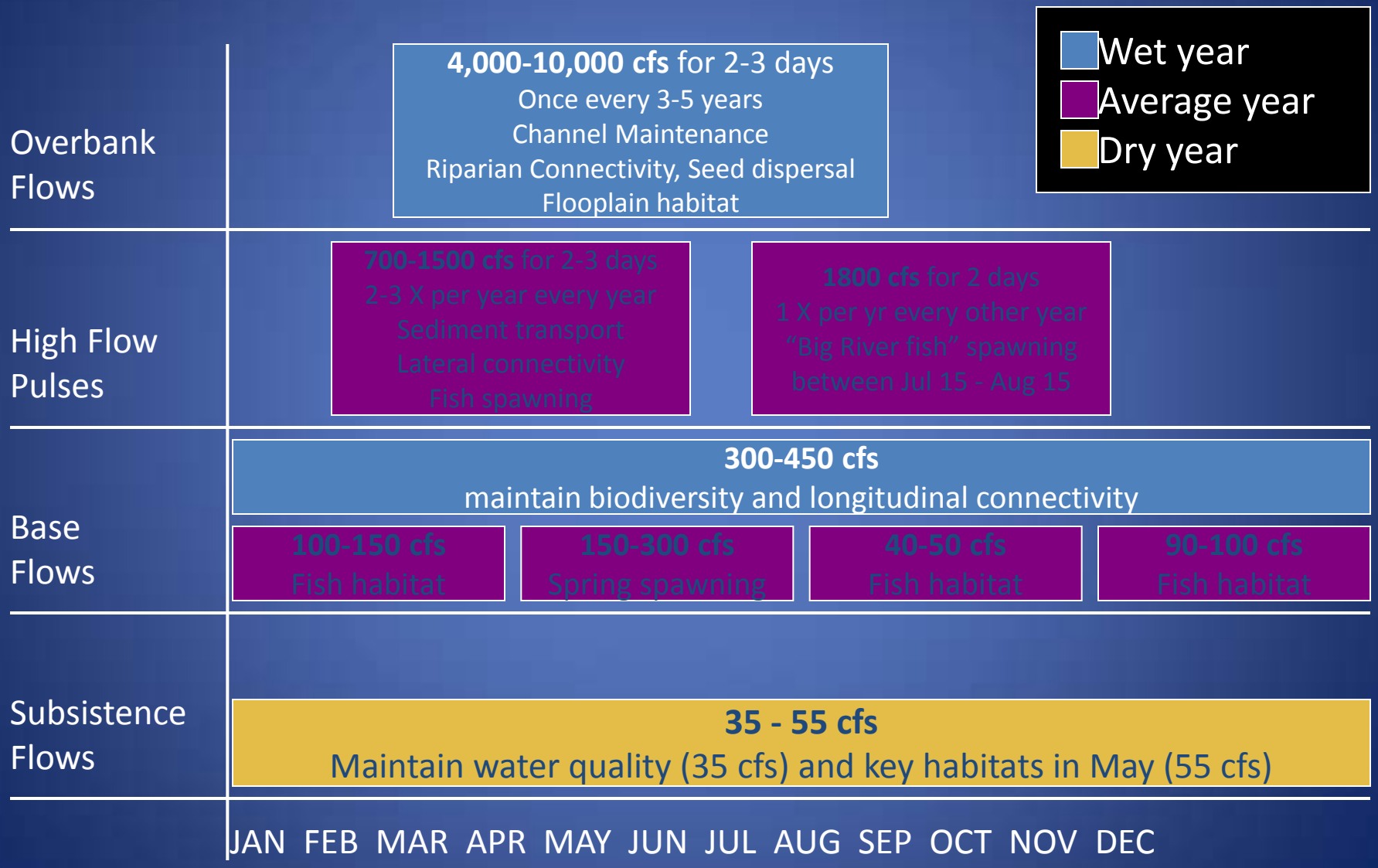
Primary Discipline

- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality

Integration to Generate a Flow Regime



Integration of Flow Components



Status of Texas Environmental Flow Process

Texas Environmental Flows Process (Stakeholder process under SB3)

Stakeholder environmental flow recommendations (instream flows and freshwater inflows to bays and estuaries):

1. Sabine-Neches-Sabine Lake
2. Trinity-San Jacinto-Galveston Bay
3. Colorado and Lavaca Rivers and Matagorda and Lavaca Bays Basin and Bay
4. Guadalupe, San Antonio, Mission, and Aransas Rivers
5. Mission, Copano, Aransas, and San Antonio Bays Basin and Bay

Analyses and draft reports in prep:

- Rio Grande, Rio Grande Estuary, and Lower Laguna Madre
- Brazos River and Associated Bay and Estuary System
- Nueces River and Corpus Christi and Baffin Bays.

Texas Instream Flow Program (Environmental studies under SB2)

Interim report:

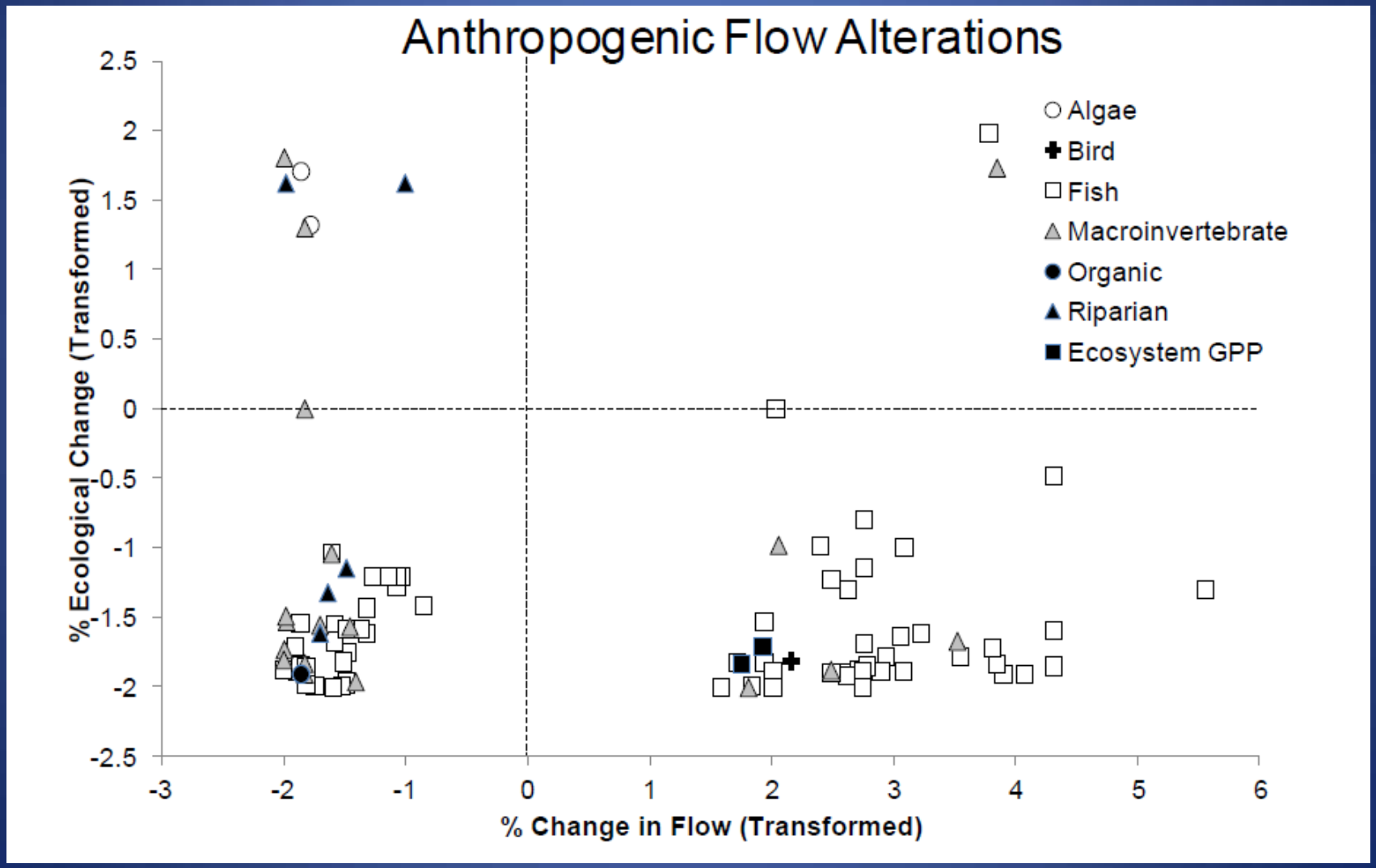
1. Lower San Antonio River

Multidisciplinary studies underway in:

- lower San Antonio River
- middle and lower Brazos River
- lower Sabine River

- Parts 3 and 4 – this is the most important part. Take care to focus on the science as much as possible, and if talking about the approach a state settled on, point out changes that were made based on other factors (economics, politics etc.)
- With regards to the science and what other states are doing, here are some questions:
  - Are they classifying/sorting streams? How?
  - How are they coming up with ecological response relationships? What metrics are they evaluating? If working with biological databases, how are they isolating flow effects from water quality effects and effects downstream of big dams not related to flow?
  - How are they evaluating degree of hydrologic alteration against which biological data is being contrasted? What metrics for flow alteration?
-

Flow-Ecology Relationships from Literature



Source: McManamay et al. 2011

Quantification of Hydrologic Alteration at Gaged Sites
(…and a little more)

Daren Carlisle, USGS National Water Quality Assessment Program

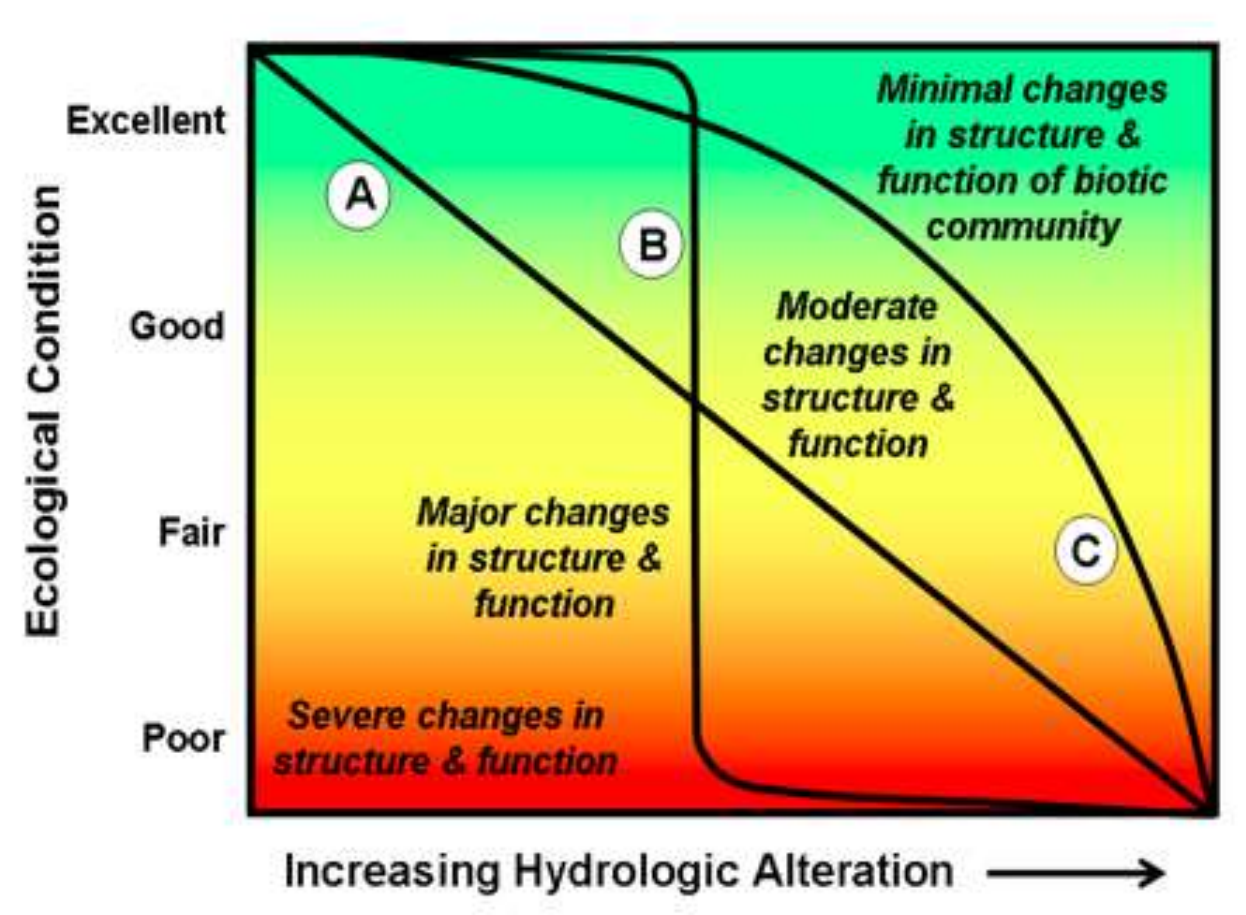
Jim Petersen, USGS Arkansas Water Science Center

Bayou Bartholomew near McGehee

This is information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government may be held liable for any damages resulting from the authorized or unauthorized use of the information.

USGS

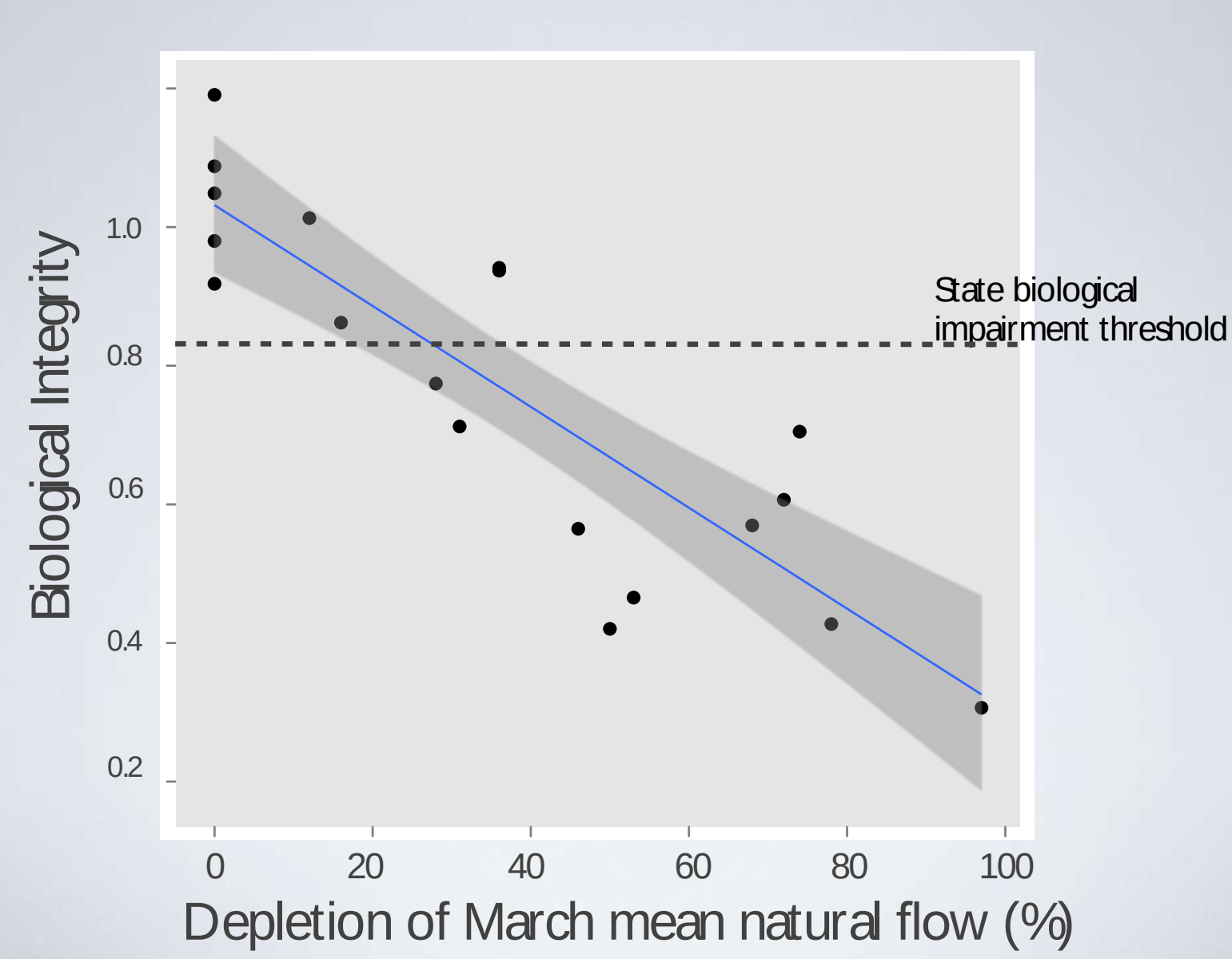
The Goal



from Poff et al. 2010 (ELOHA)

USGS

The Goal: Real Example from Utah

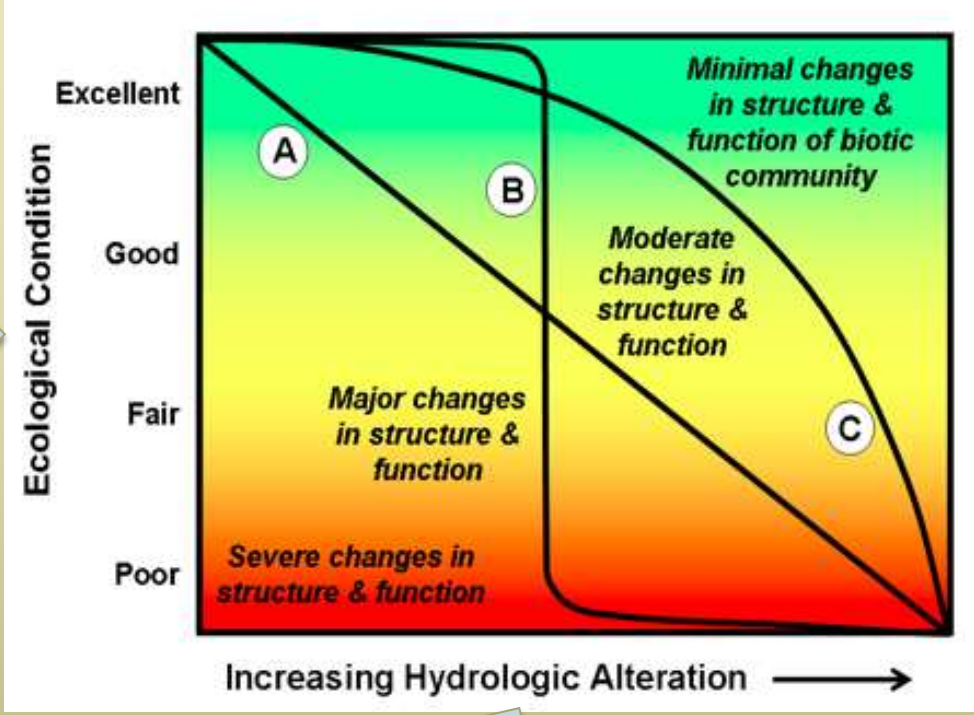


USGS

Carlisle et al. 2012, RRA

How to get there?

biological indicator relevant to management goals

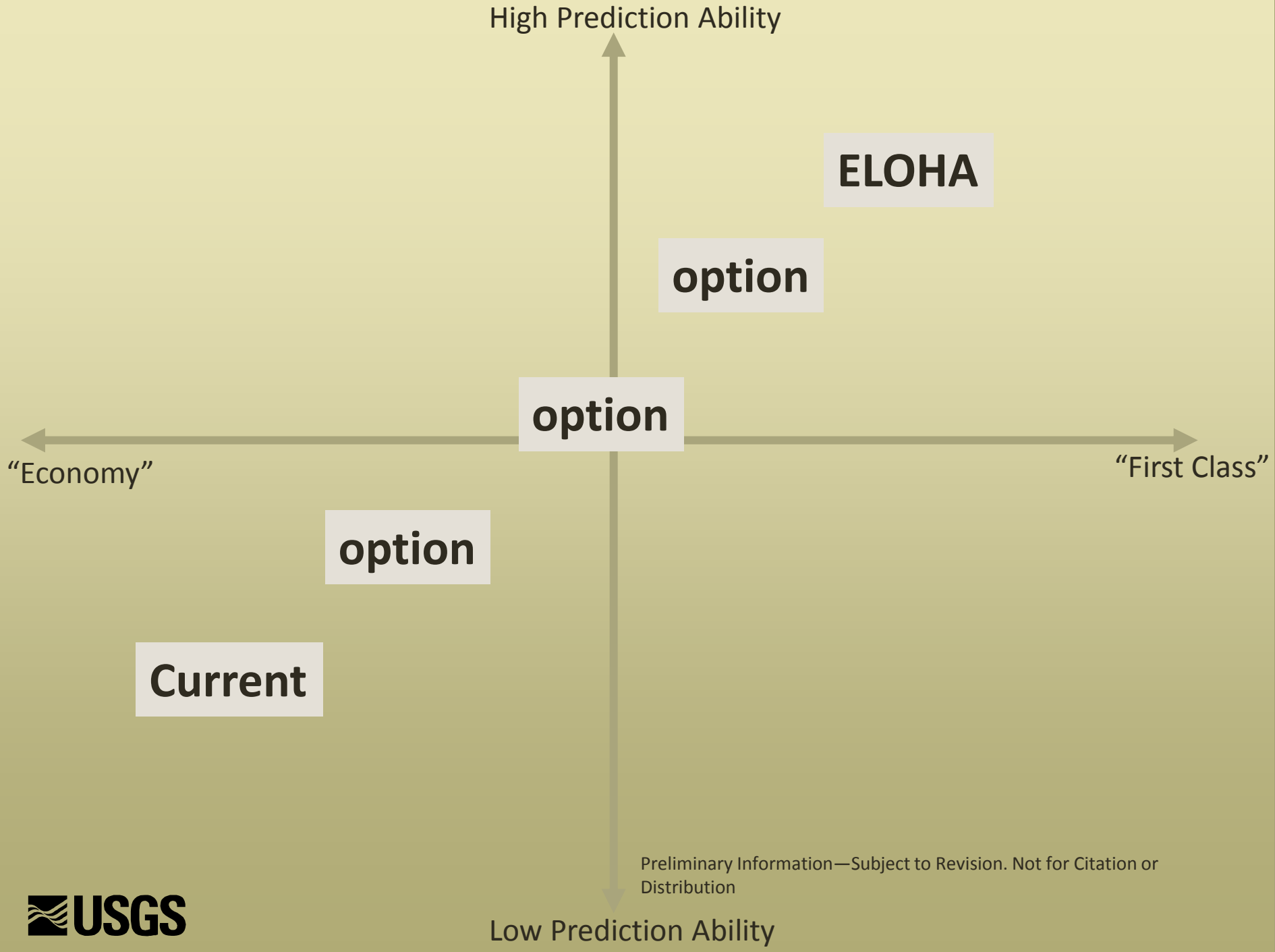


focus of this presentation

USGS

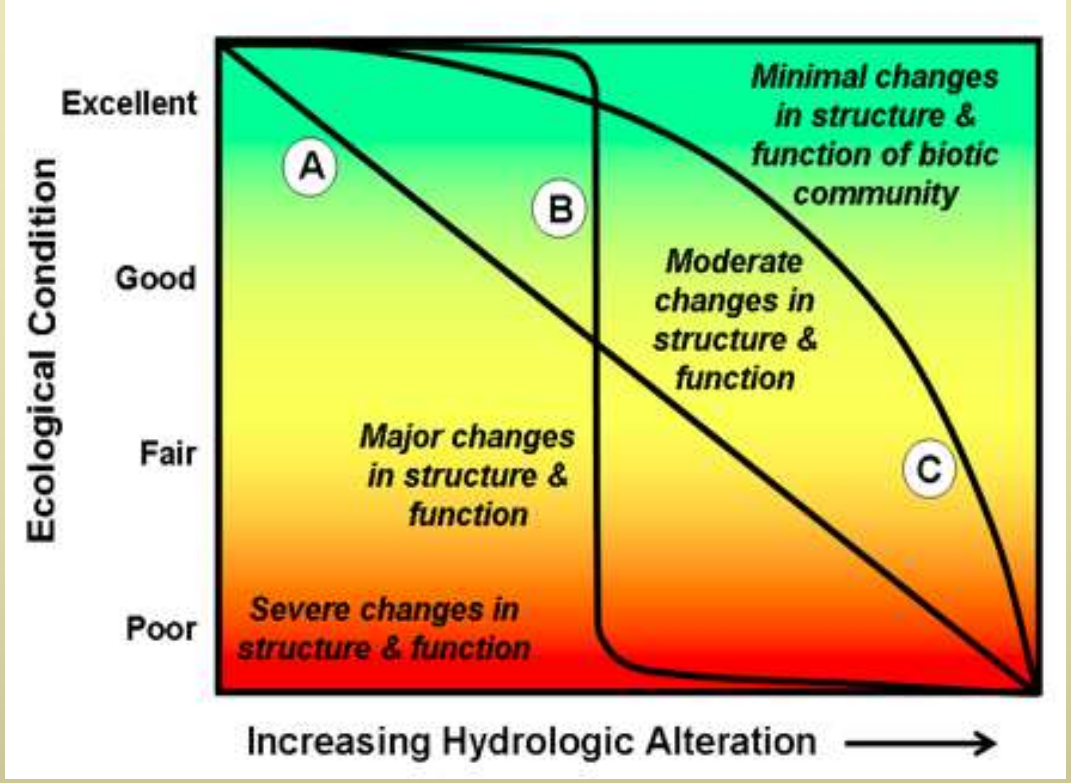
“There are many paths to the top of Mt. Fuji…” (M. Ueshiba)

USGS



Preliminary Information—Subject to Revision. Not for Citation or Distribution

USGS



- What is hydrological alteration, and
- How do we quantify it?

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Hydrological Alteration

- Implies departure from the “natural” condition
- Many analogs in environmental assessments

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Hydrological Alteration

- Implies departure from the “natural” condition
- Many analogs in environmental assessments

Percent darters in disturbed streams

vs

Percent darters in undisturbed streams

USGS

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Hydrological Alteration

- Implies departure from the “natural” condition
- Many analogs in environmental assessments

Percent darters in disturbed streams (O)

vs

Percent darters in undisturbed streams (E)

USGS

Preliminary Information—Subject to Revision. Not for Citation or Distribution

What is “natural?”

- Streamflow that would be expected in the absence of water management, regulation, and land-cover development
- a.k.a. reference, background
- Many analogs in environmental assessments

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Quantifying Hydrological Alteration

- Need, for any stream segment, to know natural conditions
  - daily flows, OR
  - flow statistics/characteristics
    - monthly mean, annual maximum, 7-day minimum, 7Q10
- Must be estimated in many places
  - no pre-disturbance information
  - no “nearby” reference sites

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PREDICTING THE NATURAL FLOW REGIME: MODELS FOR ASSESSING HYDROLOGICAL ALTERATION IN STREAMS

DAREN M. CARLISLE, JAMES FALCONE, DAVID M. WOLOCK, MICHAEL R. MEADOR and RICHARD H. NORRIS

RIVER RESEARCH AND APPLICATIONS 26: 118–136 (2010)

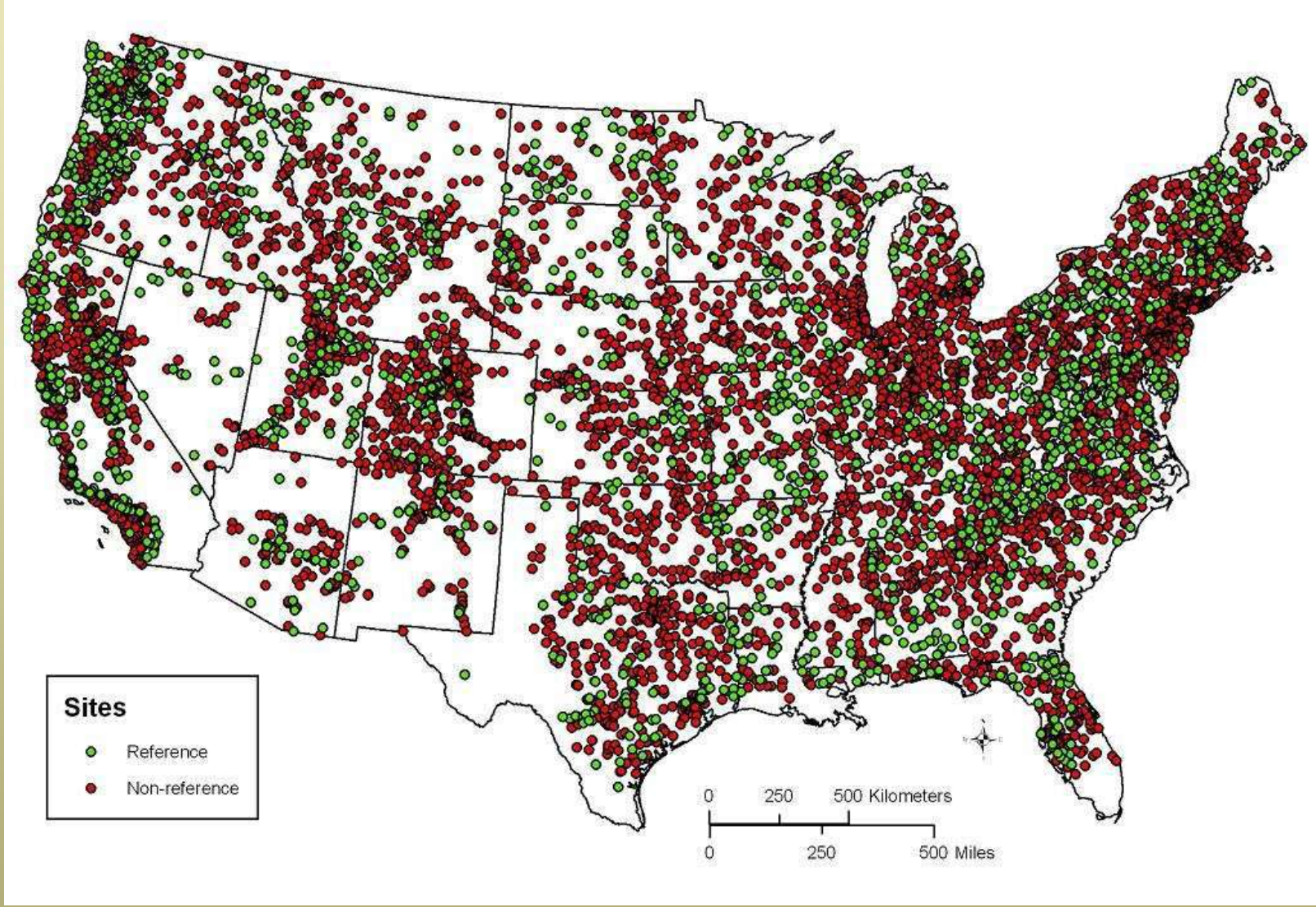
USGS

Estimating Natural Flows

- Precip/temp
- About 80 explanatory variables…
- Watershed characteristics
  - geology, soils, topography
- Streamflow data

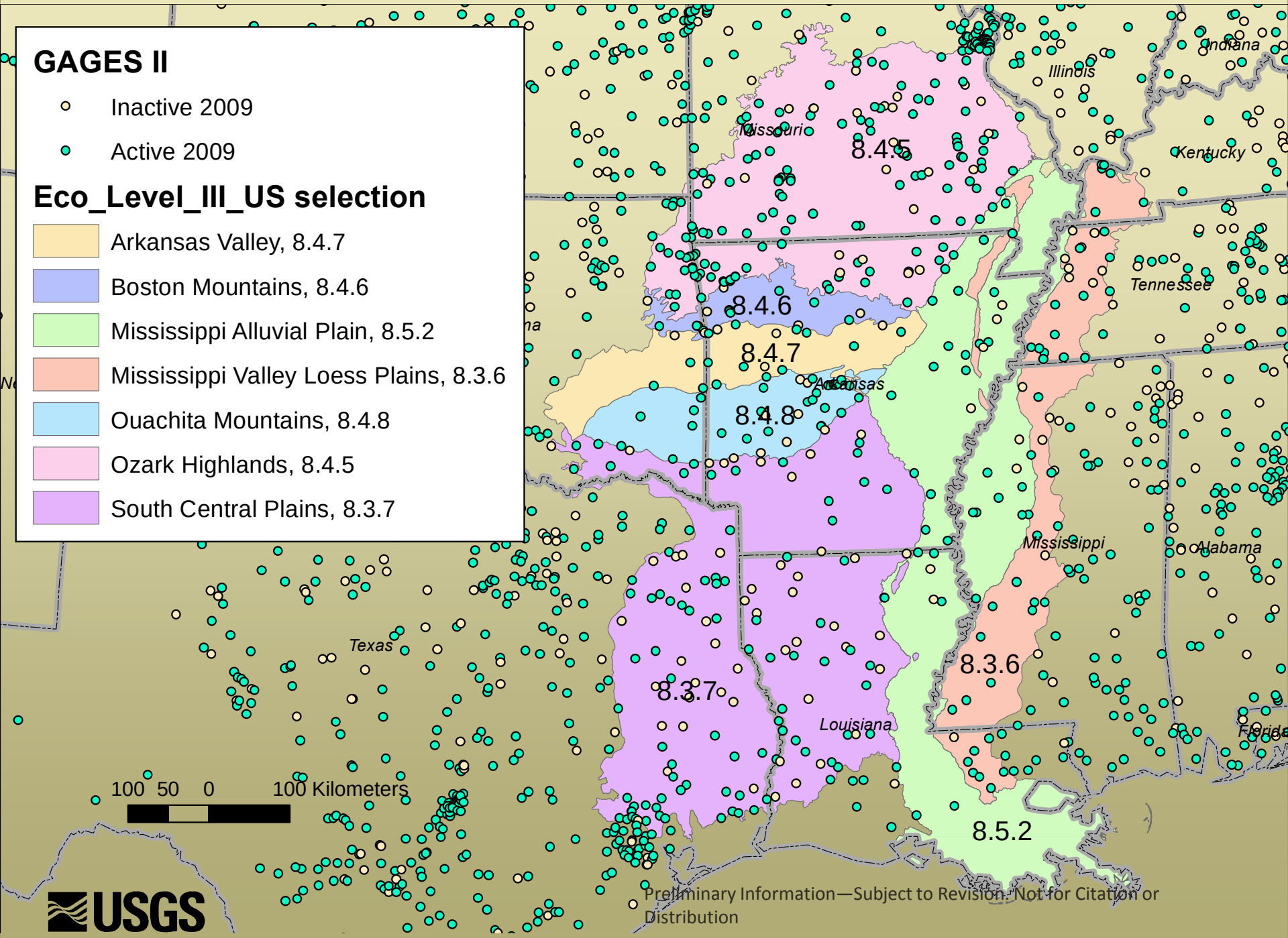
Preliminary Information—Subject to Revision. Not for Citation or Distribution

The USGS Gaging Network



USGS

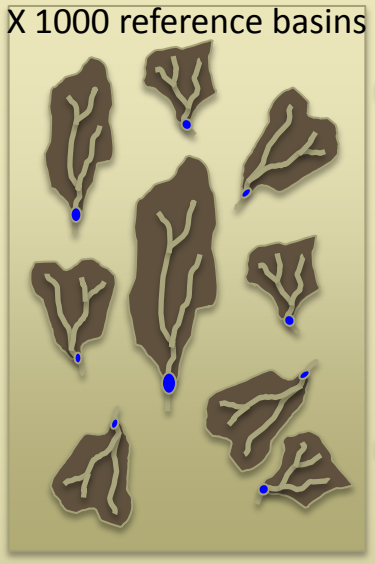
Preliminary Information—Subject to Revision. Not for Citation or Distribution


GAGES II
Inactive 2009
Active 2009
Eco_Level_III_US selection
Arkansas Valley, 8.4.7
Boston Mountains, 8.4.6
Mississippi Alluvial Plain, 8.5.2
Mississippi Valley Loess Plains, 8.3.6
Ouachita Mountains, 8.4.8
Ozark Highlands, 8.4.5
South Central Plains, 8.3.7
Missouri
Illinois
Indiana
Kentucky
Tennessee
Arkansas
Mississippi
Alabama
Texas
Louisiana
8.4.5
8.4.6
8.4.7
8.4.8
8.3.6
8.3.7
8.5.2
100 50 0 100 Kilometers
USGS
Preliminary Information—Subject to Revision. Not for Citation or Distribution

climate
topography
soils
geology

magnitude
frequency
duration
timing

X 1000 reference basins



climate
topography
soils
geology

magnitude
frequency
duration
timing

models

Example --- 7-day minimum

Preliminary Information—Subject to Revision.
Not for Citation or Distribution

climate
topography
soils
geology

Observed

7-day min

$$\frac{O}{E}$$

Expected

7-day min

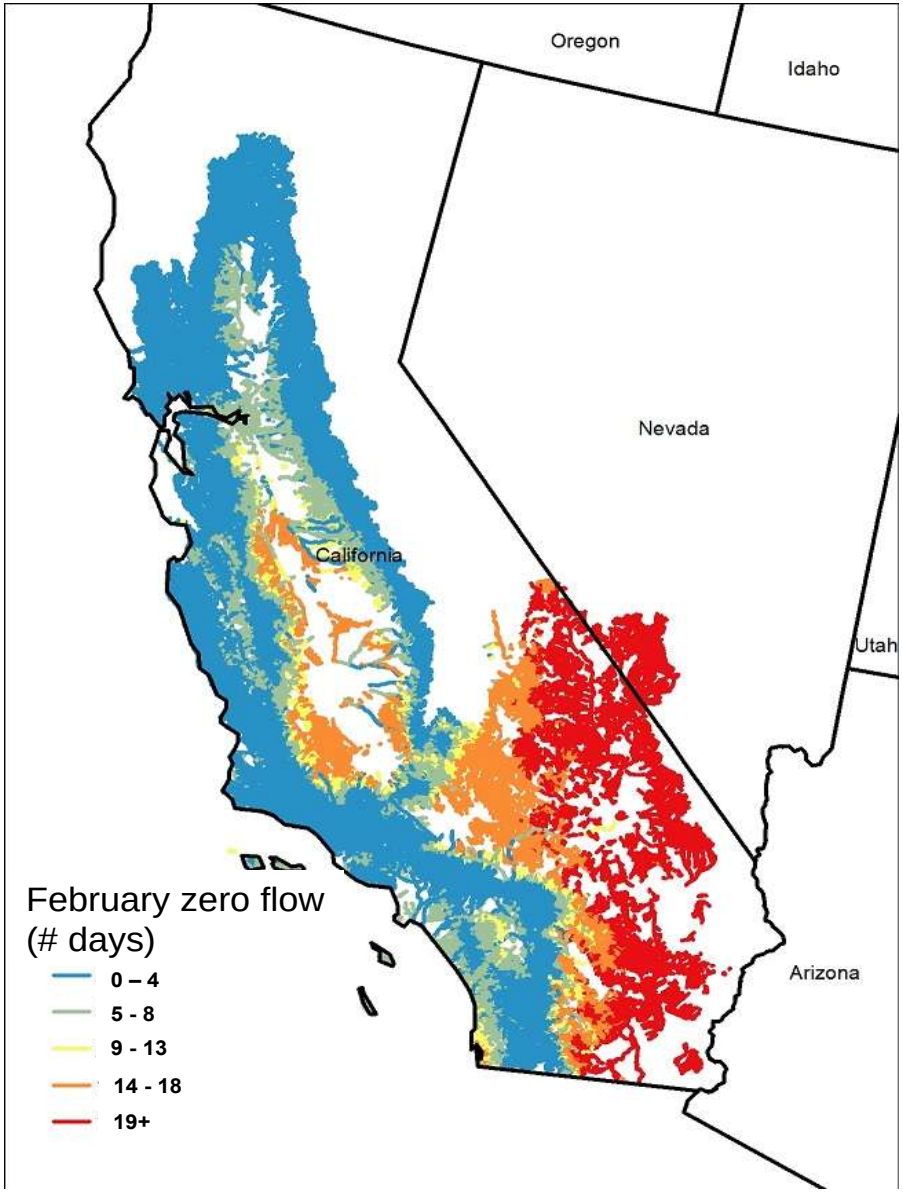
USGS

Approach Summary

- Uses existing landscape classifications
  - No need for new classification efforts
- Operates on *a priori* selected streamflow statistics
  - No need for efforts to develop daily flow simulation models
- Requires measured streamflow to obtain "observed" conditions
  - Would ADEQ develop nutrient criteria for streams using simulated nutrient data?
  - Does not necessarily require a continuous record streamgage (could make periodic measurements of Q)

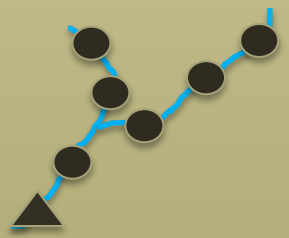
Preliminary Information—Subject to Revision. Not for Citation or Distribution

…and a little more

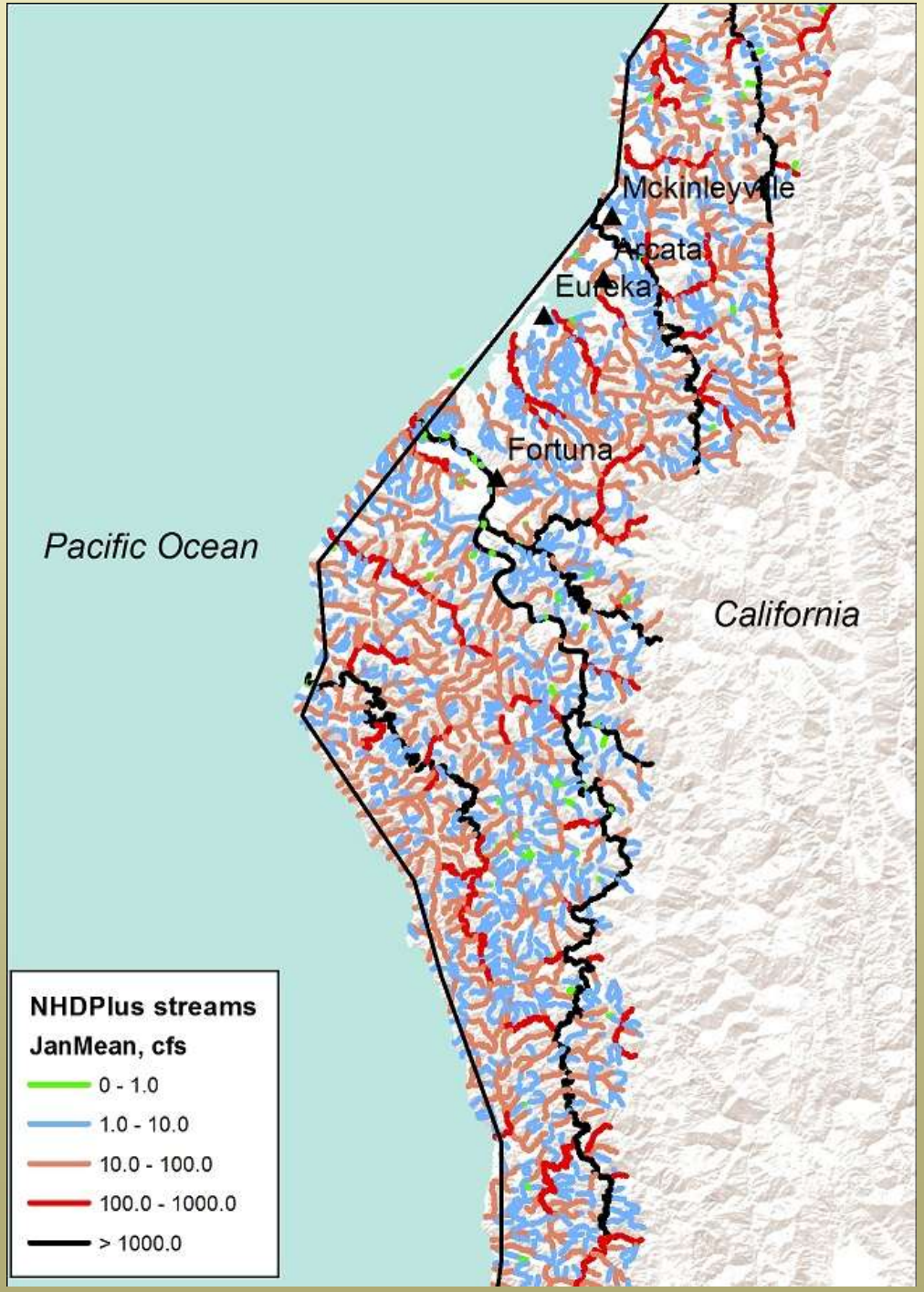


Example:
Estimating *natural* flows (February zero flow days) across an entire network

This can be done for all stream segments if you have a model for February zero flow days



Preliminary Information—Subject to Revision. Not for Citation or Distribution



Example:
Estimating *natural* flows (January mean flow) across an entire network

****Let's assume we have this data for July. That information could be used to help decide how much water could be removed from any stream reach in the state.****

Preliminary Information—Subject to Revision. Not for Citation or Distribution

A Few Key Questions

- Is estimating the effects of land & water management & climate on daily flows a priority?
- What species/target is important to stakeholders?
- Can stakeholders identify key streamflow statistics that are “important?”

Preliminary Information—Subject to Revision. Not for Citation or Distribution

Summary

- Approach can be used to calculate degree of hydrologic alteration (O/E)
- Can be used to geospatially map streamflow characteristics throughout a watershed/region/state
- Does not necessarily require a gage to implement management decisions

Preliminary Information—Subject to Revision. Not for Citation or Distribution

Arkansas State Water Plan
Fish & Wildlife Flows:
Challenges and Opportunities

Michael Armstrong
Fish & Wildlife Flow Sub-Group
27 March 2013

Presentation Objectives

- Review Vision and Goals Statements: Fish & Wildlife Flows
- Overview of 1990 Water Plan treatment of fish & wildlife flows
- Challenge audience to seek solutions using known water issues as backdrop (groundwater shortage west of Crowley's Ridge, overdraft of Bayou Bartholomew, water for mineral extraction)
- Closing comments from personal perspective

Arkansas Water Plan Vision and Goals

- Optimize the use of surface and groundwater for the differing economies of the unique regions of the State.
  - Reliably meet agriculture water needs.
  - Reliably meet municipal & industrial water needs.
  - Manage water resources in a manner that protects the ecological needs of fish and wildlife.
  - Reliably meet the water quantity and quality needs to help support navigation, recreation, and tourism.

Arkansas Water Plan Vision and Goals

- Sustainably use surface and groundwater sources for the multiple intrastate uses while complying with interstate compacts.
    - Refine criteria for declaring drought, water shortages and excess water, and advance policies and procedures for allocating water during times of shortage or drought.
    - Identify and recommend procedures and criteria to improve upon existing instream flow methodologies taking into consideration water quality, fish and wildlife needs, aquifer recharge, and navigation needs at the statewide and basin specific level.
    - Include recreation and tourism as non-consumptive water uses.

1990 Water Plan Determination of Fish & Wildlife Flows

Two Suggested Readings (in addition to 1990 Executive Summary and individual basin reports)

- ANRC Title III: Rules for the Utilizations of Surface Water
- Water law in Arkansas (revised 2011)

1990 Water Plan Determination of Fish & Wildlife Flows

1. Water management during declared shortages
2. Non-riparian diversions
3. Pre-allocation planning

1990 Water Plan Determination of Fish & Wildlife Flows

Water management during shortages

Riparian Rights

- modified by the Arkansas legislature and subsequent administrative rule-making to protect certain uses in times of shortage
- Minimum in-stream flow reserve (fish & wildlife among other uses)

1990 Water Plan Determination of Fish & Wildlife Flows

Water management during shortages

- Minimum in-stream flow for fish & wildlife determined from modified Tenant method
  - 10% of mean seasonal flow

1990 Water Plan Determination of Fish & Wildlife Flows

Water management during shortages

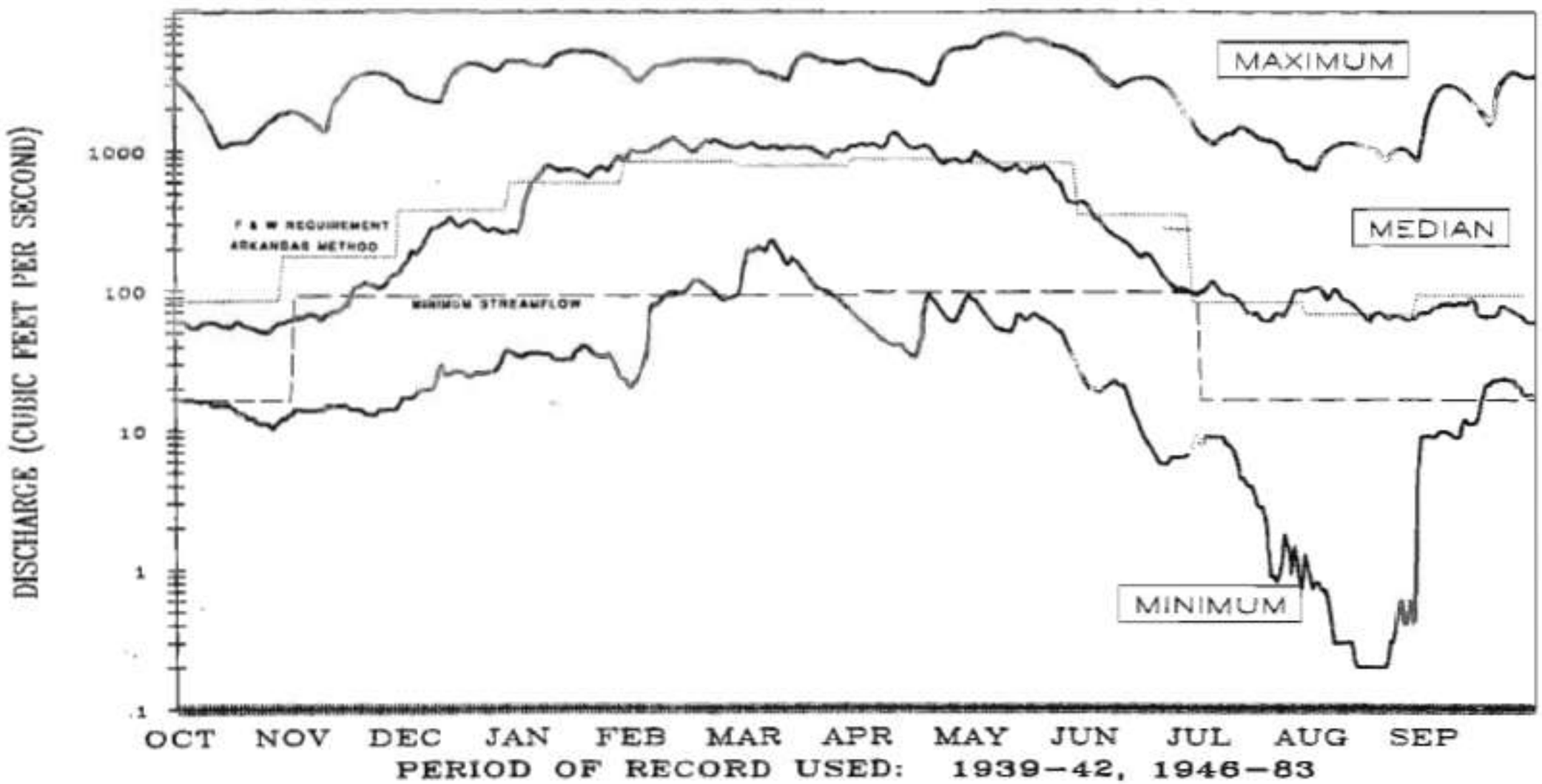
Modified Tenant Method in 1990 Plan

- Establishes base flow to protect trust state resources during uncommon, short-term events
- Incorporates seasonality
- Applicability to all streams uncertain (scale, location, ecological condition)
- Magnitude addressed- but not frequency and duration
- Flows occur naturally at lower flows
- Shortages not well defined

nReport.pdf - Adobe Reader
Window Help
70 / 266 75% Tools

Figure 3-6

MAXIMUM, MEDIAN, and MINIMUM DAILY DISCHARGES, and SELECTED INSTREAM NEEDS for the PERIOD of RECORD at BAYOU BARTHOLOMEW NEAR McGEHEE



SOURCE: DAILY DISCHARGE DATA FROM U.S. GEOLOGICAL SURVEY STREAMFLOW RECORDS.

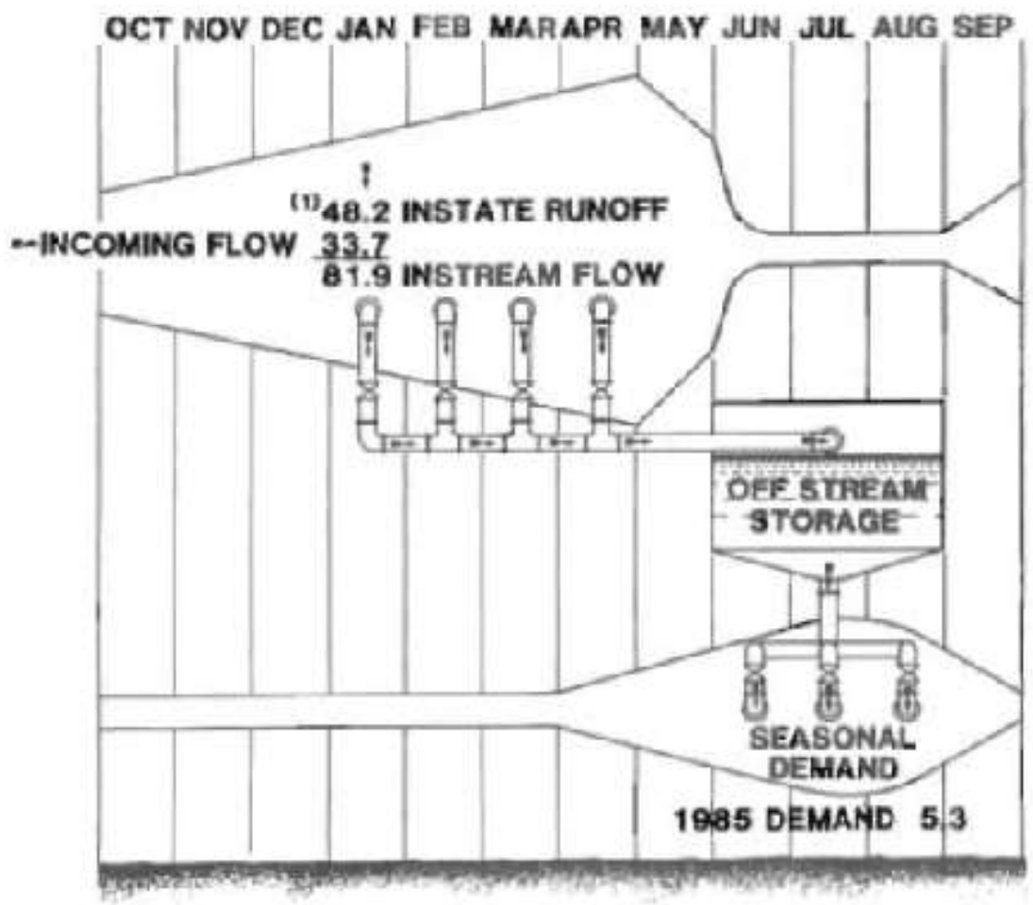
1990 Water Plan Determination of Fish & Wildlife Flows

Non-riparian diversions

- “Wine-glass” model and “Excess Water” as policy constructs

1990 Water Plan Determination of Fish & Wildlife Flows

"Wine glass" model for meeting agricultural water demand



2030 Demand	12.9
Ground Water Safe Yield	-4.0
Surface Water	8.9

Ground Water Safe Yield .75% of Total Water Use

(1) Based on - State Area 53,104 Sq. Mi.
Run off - 17" Per Sq. Mi. Per Year

1990 Water Plan Determination of Fish & Wildlife Flows

Excess Water defined: Twenty-five percent of that amount of water available on an average annual basis from any watershed above that amount, as determined by the commission, required to satisfy all of the following:

(1) Existing riparian rights as of June 28, 1985
(2) Federal water needs existing on June 28, 1985
(3) Firm yield of all reservoirs existing on June 28, 1985
(4) Maintenance of in-stream flows for fish and wildlife, water quality, aquifer recharge and navigation
(5) Future water needs of the basin of origin

1990 Water Plan Determination of Fish & Wildlife Flows

Non-riparian diversions

"Excess water" determined by Arkansas Method

- Incorporates seasonality
- Addresses long-term viability of large suite of in-stream species
- Aquifer re-charge occurring where stream course penetrates confining layer
- Floodplain connectivity not explicitly addressed
- Flow criteria may not "fit" all systems (scale, geographic location and ecological condition considerations)

1990 Water Plan Determination of Fish & Wildlife Flows

Pre-Allocation Plans

- Incorporates system specific flow and environmental conditions (ex. White River Allocation Plan)
- Establishes definitive triggers for shortages
- Reduces uncertainty of water rights during critical times
- Time consuming process
- Process criteria for drafting plan not well defined

1990 Water Plan Determination of Fish & Wildlife Flows

Re-Cap: Positive Aspects of 1990 Plan

- Three Methodologies (Modified Tenant, Arkansas, Pre-Allocation Planning)
- Methods sustain certain ecosystem attributes during times of shortage and long-term non-riparian usage
- Methods provide certainty when determining water available for off-stream use statewide
- Pre-allocation planning provides venue for deliberative, system specific risk-based flow determinations

1990 Water Plan Determination of Fish & Wildlife Flows

Re-Cap: Improvement Opportunities (Challenges)

- Three Methodologies (Modified Tenant, Arkansas, Pre-Allocation Planning)
- May not sufficiently address diversity of scale, geographic location or ecological condition
- Arkansas Method may or may not address floodplain connectivity
- Minimum in-stream flow (Modified Tenant) lacks frequency and duration components
- Criteria for declaring a shortage not well defined
- Pre-allocation planning procedures not well defined

1990 Water Plan Determination of Fish & Wildlife Flows

Closing Comments

- Our stewardship responsibility is to offer science-based fish and wildlife flow determination criteria that protects the long-term ecological viability of all Arkansas rivers and streams
- Disclose the inherent uncertainties and assumptions built into the fish & wildlife flow criteria methods
- Seize uncertainties as opportunities in the 2014 Plan
- Offer solutions that are pragmatic and comprehensible to the lay public (connect people with their environment and their economy)
- Move the conversation to a risk-based model for assessing the trade-offs between competing water management needs
- All solutions are on the table

Two Pathways

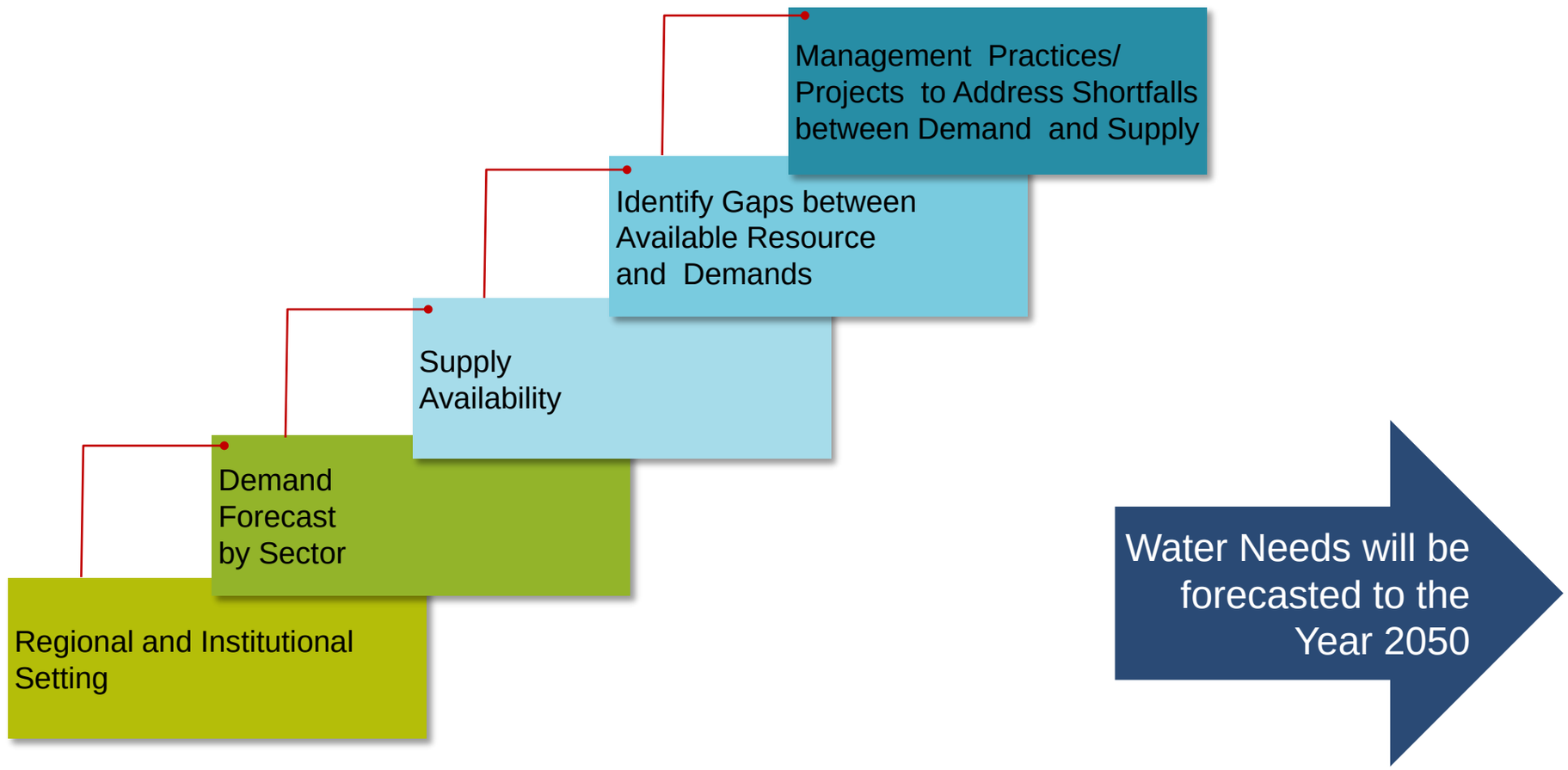
“Whiskey is for drinkin’ and water is for fighting!”

Colorado Model of Water Management

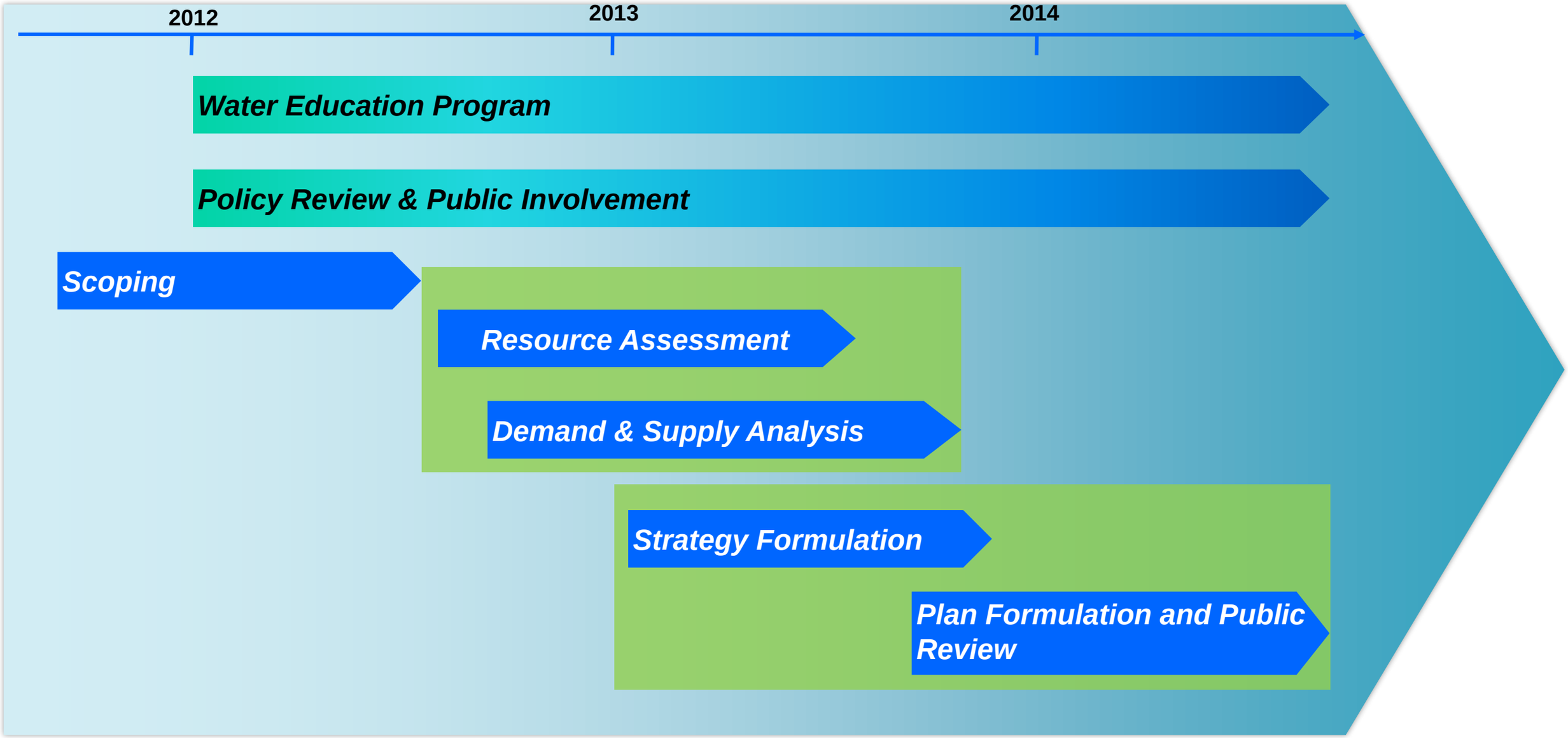
“Help find the water agriculture and industry needs to grow Arkansas’ economy and protects the ecological integrity of Arkansas streams and rivers.”

Tim Snell paraphrased

The Major Technical and Planning Elements of the Water Plan Update



Charting the Plan Forward



Final Plan Rulemaking Nov 2014

Fish & Wildlife Flow Sub-Group

- Sub-group of the Supply Availability Group
- Technical members comprised of AGFC, ANRC, USGS, USFW, TNC, FTN Assoc., U of A F&W Research Coop., UALR Bowen School of Law

Fish & Wildlife Flow Sub-Group Charge

- Refine criteria for declaring drought, water shortages and excess water, and advance policies and procedures for allocating water during times of shortage or drought.
- Identify and recommend procedures and criteria to improve upon existing in-stream flow methodologies taking into consideration water quality, fish and wildlife needs, aquifer recharge, and navigation needs at the statewide and basin specific level.

Fish & Wildlife Flow Sub-Group Current Tasks

- Update “excess water” calculations

  CDM Smith and FTN Associates

- Determine sufficiency of 1990 Water Plan to protect fish and wildlife

  Expert mini-conference late March

  Identify strengths and weaknesses of all environmental flow methods

- Recommend alternative methods, frameworks or procedures

Fish & Wildlife Flows Issues

Fish & Wildlife Flows Issue #1

Current plan relies on defining “excess water” for meeting demand

- *Nature abhors a vacuum*- no such thing as “excess water”
- Risk-based assessment balancing demand with impacts

Fish & Wildlife Flows Issue #2

Current plan uses two different methods (Arkansas Method and Modified Tenant Method) for determining F&W flows- depending if the withdrawal is riparian or non-riparian.

Comparison of selected fish & wildlife flow regimes on mean and median flows for Newport gage

Fish & Wildlife Flows Issue #3

Current plan fish & wildlife flow methods are a “one size fits all” approach- regardless of geographic location, size, timing or resource health

Fish & Wildlife Flows Issue #4

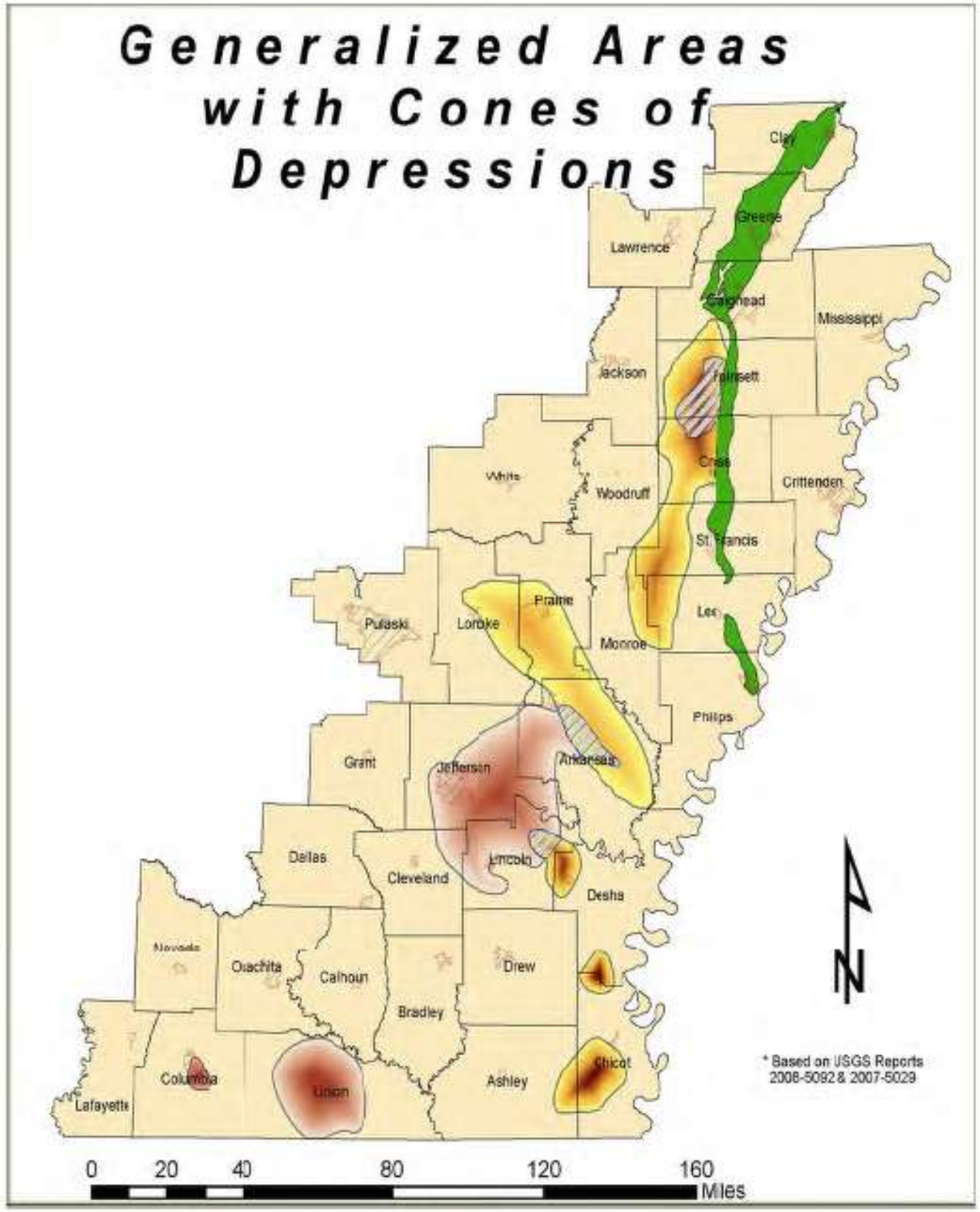
Planning Pressure Points

Unsustainable use of alluvial aquifer west of Crowley's Ridge

Overuse of Bayou Bartholomew

Frac-water source for natural gas extraction

Water treatment infrastructure upgrades in east Arkansas



Legend

- Intersection of the two cones
- Cones of Depression in the Alluvial Aquifer
- Cones of Depression in the Sparta Aquifer
- County Seat
- Crowleys Ridge
- County Boundaries

Fig. 2

Fish & Wildlife Flows Issue #4

Planning Pressure Points

- Unsustainable use of alluvial aquifer west of Crowley's Ridge
- Overuse of Bayou Bartholomew
- Frac-water source for natural gas extraction
- Water treatment infrastructure upgrades in east Arkansas

Final Thoughts and Discussion

- Arkansas has an abundance of water.
- The economic vitality of Arkansas agriculture and industry is dependent on abundant, relatively inexpensive sources of clean water
- Arkansas's biodiversity and robust water-based recreational industry is dependent on healthy, intact ecosystems
- Key is finding the water agriculture, industry and municipalities need that has the lowest risk of unacceptable ecological consequences

Environmental Flow Standards in Michigan

Slides courtesy of Paul Seelbach, USGS
and Richard Bowman, TNC

Michigan's Instream Flow Program

- State legislation directed development of ecologically-based flow criteria to guide review of water withdrawals to avoid "Adverse Resource Impact" (ARI)

- Stakeholder process informed by
  - Hydrologic model
  - River Classification
  - Modeled fish species habitat requirements
  - Tiers of ecological responses to flow alteration

- Water use registration program
  - Web-based user application process
  - Encourages use of water where available

Michigan River Classification Approach

Spatial framework

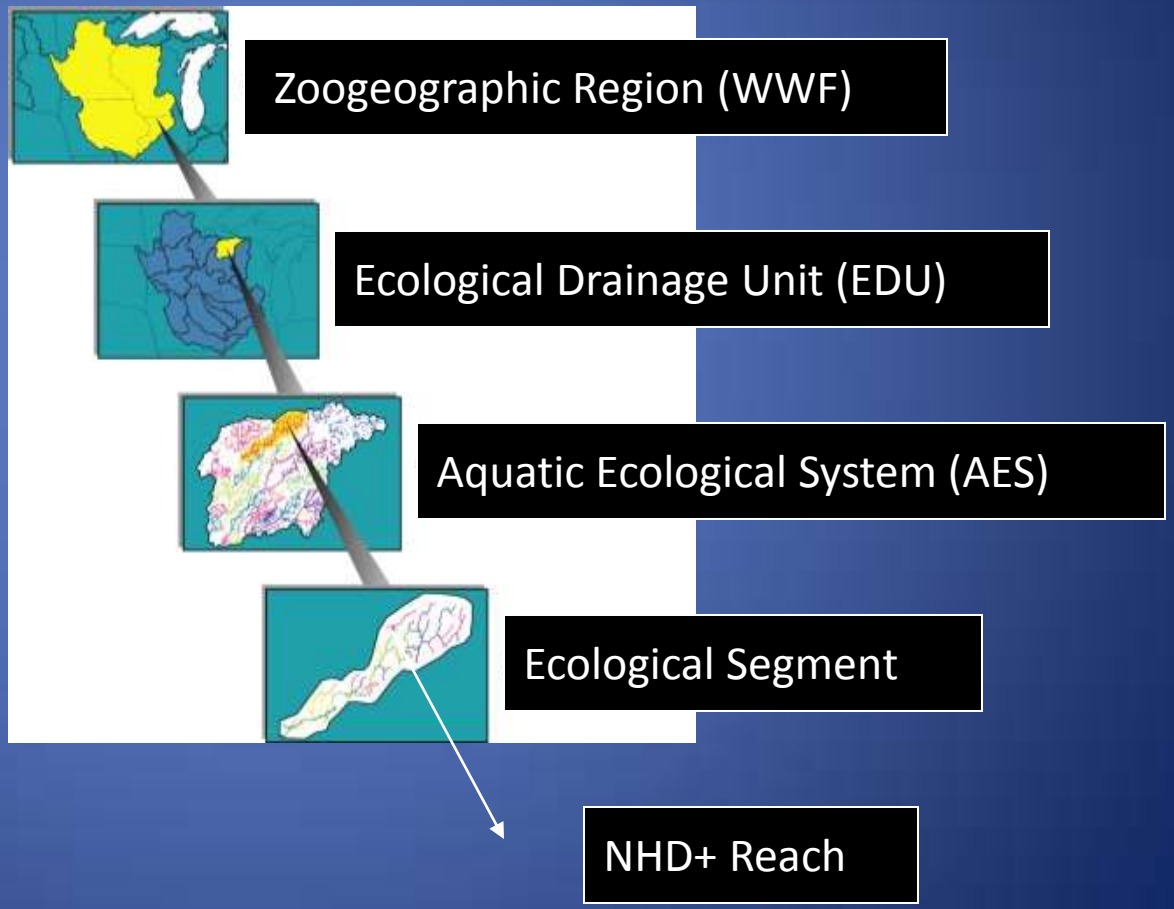
Reach attribution

MI fisheries classification

Coordination is good

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

Provides for multi-state coverage.



Spatial framework

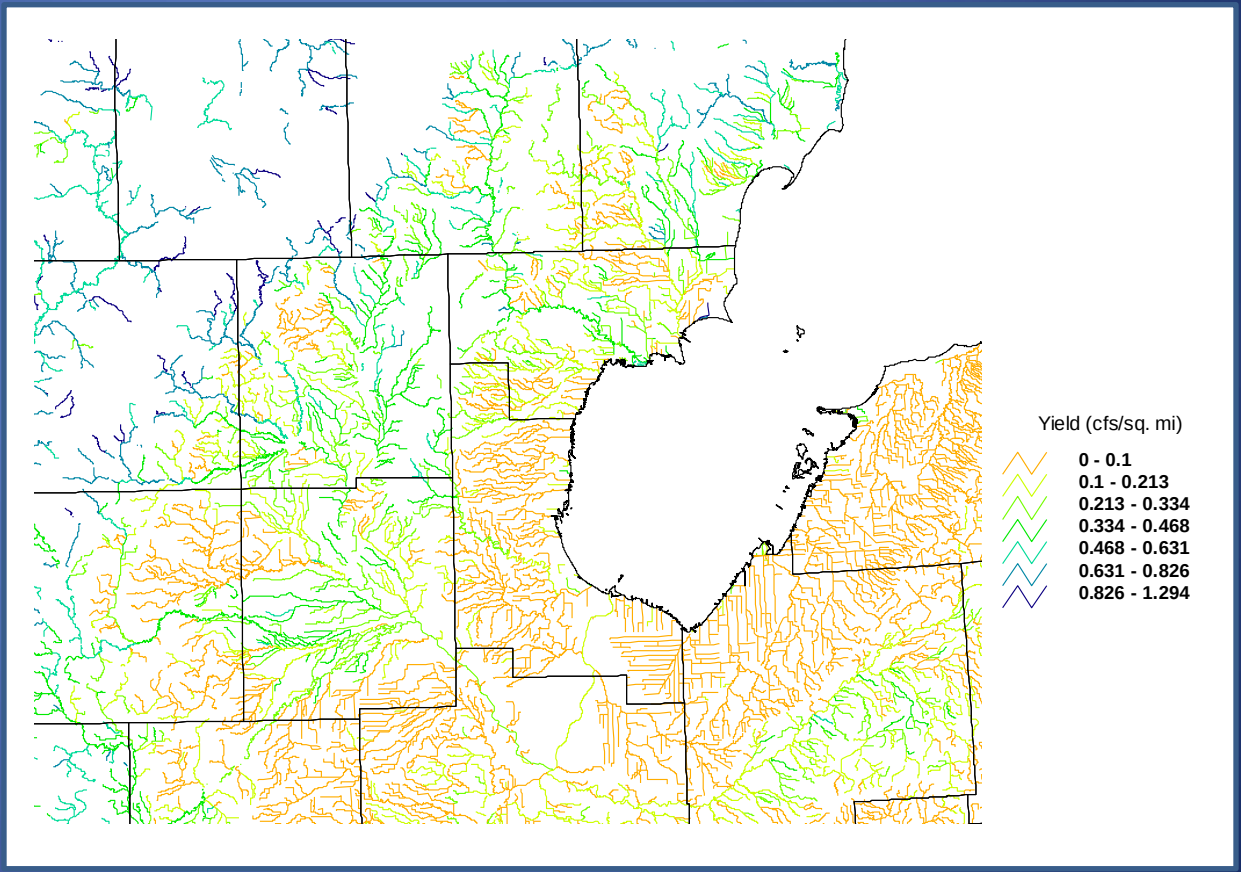
Reach attribution

MI fisheries classification

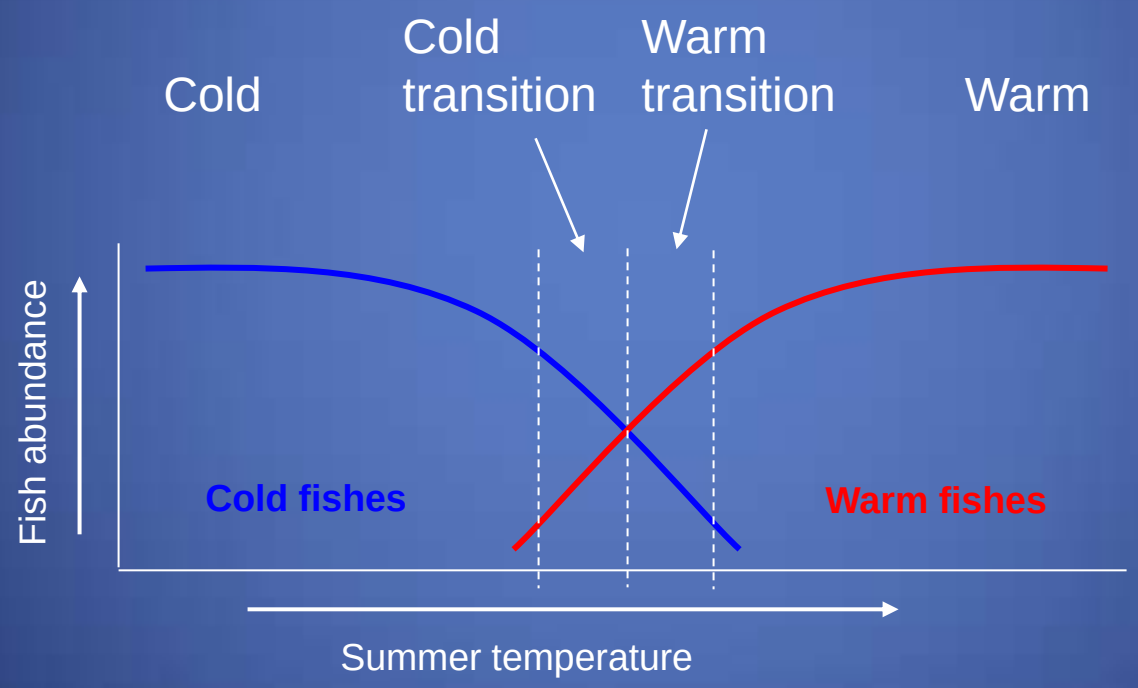
Coordination is good

Key landscape and riverine attributes for every reach came from existing map-level data and state-level models.

Examples: flow, temperature, slope, and elevation.

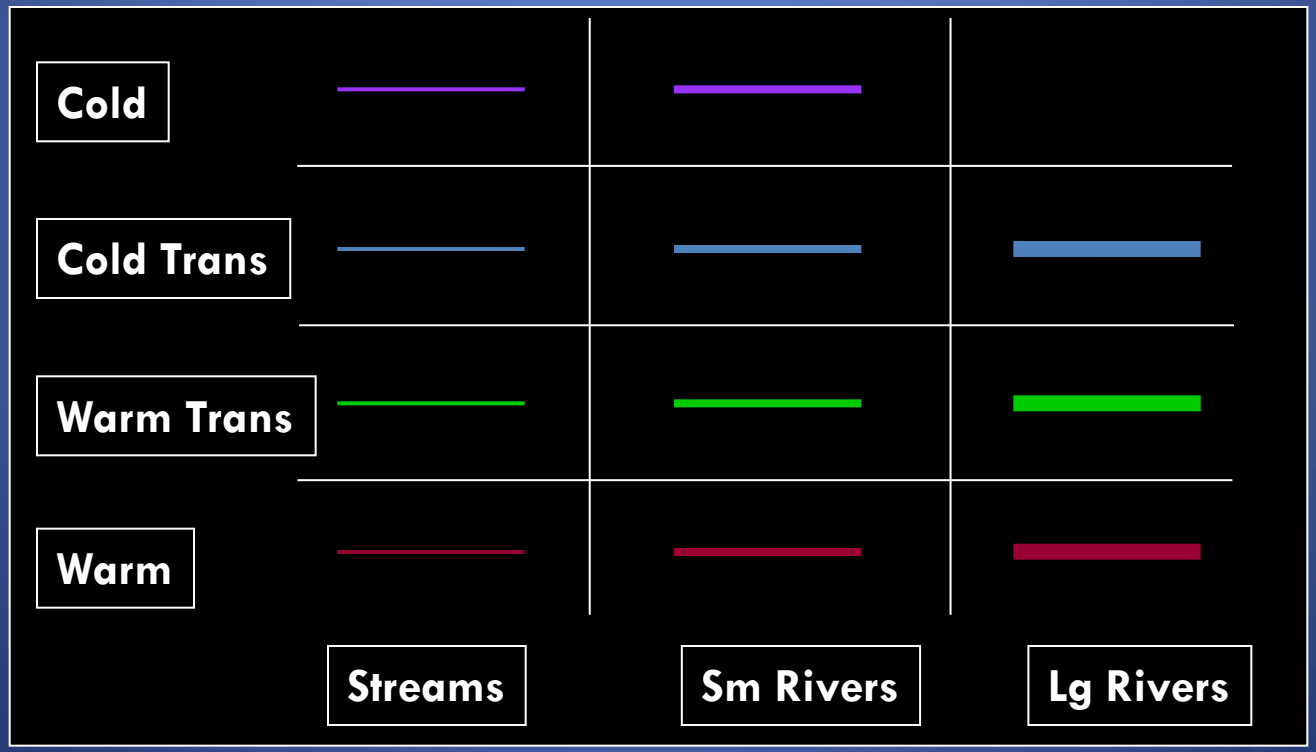


Spatial framework | Reach attribution | **MI fisheries classification** | Coordination is good



Spatial framework | Reach attribution | **MI fisheries classification** | Coordination is good

11 river classes based on flow and temperature

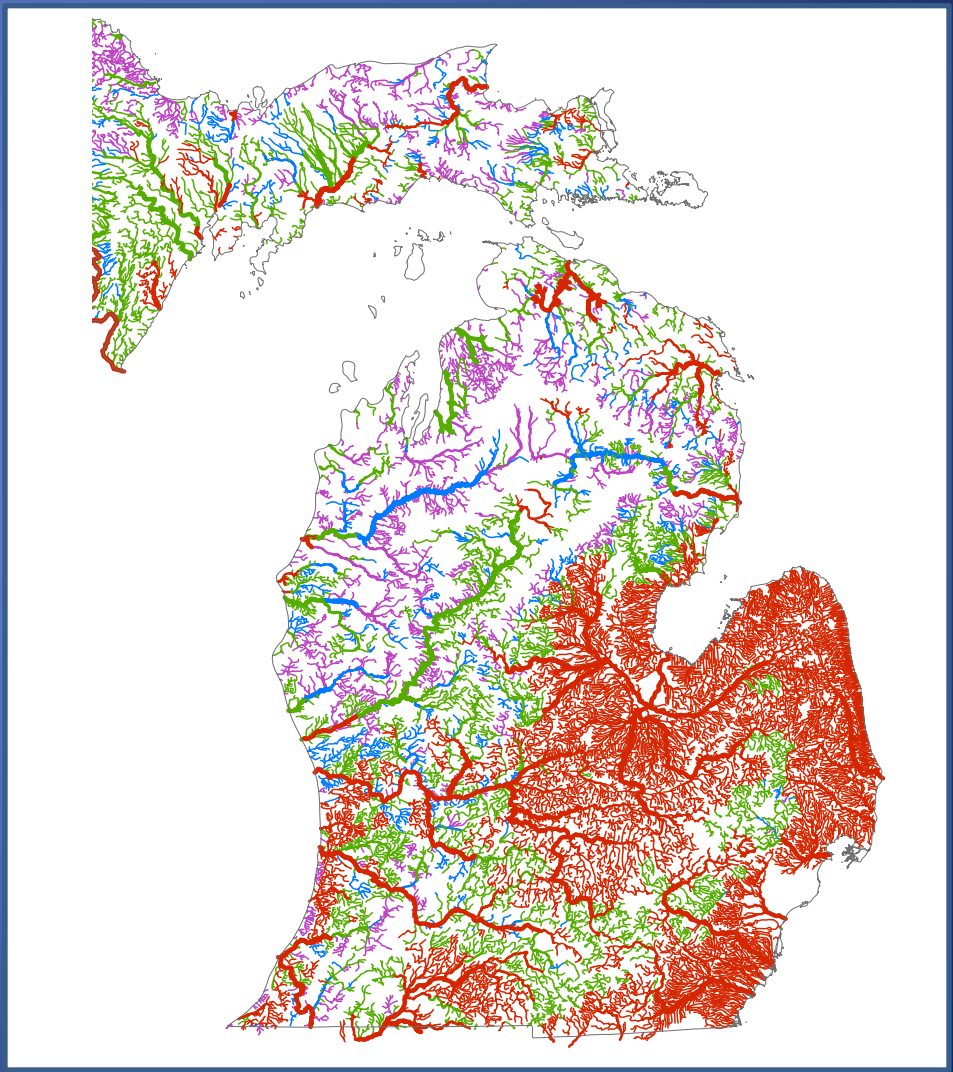


Spatial framework | Reach attribution | **MI fisheries classification** | Coordination is good

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.



Michigan Surface Water Hydrologic Model

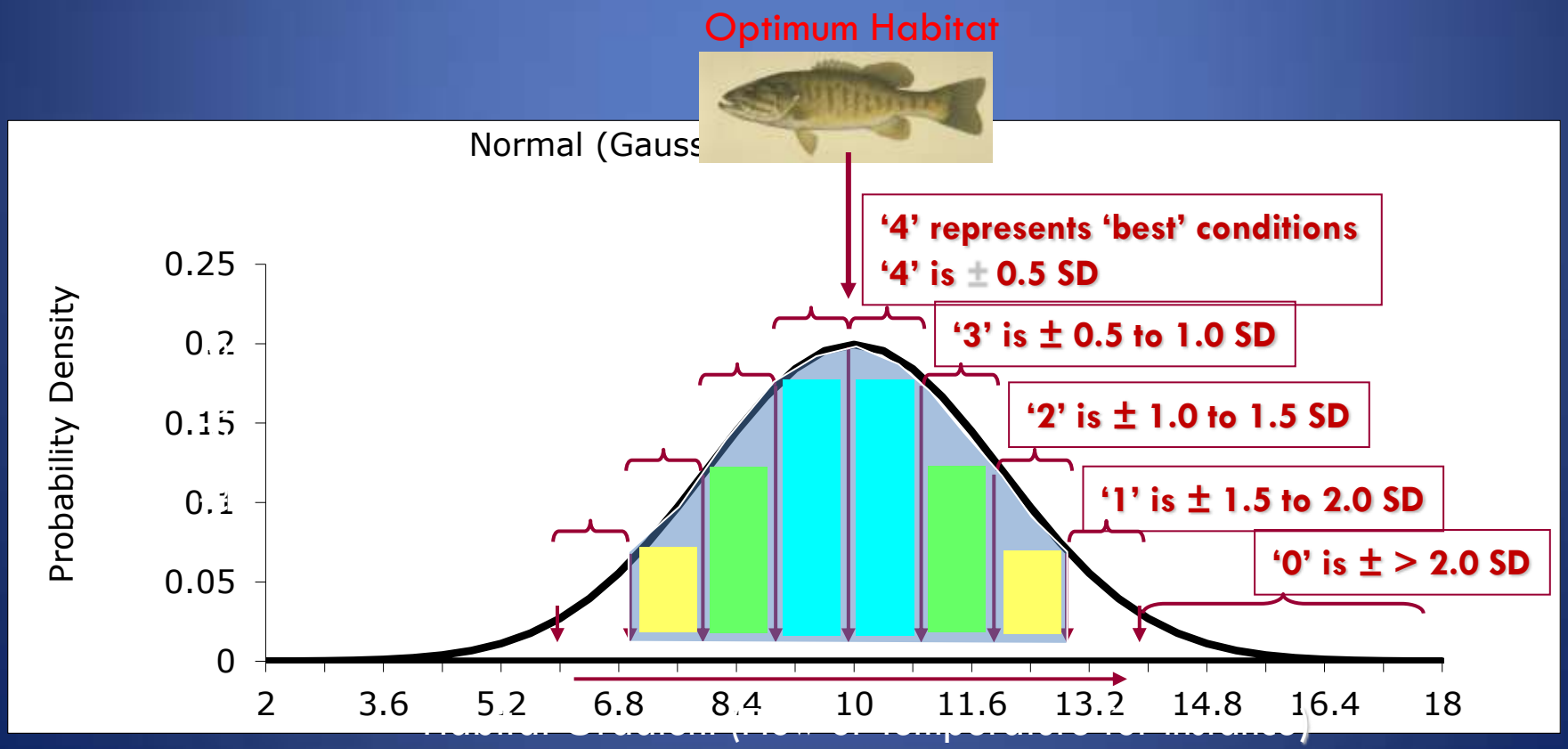
- Relatively uniform hydrologic conditions across state
- Modeled summer flow levels at ungaged locations based on basin-area adjustment of observed flows at gaged location.
- Output for NHD+ segments
- Impact of withdrawals accumulated in user interface

Modeling Fish Assemblage Response to Base Flow Reduction

- Based on fish abundance survey data (1,720 sites statewide)

- Modeling process
  1. Identify optimal habitat conditions for each species
     - Catchment area,
     - July mean water temp,
     - Base flow yield (median August flow)
  2. Score optimal density for each species at a site
  3. QA/QC observed to predicted species scores
  4. Predict changes to habitat and overall species scores at sties for successive 10% increments in base flow reductions
  5. Identify thriving and characteristic fish assemblages
  6. Summarize fish assemblage responses to water withdrawals

- Statewide habitat suitability info: flow and temperature
- Rank scores per normal distribution; 60+ species
- Identified 'Characteristic' and 'Thriving' species



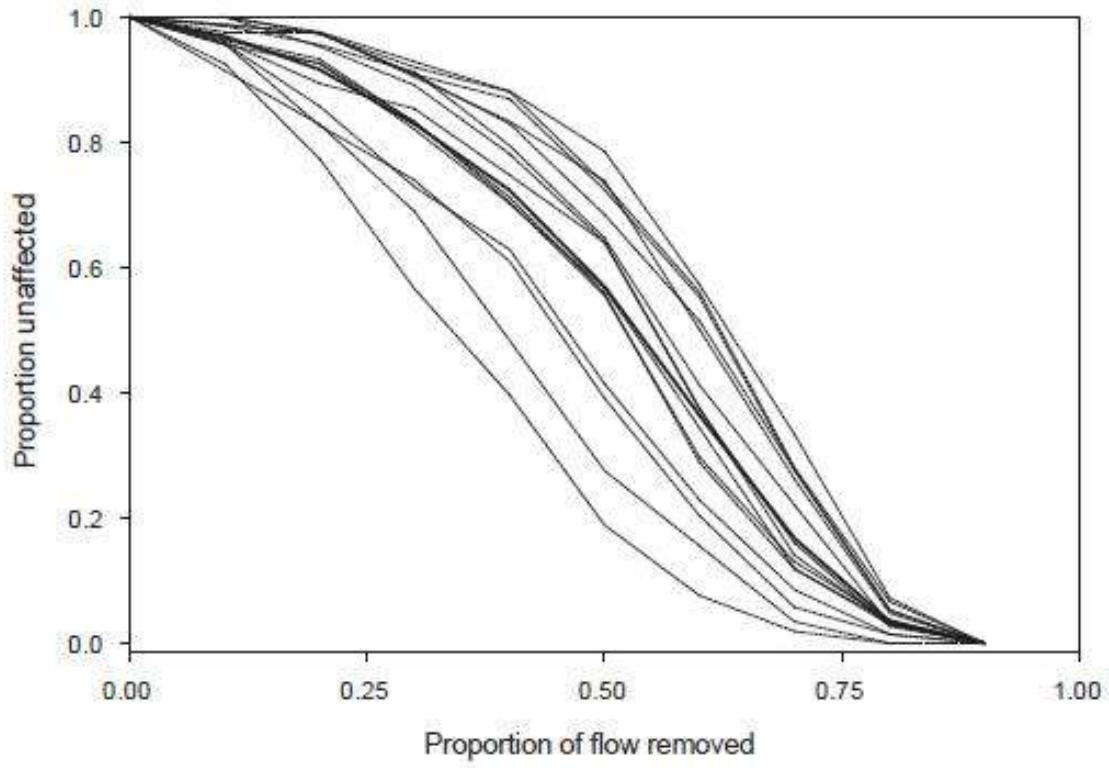
For representative sites per river type:

Considered initial "characteristic" species

Ran withdrawal simulations and followed scores

	Percent flow reduction						
	0	10	20	30	40	50	60
common shiner	4	4	4	3	3	3	2
white sucker	4	3	3	3	2	2	2
longnose dace	3	3	2	2	2	0	0
rainbow darter	2	2	1	0	0	0	0

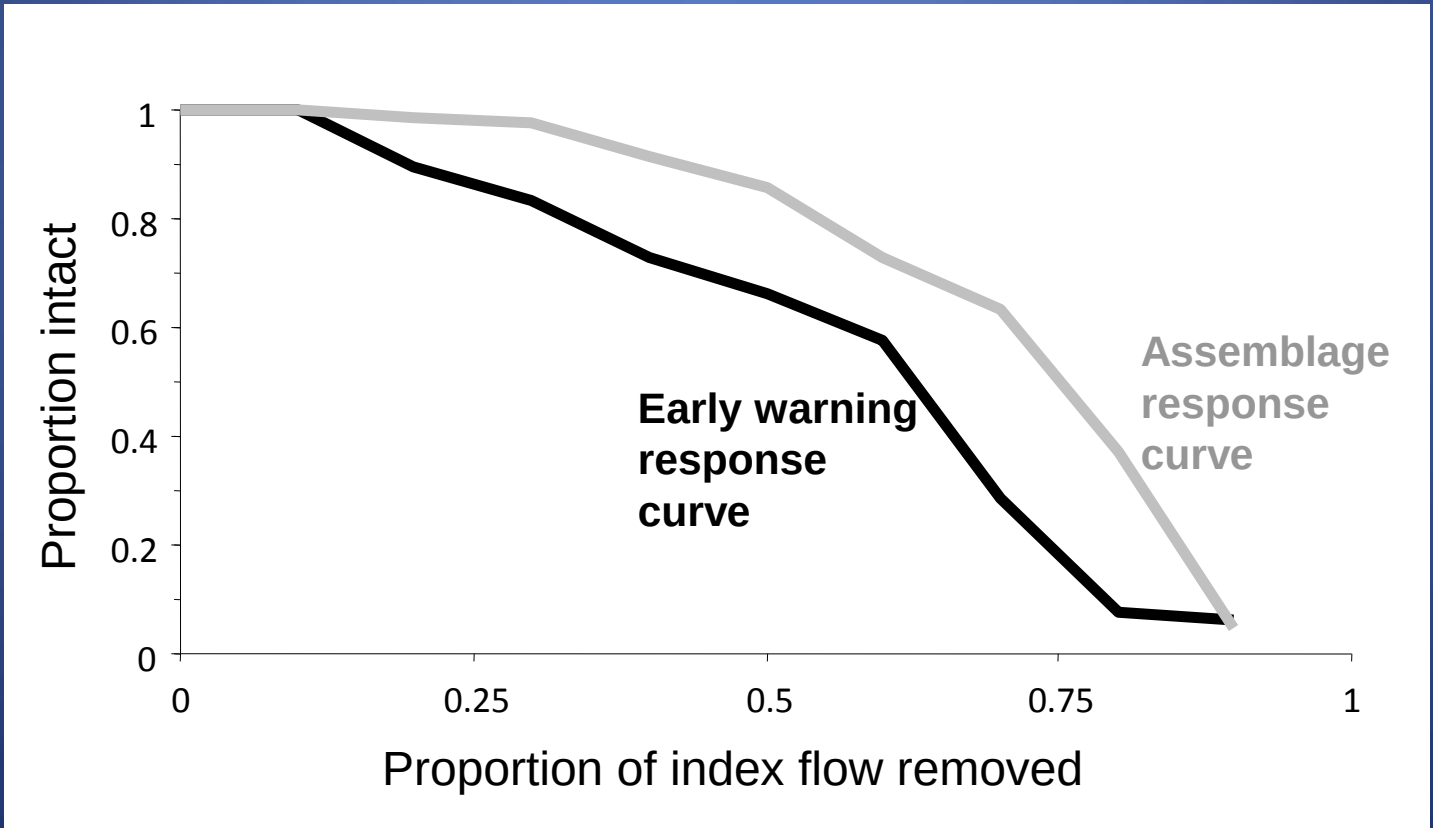
Reference flows | River types | Degree flow alteration | **Ecological response curves** | Ecological targets | Enviro. flow targets | Implement program

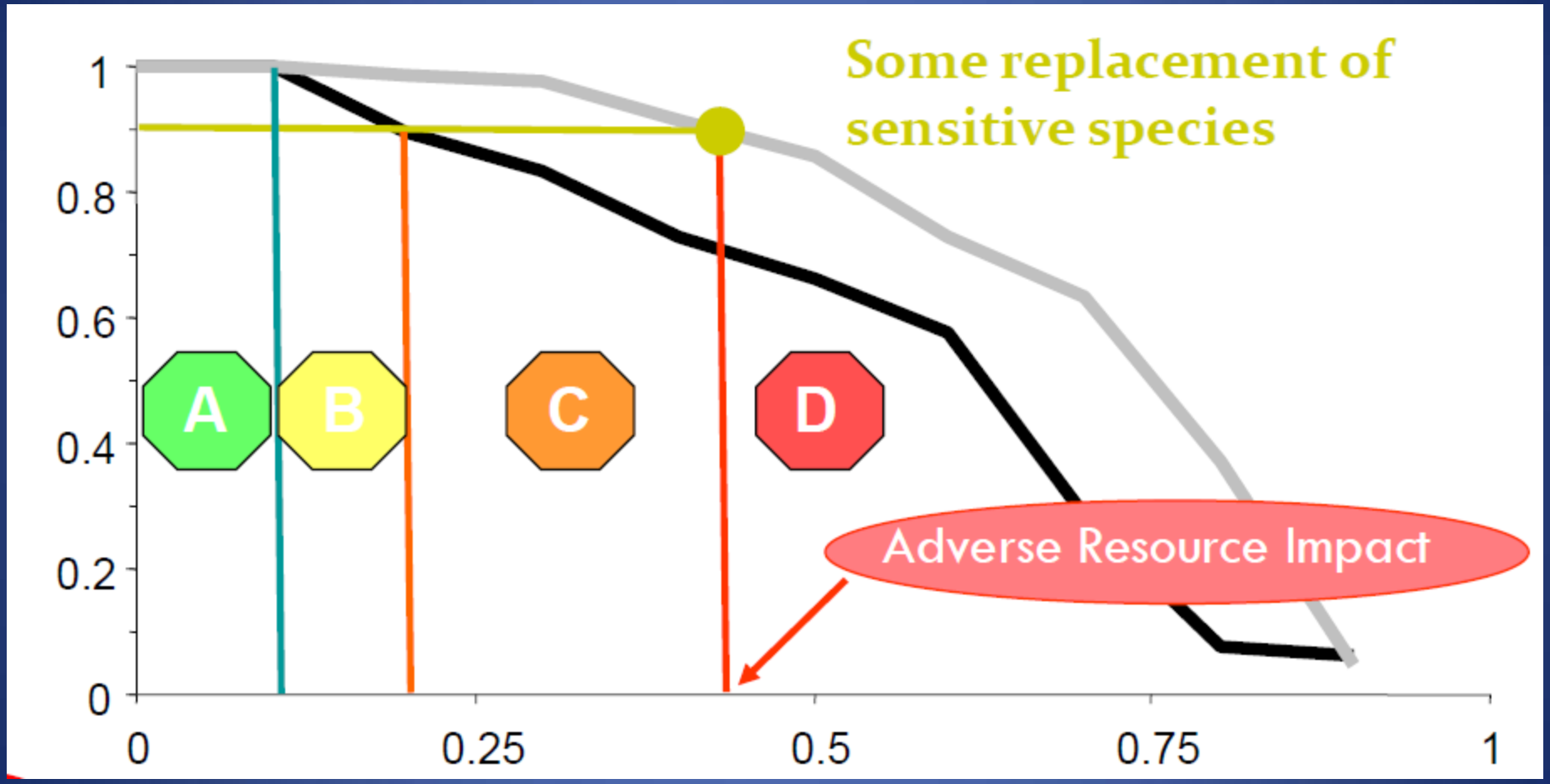


Variation in fish assemblage response curves. The mean response (dark line) was used in the water management program, and policy safeguards were used in recognition of the degree of variation.

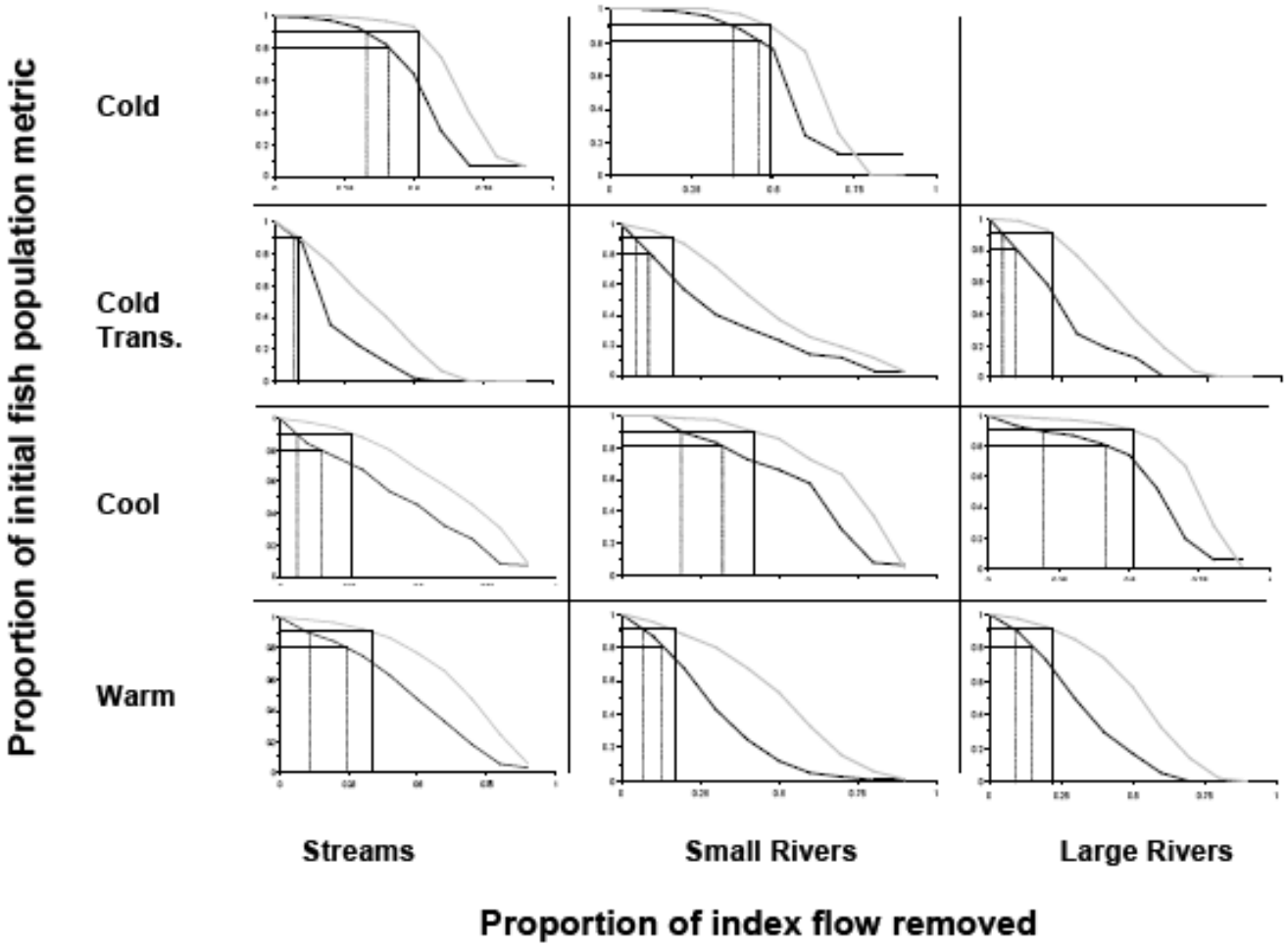
Reference flows | River types | Degree flow alteration | **Ecological response curves** | ological gets | Enviro. flow targets | Implement program

Summaries of simulations create early warning and total impact curves (for assemblage)




Some replacement of sensitive species
1
0.8
0.6
0.4
0.2
0
0
0.25
0.5
0.75
1
A
B
C
D
Adverse Resource Impact

Curves and target zones per each ecological river type.
Geographies of biological response and social values.



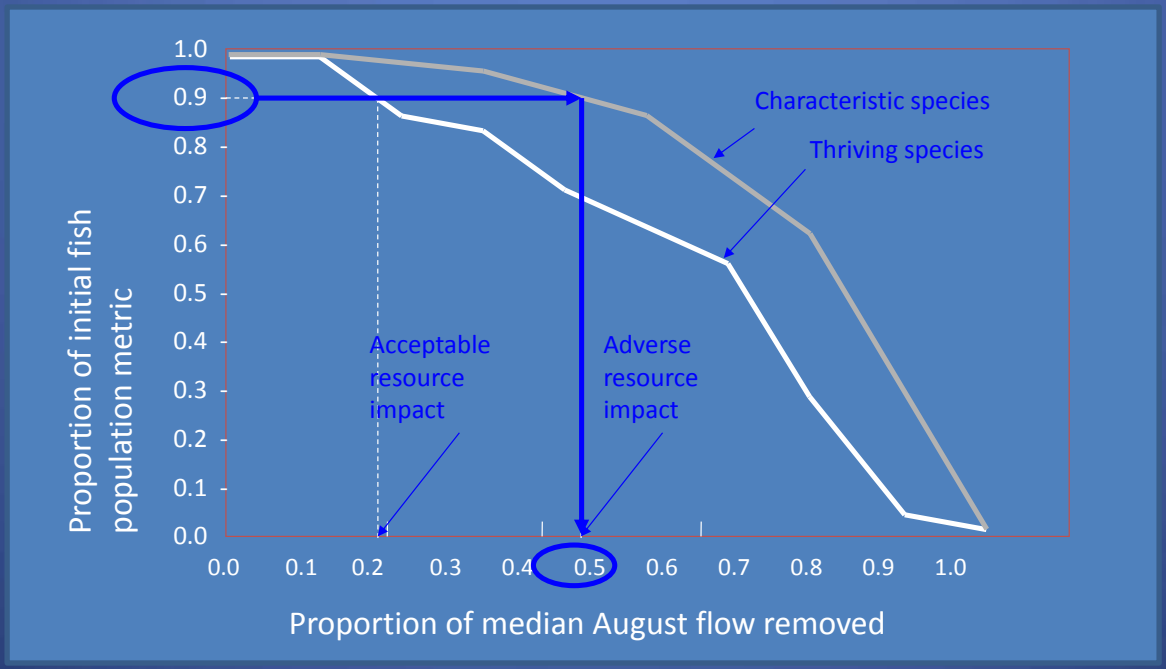
Michigan's Screening Tool for Ground-Water Withdrawals

	A/B	B/C	ARI	A/B	B/C	ARI	A/B	B/C	ARI
COLD	14%	14%	20%	10.5%	10.5%	21%			
TRANS		4%	4%		2%	2%		3%	3%
COOL	6%	15%	25%	15%	19%	25%	14%	19%	25%
WARM	10%	18%	24%	8%	13%	17%	10%	16%	22%
	Stream			Small River			Large River		

Allowable cumulative withdrawal
(% median August)

Michigan Instream Flow Program

- River classification informed by fish assemblages
- *PHABSim-style methodology*
- *Percent of Flow Reduction Criteria*



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WATER WITHDRAWAL ASSESSMENT TOOL

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Related Articles

- Education Material
- Tool Introduction

Collaborators

Department of Environmental Quality

Department of Natural Resources

United States Geological Survey

Institute of Water Research

Finding the Location of Your Water Withdrawal

Please select one of the following options for locating the position of your water withdrawal.

Locate by Address

Enter the address and zip code at or near the withdrawal location. Please spell street names correctly in order to ensure system accuracy.

Address:

Zip Code:

Find Address

Locate by County

To select the county where the water withdrawal will occur, click the map or choose from the drop down menu.

Kent

Find County

Arkansas WATERplan
Essential For Life

ARKANSAS WATER PLAN UPDATE

Fish & Wildlife Flows Subgroup Meeting

Non-Riparian Permitting in Fayetteville Shale Play

Wednesday, March 27, 2013
River District Nature Center

Arkansas Natural Resources Commission

Non-Riparian Permitting
Existing Arkansas Water Law

- Individual riparian rights have not been quantified.
  -reasonable use theory-

- Riparian users have right to fair share of water.
  -without detriment or harm to other users-

Non-Riparian Permitting
Existing Arkansas Water Law

Category of Water Use

Non-Riparian Permitting
Existing Arkansas Water Law

- **Riparian Water Use**

  Use of surface waters on land that is contiguous to the surface water source.

Non-Riparian Permitting
Existing Arkansas Water Law

- **Non-Riparian Water Use**

  Use of surface waters on land that <u>is not</u> contiguous to the surface water source.

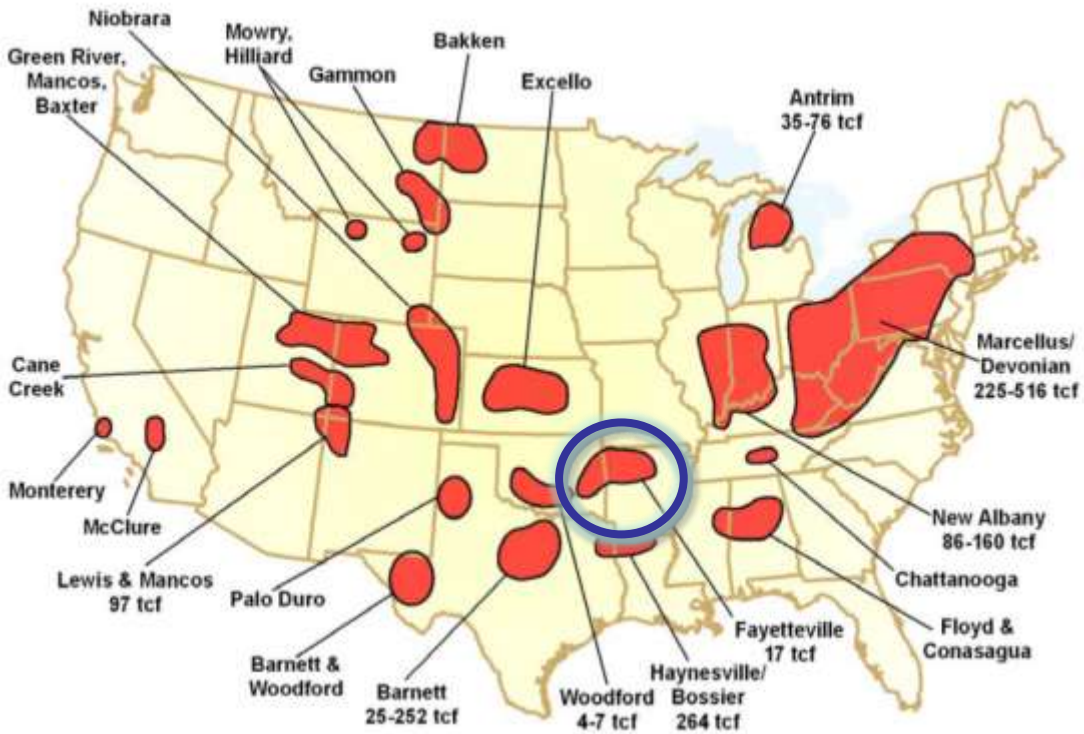
Non-Riparian Permitting
Existing Arkansas Water Law

Riparian & Non-Riparian Water Rights are associated with the land.

Non-Riparian Permitting
Existing Arkansas Water Law

Non-Riparian Permitting
Fayetteville Shale

Estimated Gas Reserves in U.S. Shale Basins



Arkansas WATERplan
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Non-Riparian Permitting
Fayetteville Shale

The Fayetteville Shale is an unconventional gas reservoir located in Arkansas, ranging in thickness from 50 to 325 feet, and depths from 1,500 to 6,500 feet.

In 2004, Southwestern Energy Company announced it had successfully drilled test wells and commercially produced gas from the Fayetteville Shale.

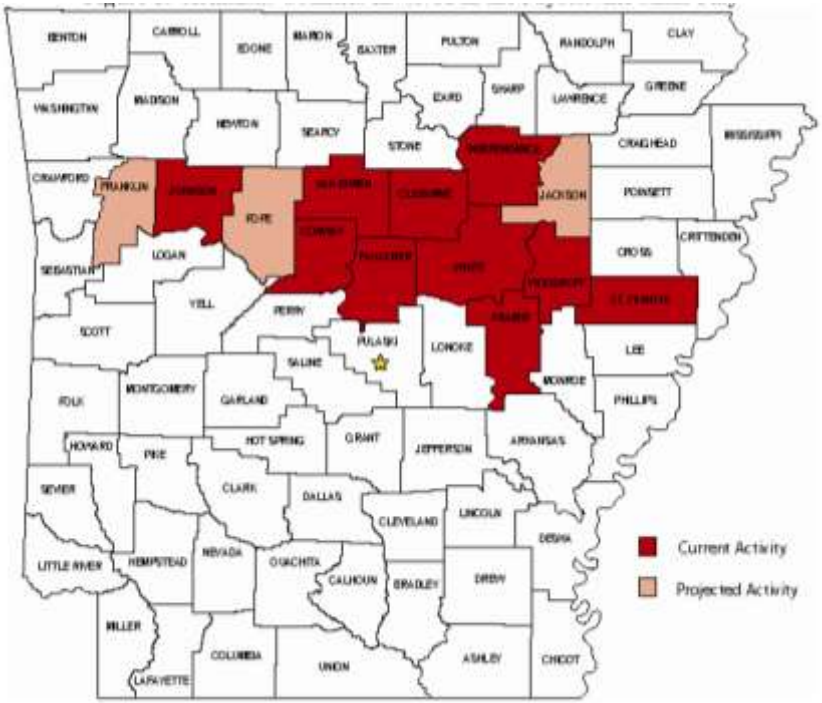
Fayetteville Shale

Non-Riparian Permitting
Fayetteville Shale

Arkansas Counties with current activity associated with Fayetteville Shale Play.

Franklin, Johnson, Pope, Yell, Conway, Van Buren, Faulkner, Cleburne, Crawford, Sebastian, Logan, Cleburne, White, Jackson, Woodruff, Prairie, Monroe, Lee, Phillips, St. Francis, and Lonoke.

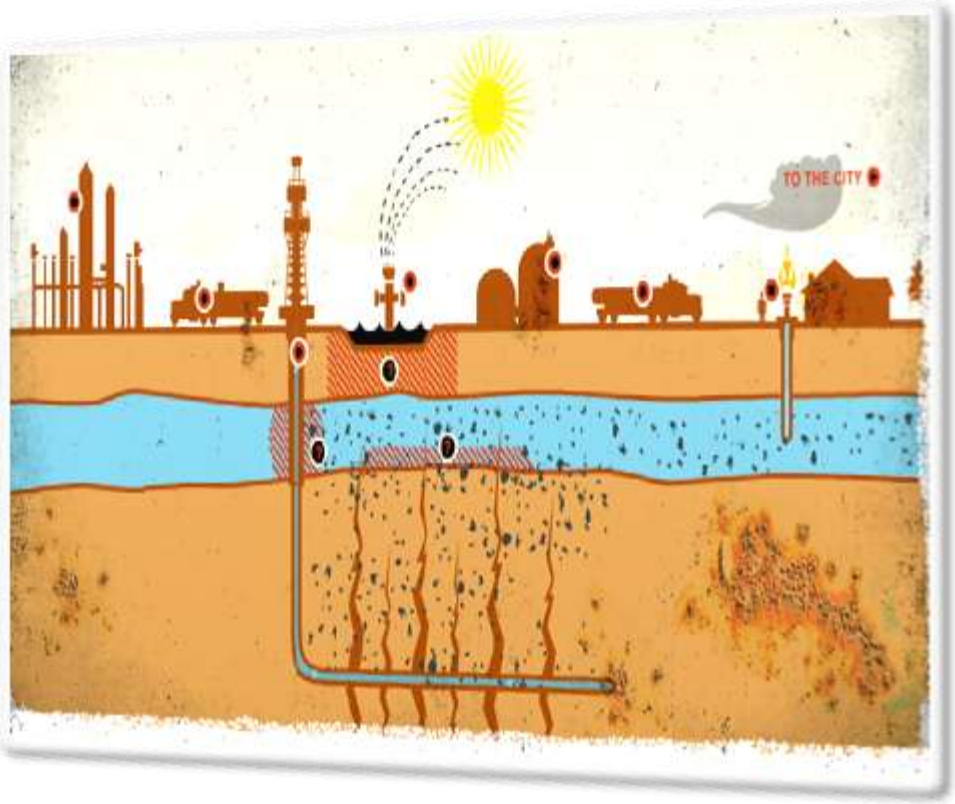
Affected Arkansas Counties



Non-Riparian Permitting
Fayetteville Shale

Hydraulic Fracturing

Recent advances in fracturing and drilling techniques in the Fayetteville Shale have increased the industry's demand for "frack" water. More wellheads grouped together on one surface location (pad) allows fewer rig moves, less surface area disturbance, and cheaper costs to complete and produce the wells.



Non-Riparian Permitting
Fayetteville Shale

To reach multiple subsurface locations from one pad through multiple horizontal bores, lengths ranging from 1500 to over 3000ft, can require 3-5 million gallons to complete a "frack".

Groundwater is limited in the Fayetteville Shale Area, so the industry relies on surface water to meet fracking water needs.

Individual Well Requirements

Non-Riparian Permitting
Excess Surface Water

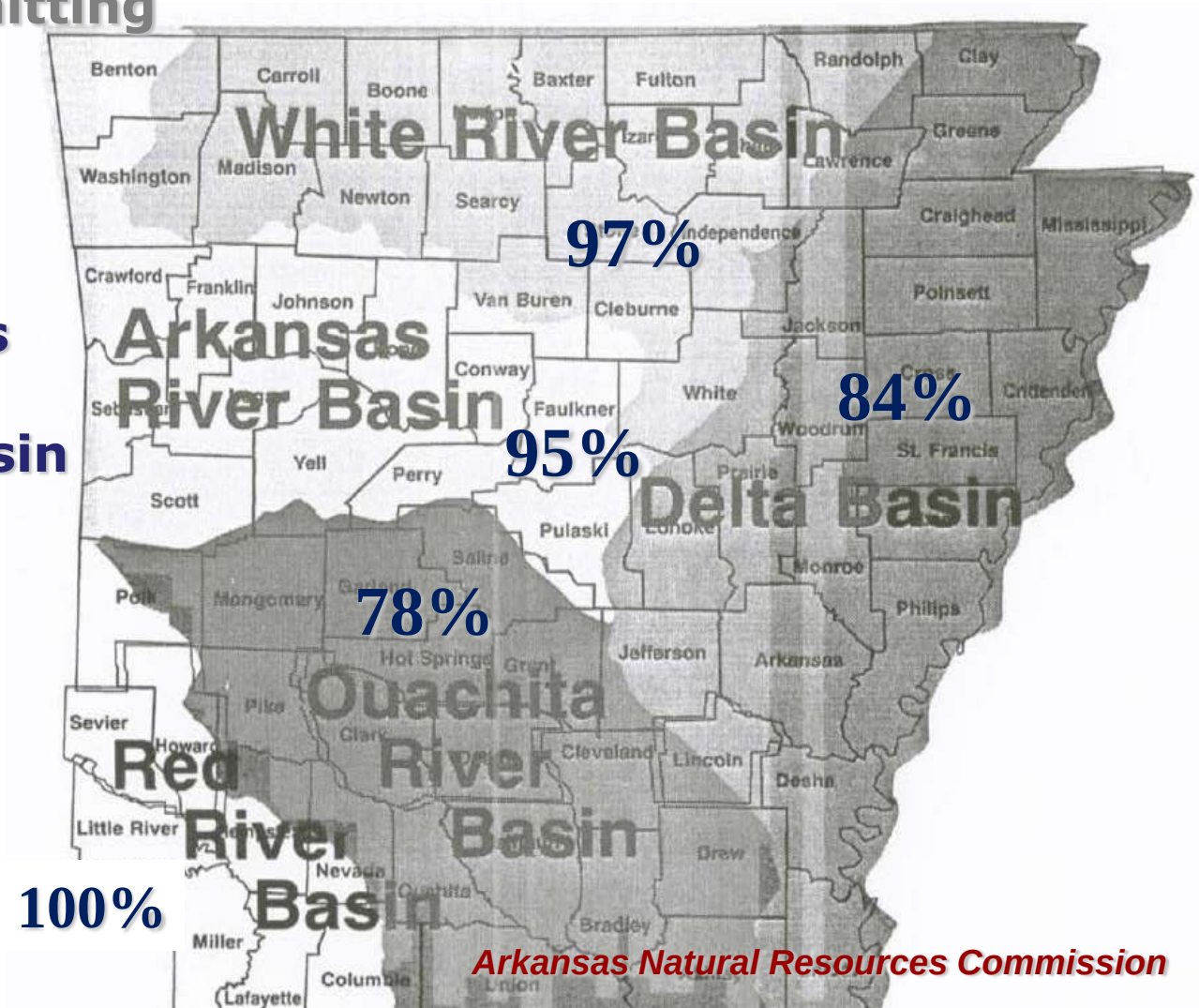
Excess Available Surface Water

- 25% of the average annual yield from any watershed above that amount, as determined by the Commission, required to satisfy all of the following as applicable:
  - All registered riparian use
  - Maintenance of minimum streamflows
  - Projected future needs
  - Water needs of federal projects
  - The firm yield of affected reservoirs existing in 1985

Arkansas WATERplan
Essential For Life

Non-Riparian Permitting

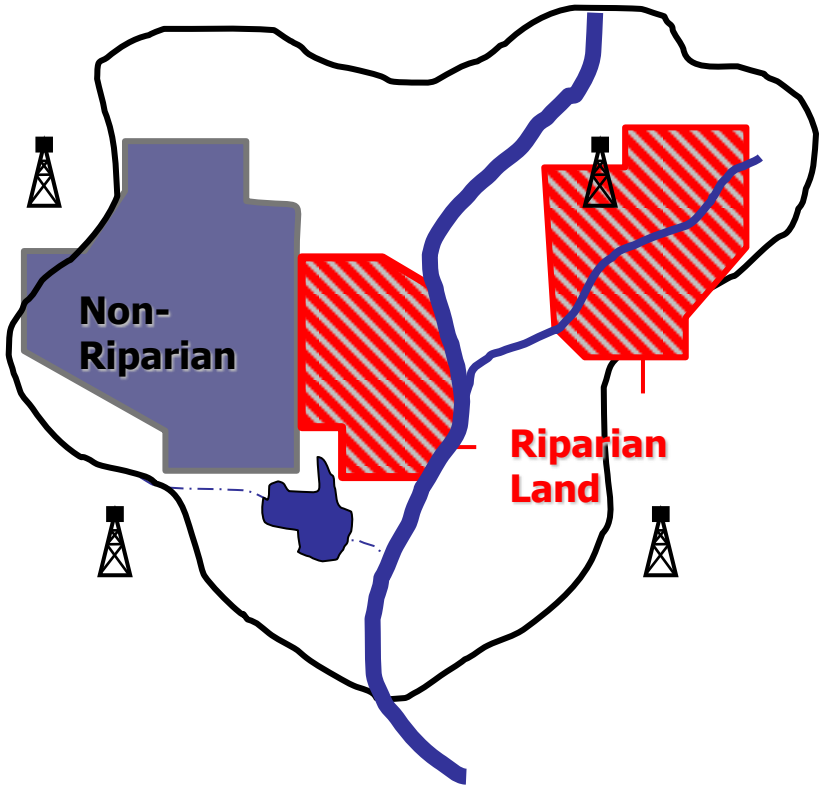
Percent of Excess Surface Water Remaining by Basin



Arkansas Natural Resources Commission

Non-Riparian Permitting
Administrative Procedures

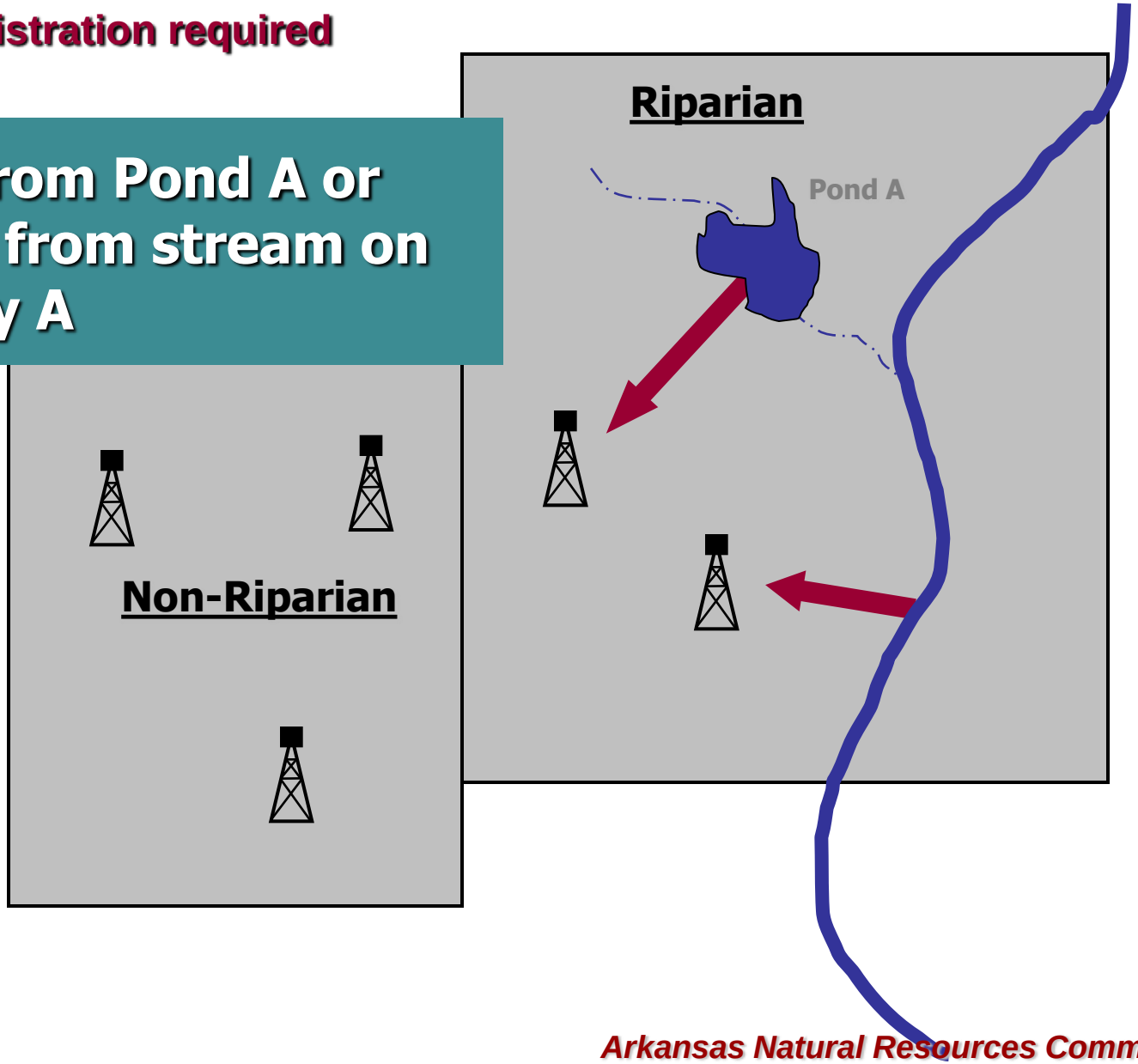
The industry is required to apply for a non-riparian permit for any proposed water use. The Commission makes determination of proposed use as riparian, non-riparian, or diffuse.



Riparian Use

Water use registration required

Water from Pond A or directly from stream on Property A

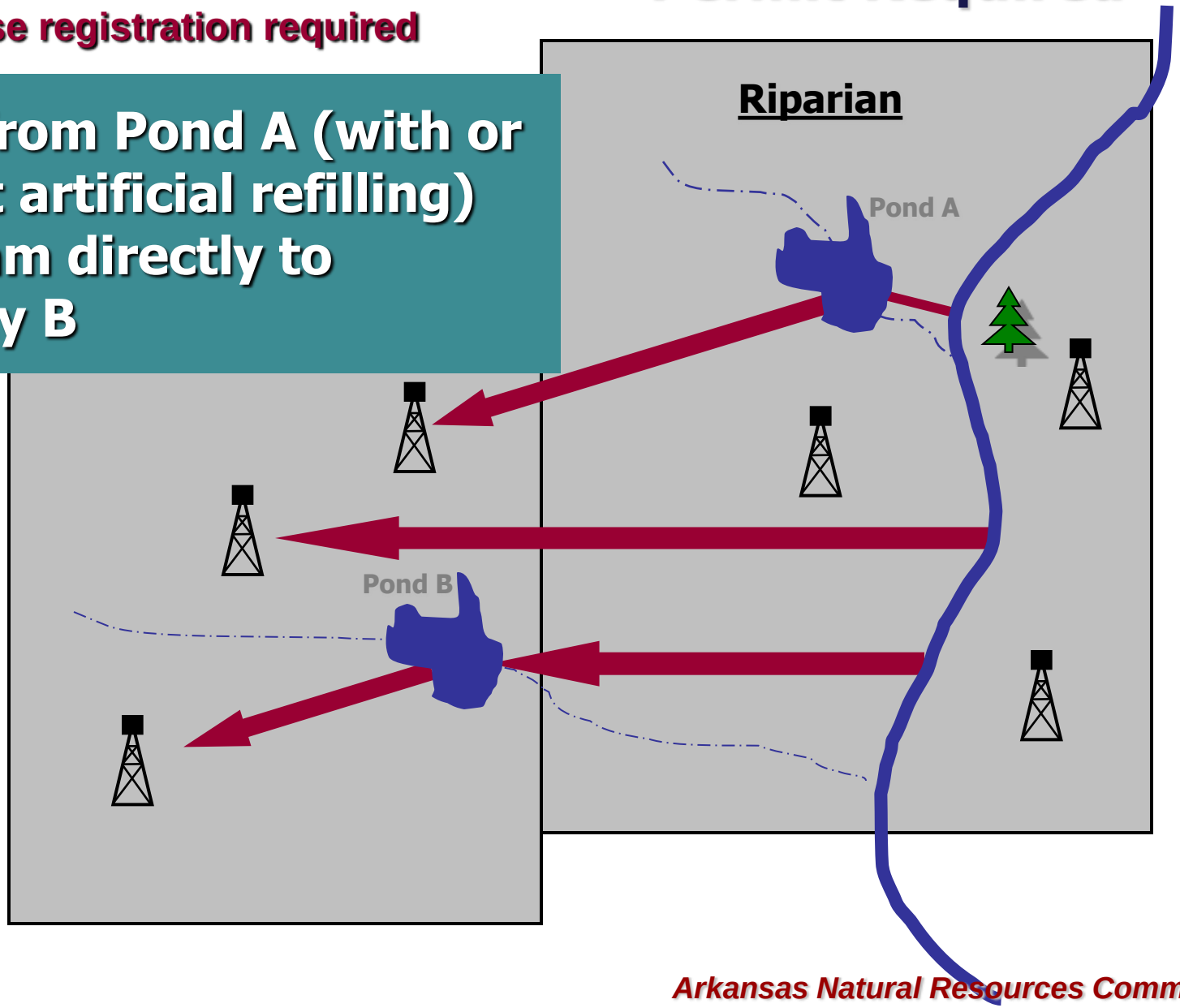


Non-Riparian Use

Water use registration required

Permit Required

Water from Pond A (with or without artificial refilling) or stream directly to Property B

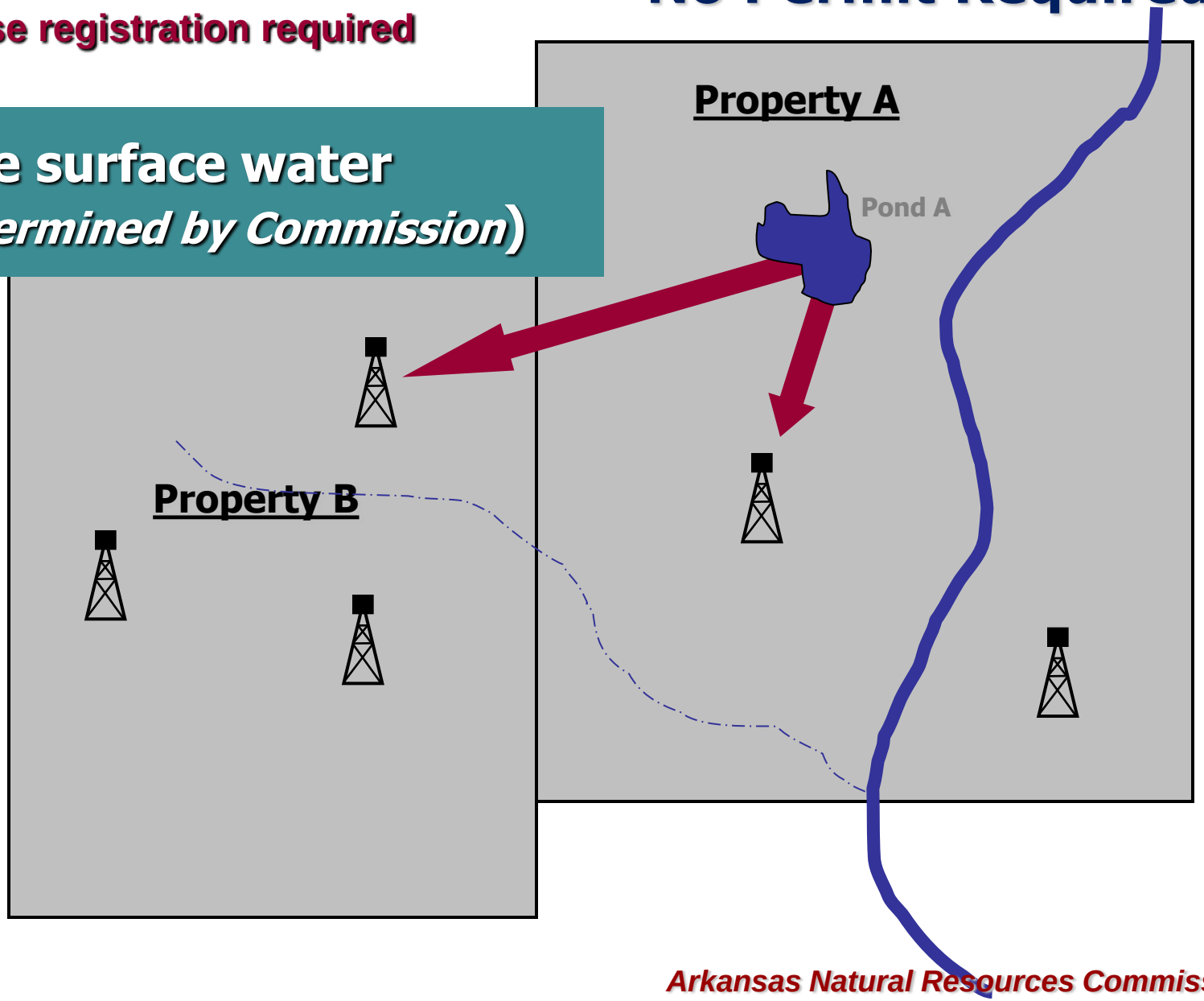


Diffuse Surface Water

Water use registration required

No Permit Required

Diffuse surface water
(as determined by Commission)



Non-Riparian Permitting
Administrative Procedures

- Non-riparian permits are issued to the water user (industry), not individual property owners in the Fayetteville Shale Area.
- Permits are issued for 5 years contingent on an annual compliance review.

Non-Riparian Permitting
Administrative Procedures

- Any changes in project operation or amendment requests are submitted in annual compliance report.

Sub-Form A Water Use Summary

Non-riparian water use during previous permit year.

Sub-Form B Off-stream Storage Summary.

Quantity and routing of off-stream storage as authorized in non-riparian permit.

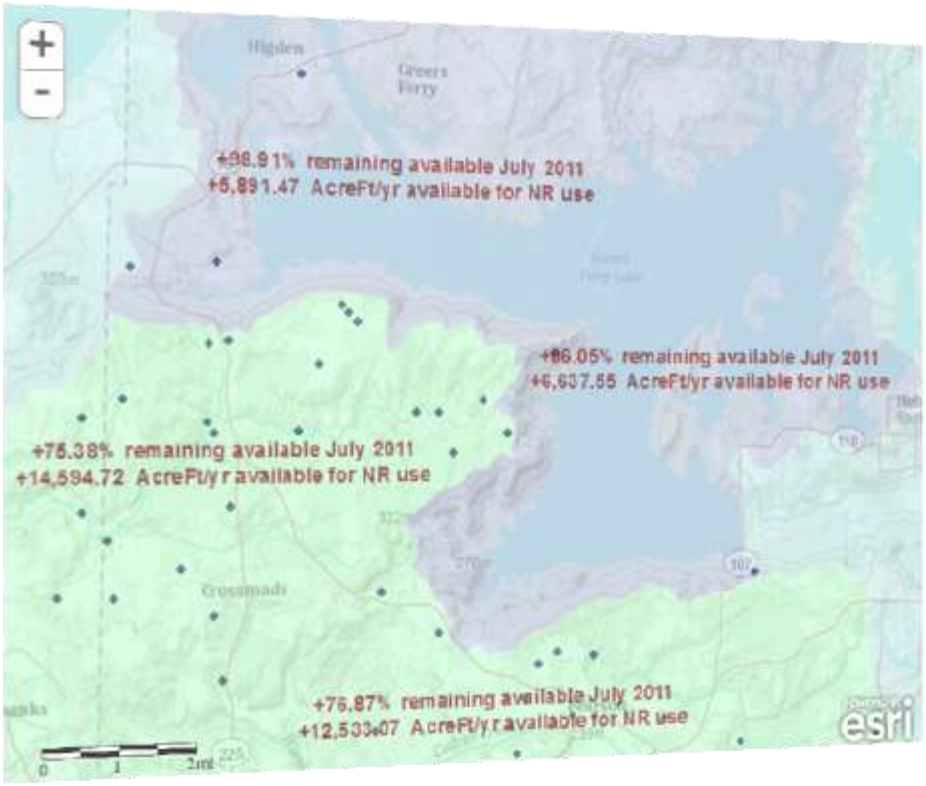
Non-Riparian Permitting
Administrative Procedures

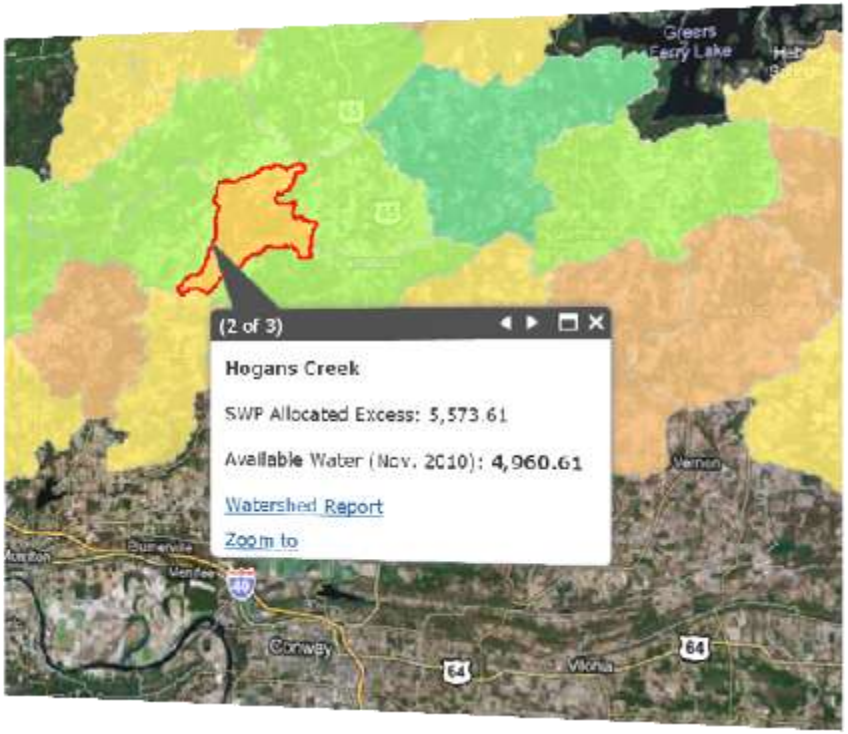
Permit Conditions

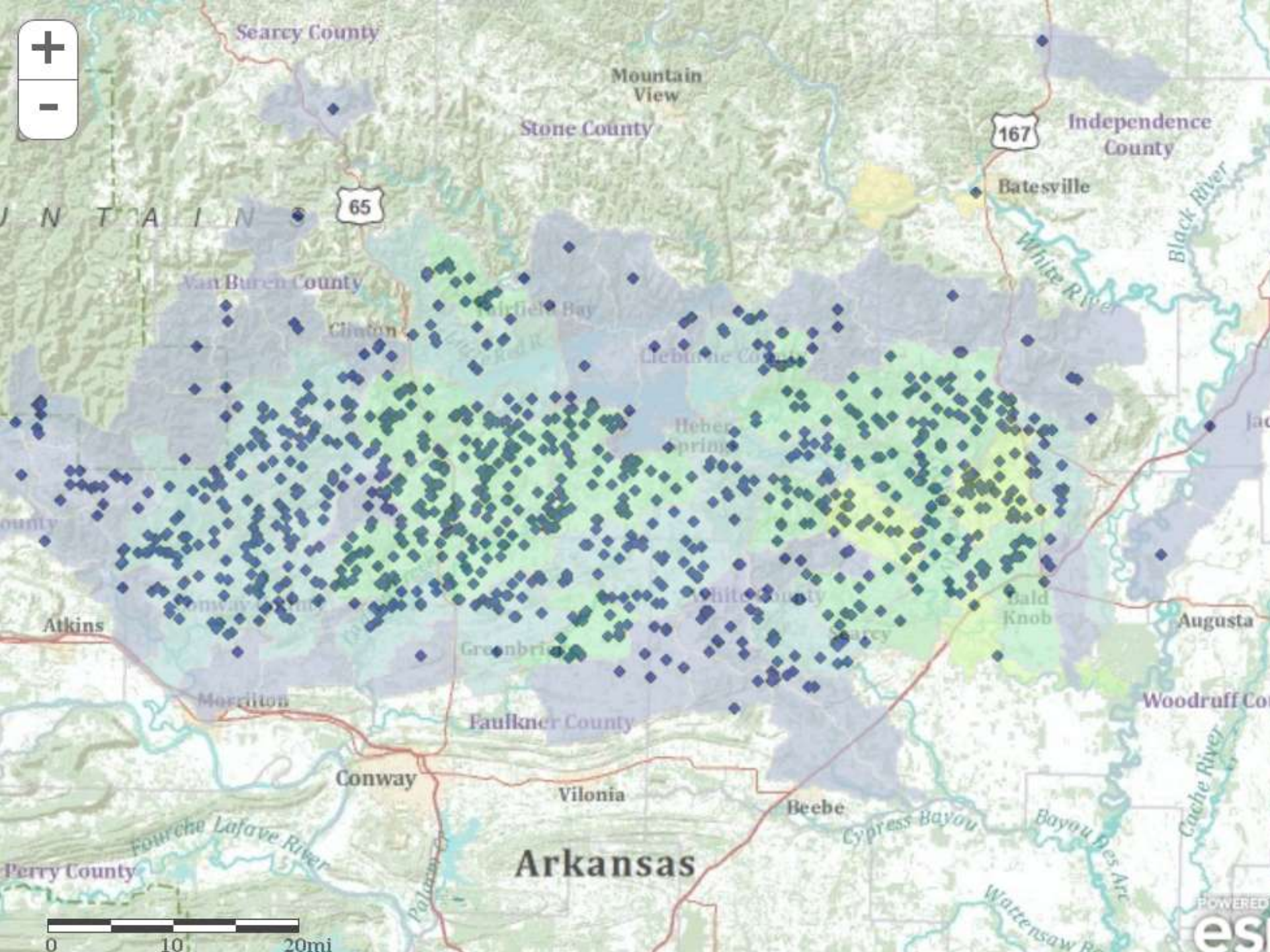
- Issued for up to five years, contingent on submission & approval of ANNUAL COMPLIANCE REPORT.
- Diversion may be restricted during shortage or low flow conditions.
- Site-Specific or reach conditions may be included.

Arkansas WATERplan
Essential For Life

Non-Riparian Permitting
Administrative Procedures






Searcy County
Mountain View
Stone County
167
Independence County
Batesville
65
Black River
White River
Van Buren County
Clinton
Heber Springs
Bald Knob
Augusta
Atkins
Morrilton
Faulkner County
Woodruff Co
Conway
Vilonia
Beebe
Cypress Bayou
Bayou Des Arc
Cache River
Fourche Lafave River
Perry County
Arkansas
0
10
20mi

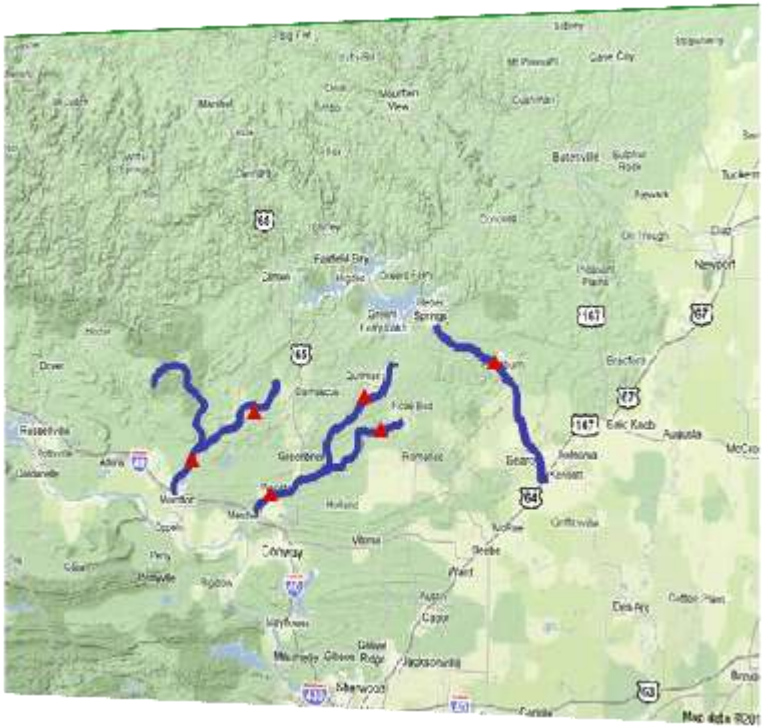
Non-Riparian Permitting
Administrative Procedures

Non-Riparian Permitting 1989-2008			Non-Riparian Permitting 2008 to Present		
Category	Applications	Permits Issued	Fayetteville Shale	Water Use	
Municipal	8	8	Applications	1518	
Agricultural	5	5	Determinations	1202	
Industrial	3	3	Denials/Expired	71	
Total	16	16	Diffuse	434	
			Total Active	745	

Non-Riparian Permitting
Administrative Procedures

Stream Gaging

- Additional USGS stream gages have been installed in the Fayetteville Shale Area.



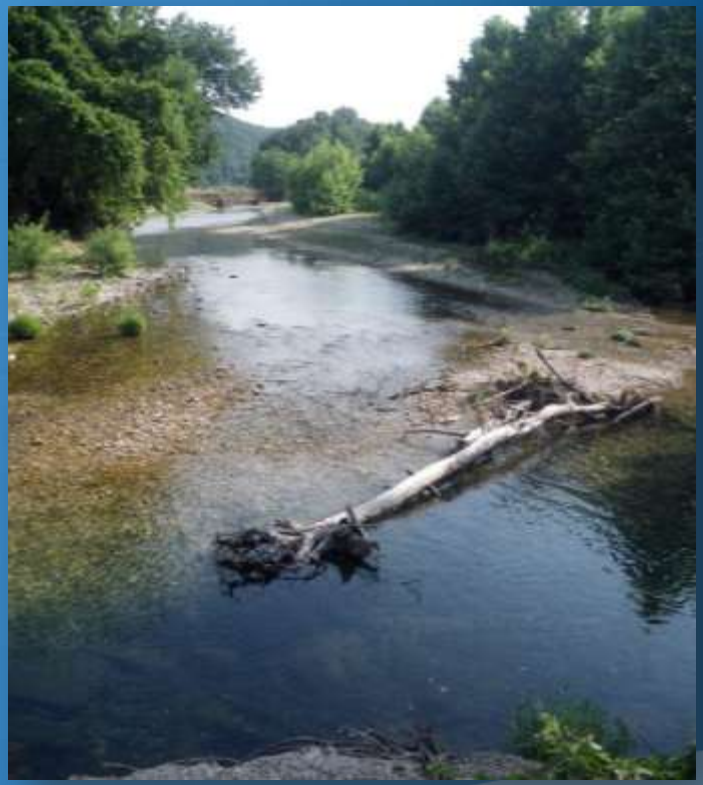
Ozark Highland Fish Community Response to Hydrological Disturbance and Stream Discharge

Jared R. Schluterman and John R. Jackson
Arkansas Tech University

Dan D. Magoulick and Dustin Lynch
Arkansas Cooperative Fish and Wildlife Research Unit

Background

- AGFC Wildlife Grant
- Acquire biological information for the new state water plan
- June 2012 study began



Rationale

- Urbanization of rural areas and land use changes have increased.
- How have these changes affected the community composition of fishes?

Objective

- Identify relationships among different fish community metrics, hydrological disturbance and stream discharge in the Ozark Highland Ecoregion of Arkansas, Missouri, and Oklahoma.

Hydrological Disturbance Index (HDI)

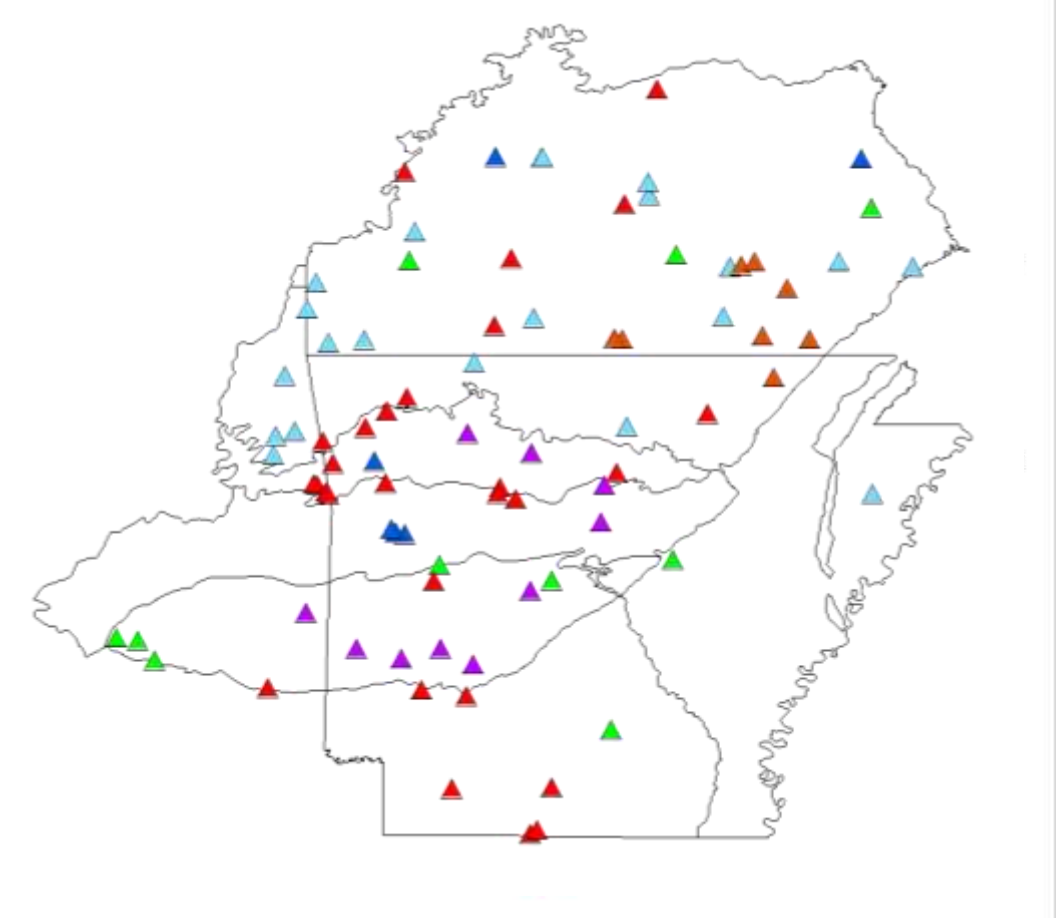
- Falcone (2010)
- 6785 gauged streams
- Combination of hydrological and terrestrial variables
- Allows for cross stream comparisons
- HDI: 1 to 41

HDI

- Major dam density
- Water withdrawals
- Change in dam storage (1950 – 2009)
- Percent canals in watershed
- Distance to nearest NPDES
- Road density

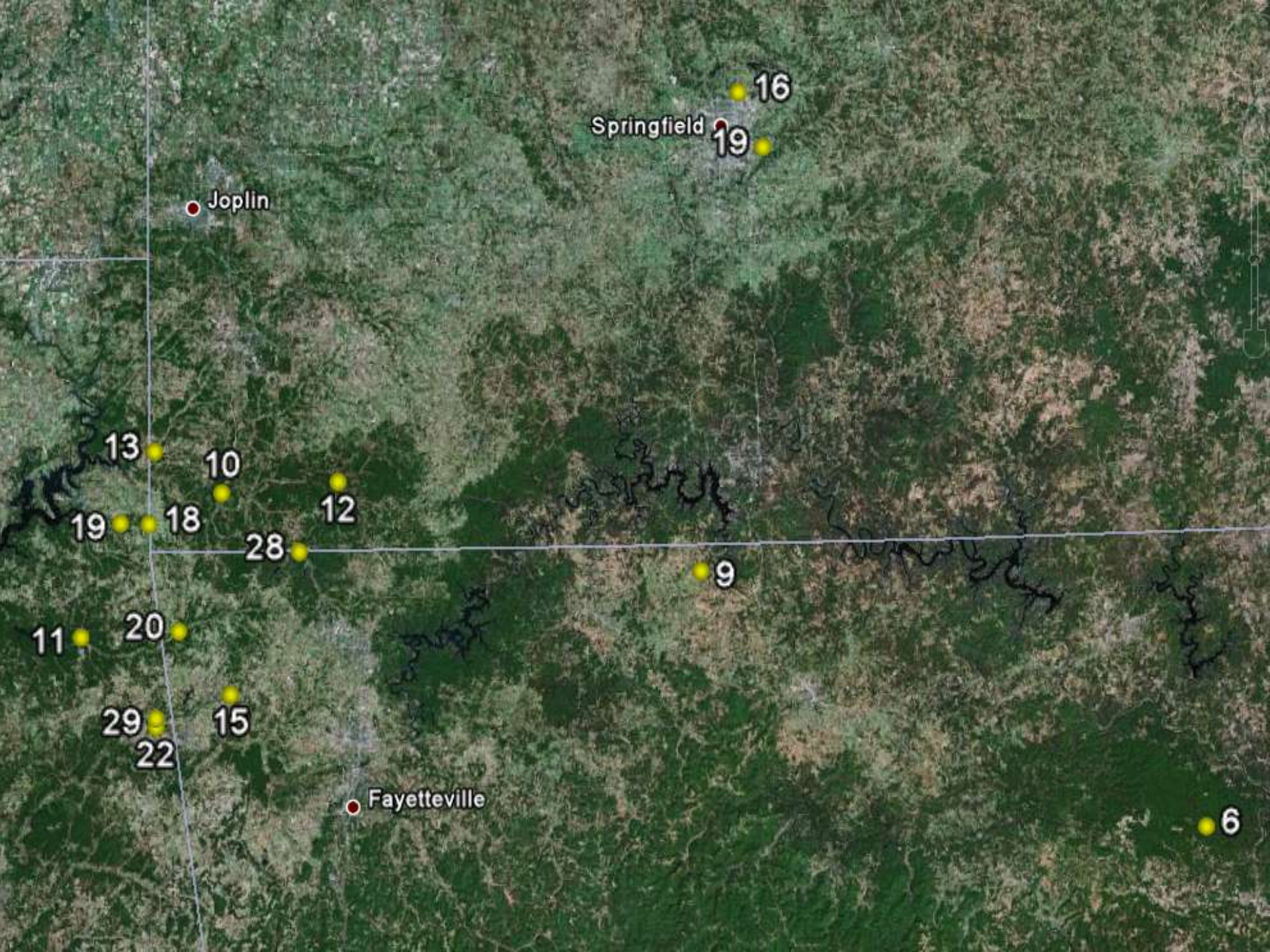
Stream Selection

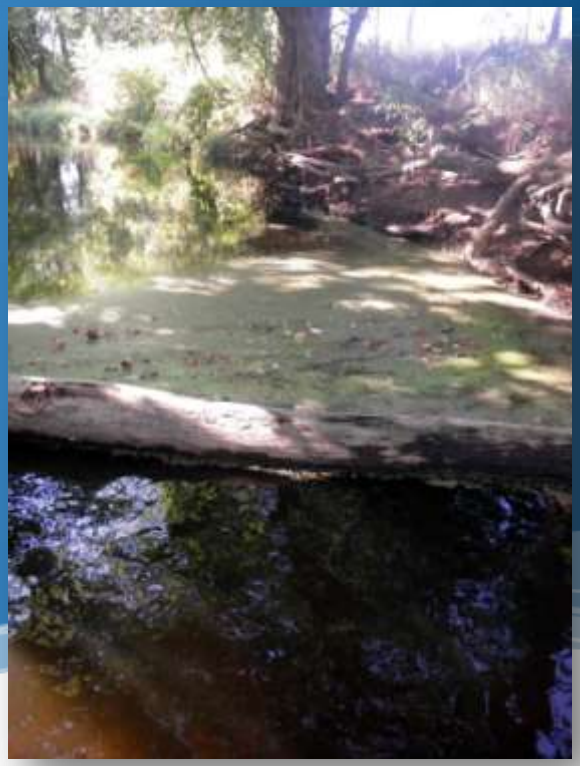
- Gauged streams
- Six flow regimes were assigned
- Watershed size was analyzed
- Fifteen suitable streams were selected



Stream Characteristics

- Moderately stable groundwater
- Watershed: $20km^2$ – $617km^2$
- Average HDI: 16 (6-29)
- Forested to agriculture to urbanized


16
Springfield
19
Joplin
13
10
12
19
18
28
9
11
20
29
15
22
Fayetteville
6



Methods

- Stream Sampling
  - Divided site into nine units
    - 3 Pools
    - 3 Runs
    - 3 Riffles

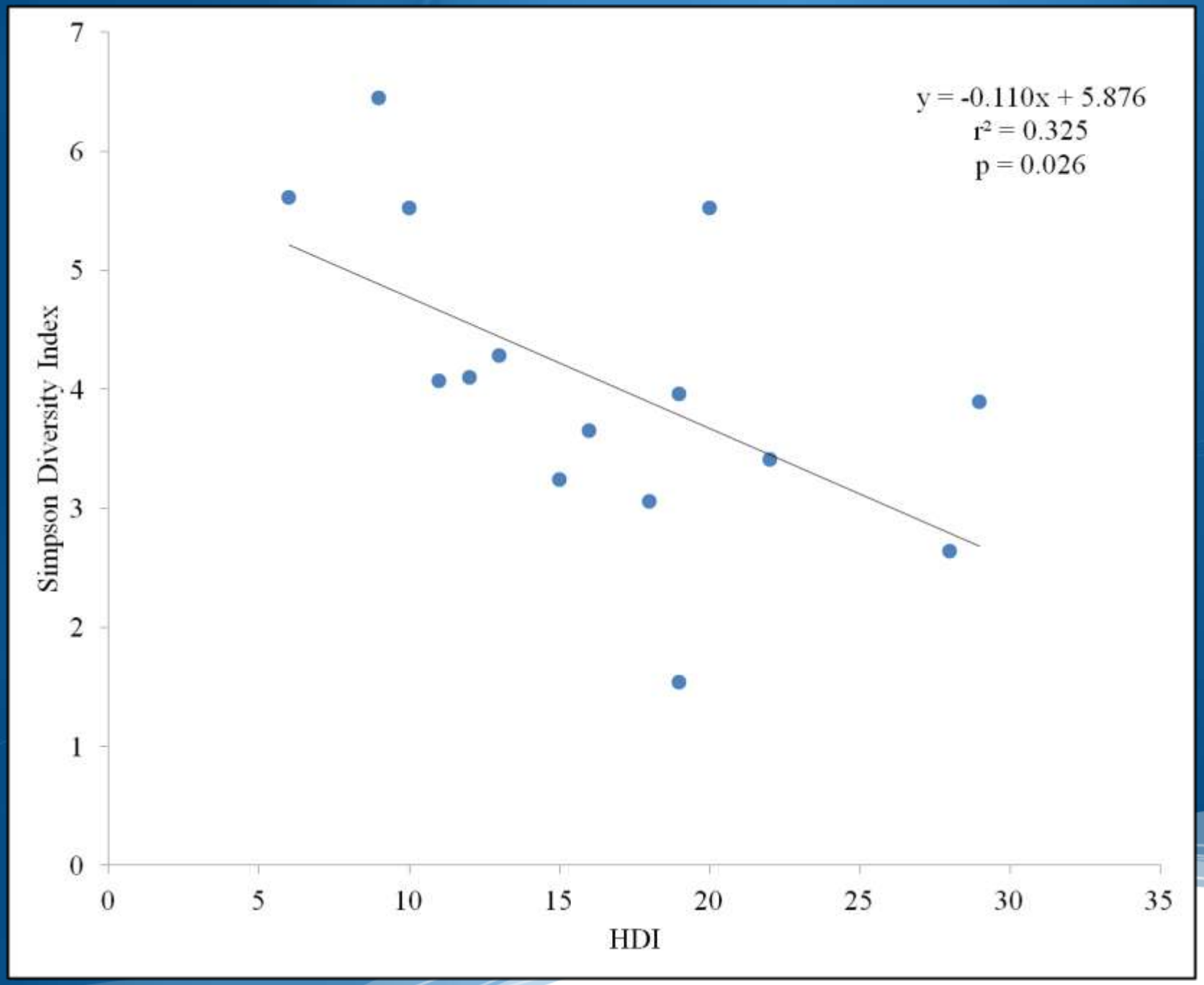
- Fish caught were:
  - Identified to species
  - Classified into:
    - Community metrics
    - Reproductive guilds
    - Trophic guilds

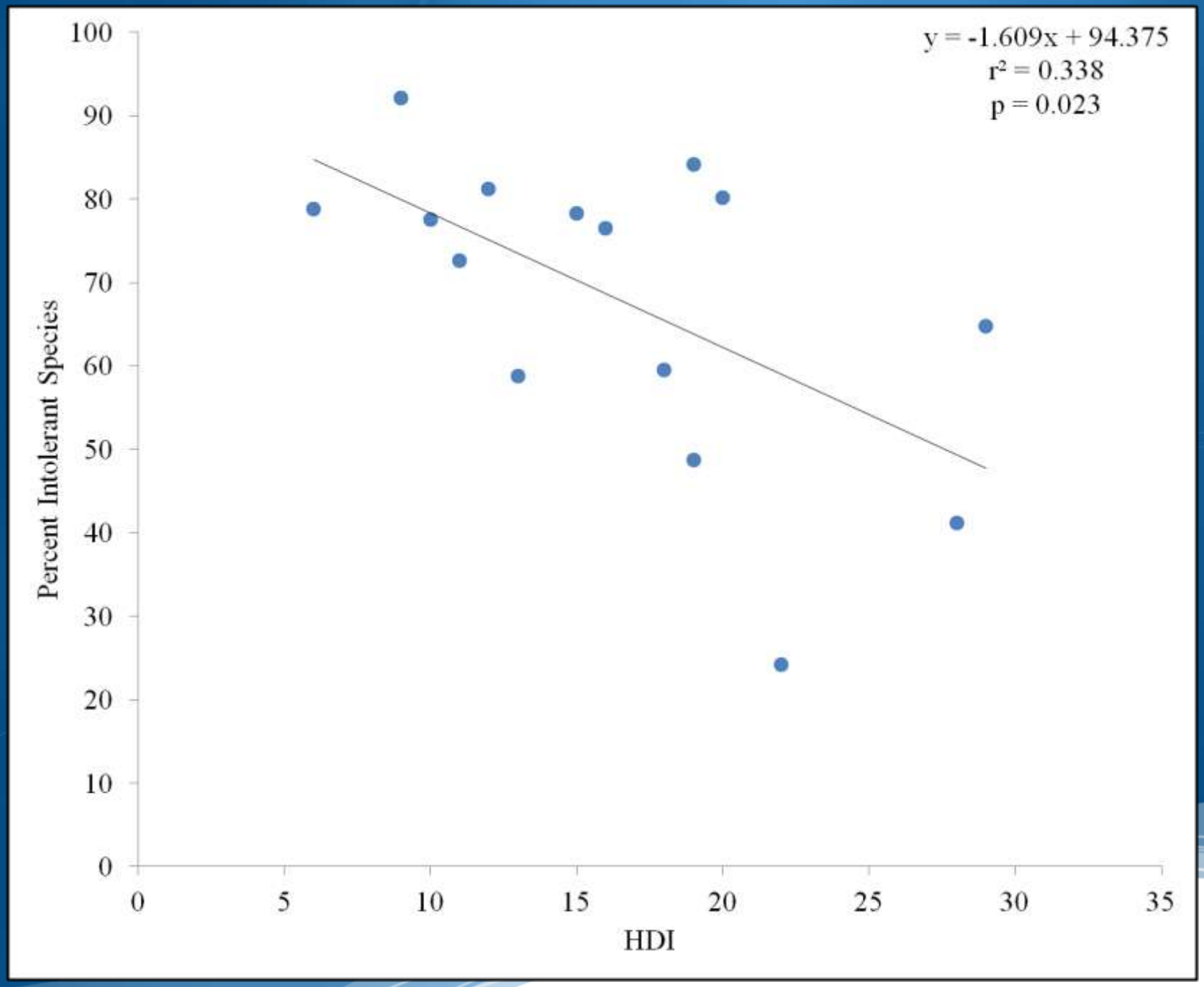
Methods (Preliminary Analyses)

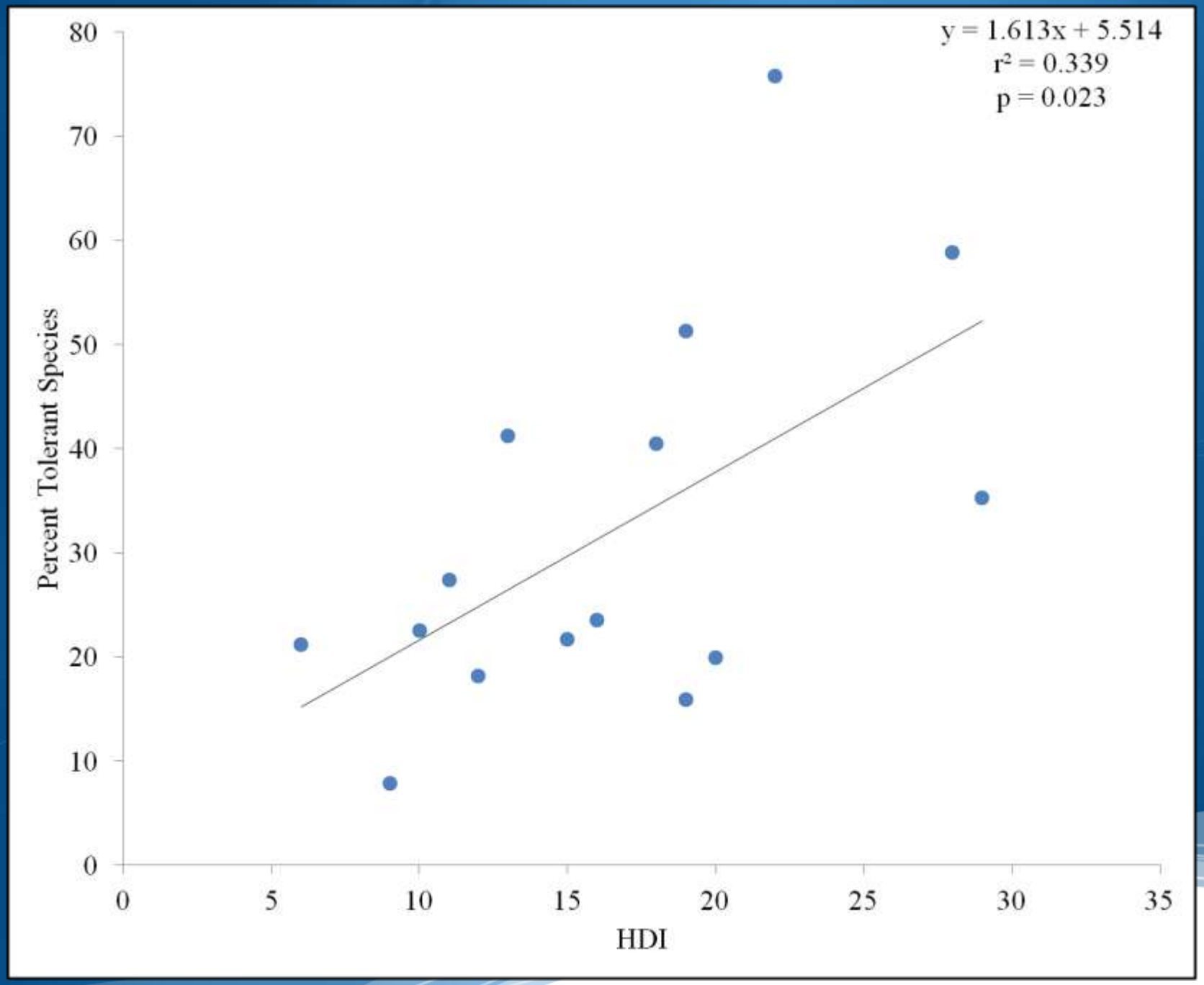
- Linear regression
- Independent variables: HDI, mean high discharge and variation, and low discharge and variation
- Twenty-two response variables
  - Community metrics
  - Reproductive guilds (Balon, 1975)
  - Trophic guilds (Dauwalter, 2002)

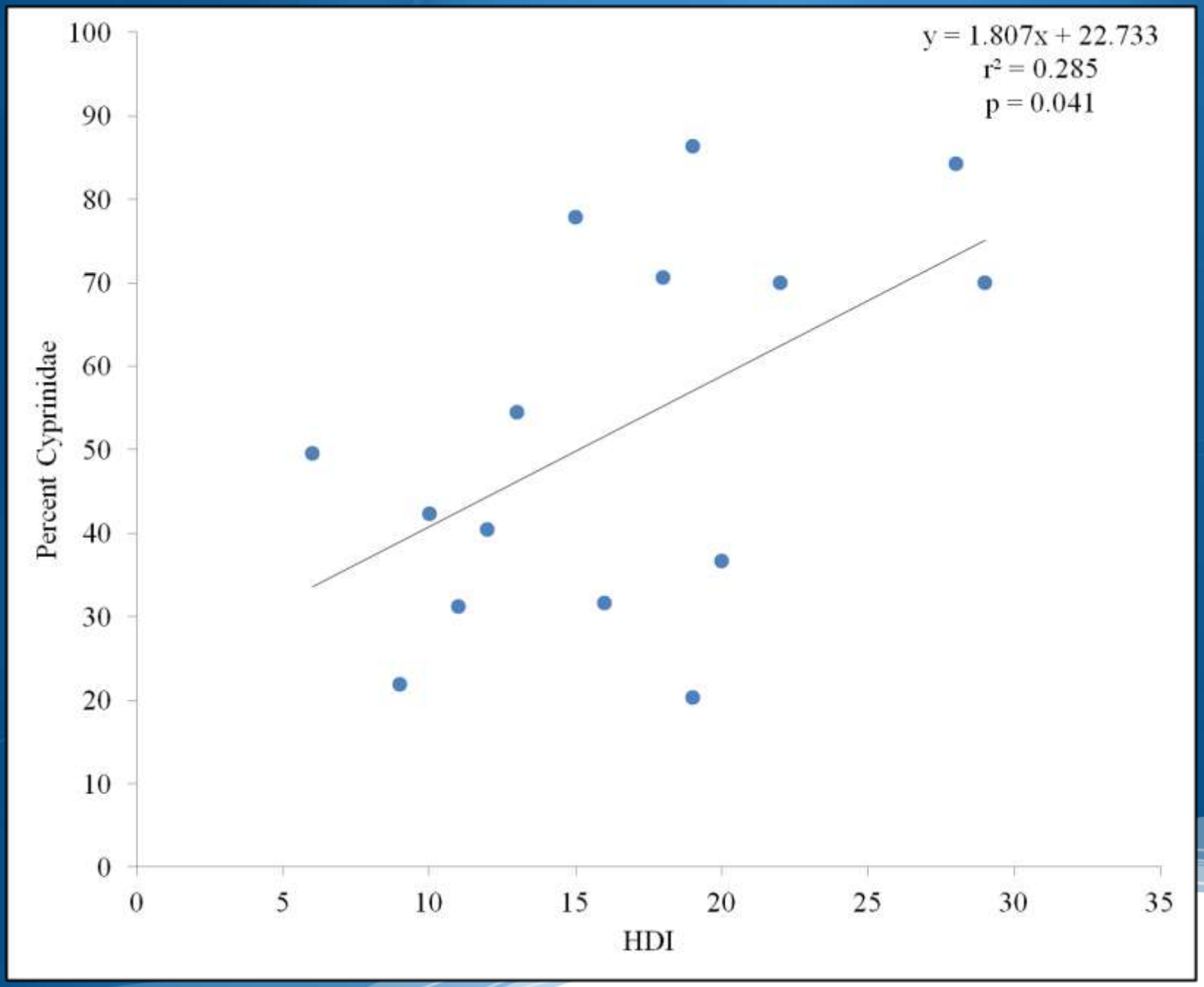
HDI

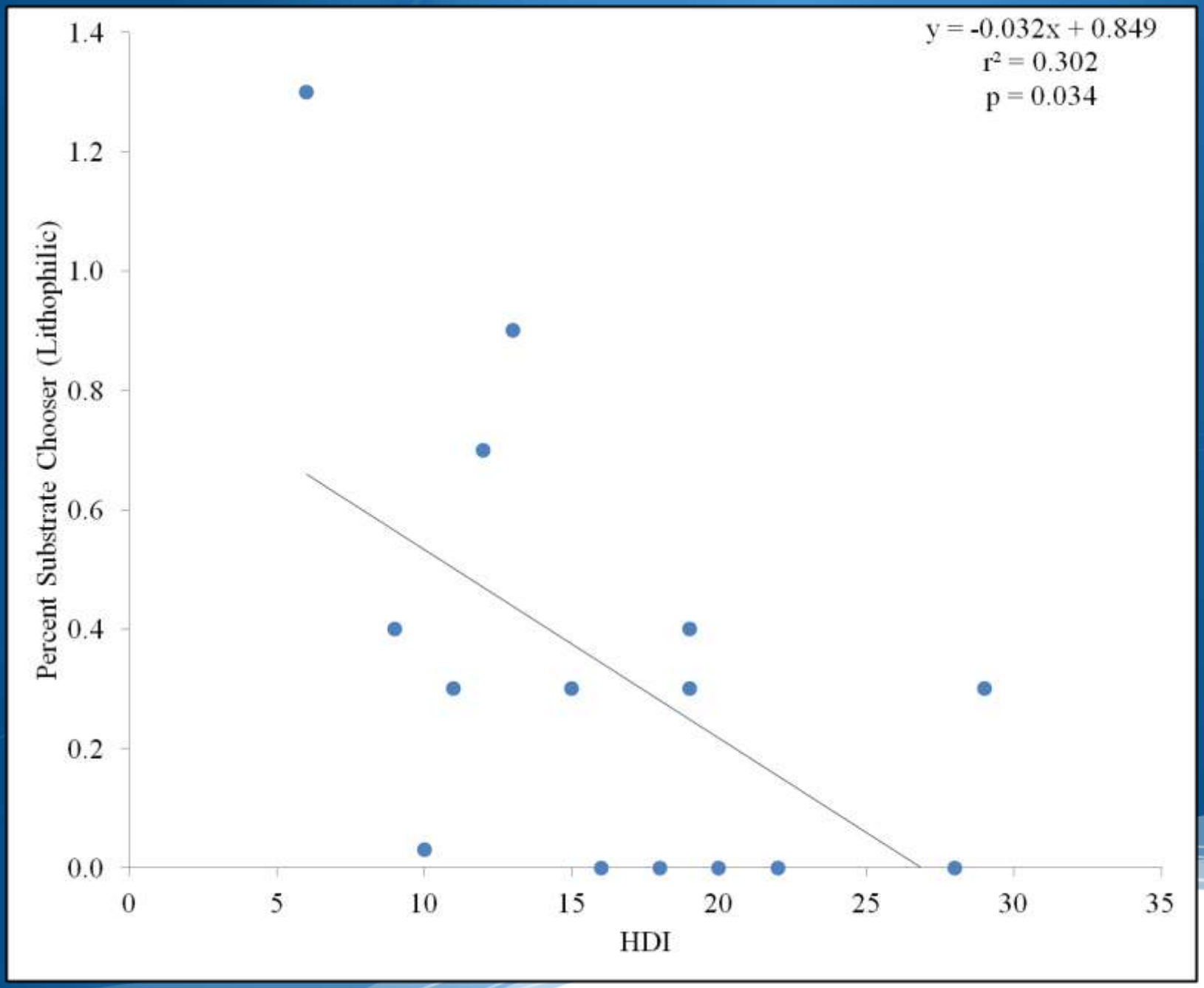
- Showed the most influence of all independent variables
- Out of the 22 response variables, 5 showed significance


y = -0.110x + 5.876
r² = 0.325
p = 0.026
Simpson Diversity Index
HDI
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35


y = -1.609x + 94.375
r² = 0.338
p = 0.023
Percent Intolerant Species
HDI
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30
35

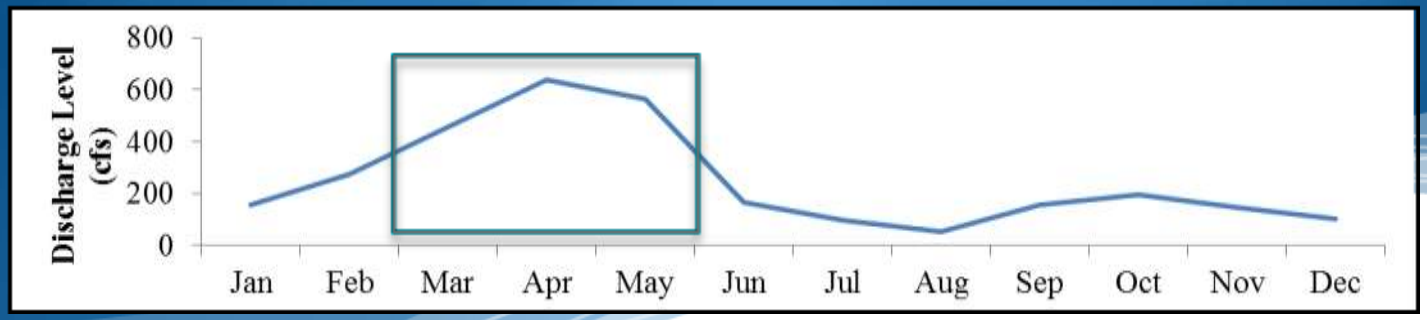

y = 1.613x + 5.514
r² = 0.339
p = 0.023
Percent Tolerant Species
HDI
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
35

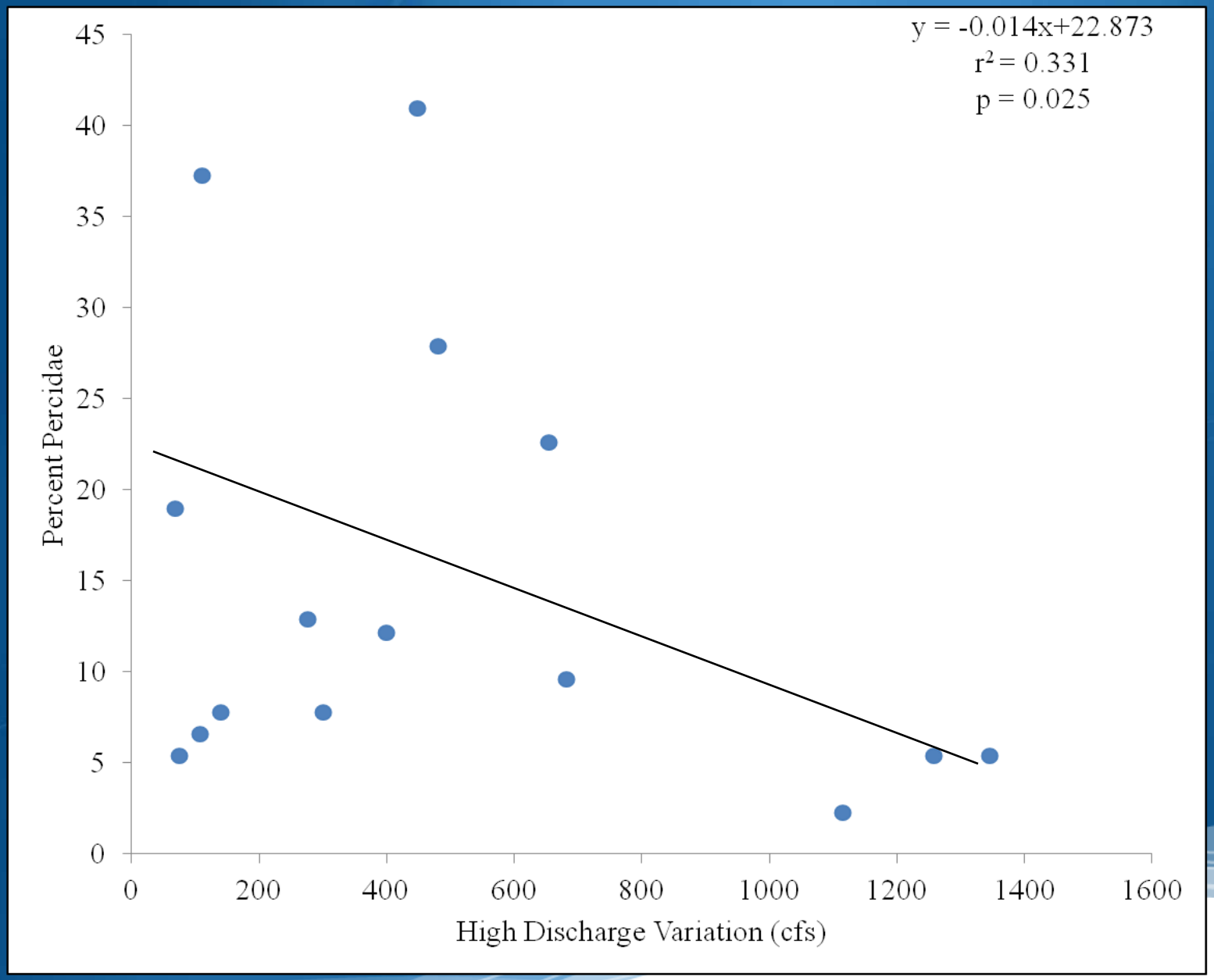

y = 1.807x + 22.733
r² = 0.285
p = 0.041
Percent Cyprinidae
HDI
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30
35


y = -0.032x + 0.849
r² = 0.302
p = 0.034
Percent Substrate Chooser (Lithophilic)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
35
HDI

High Discharge Variation

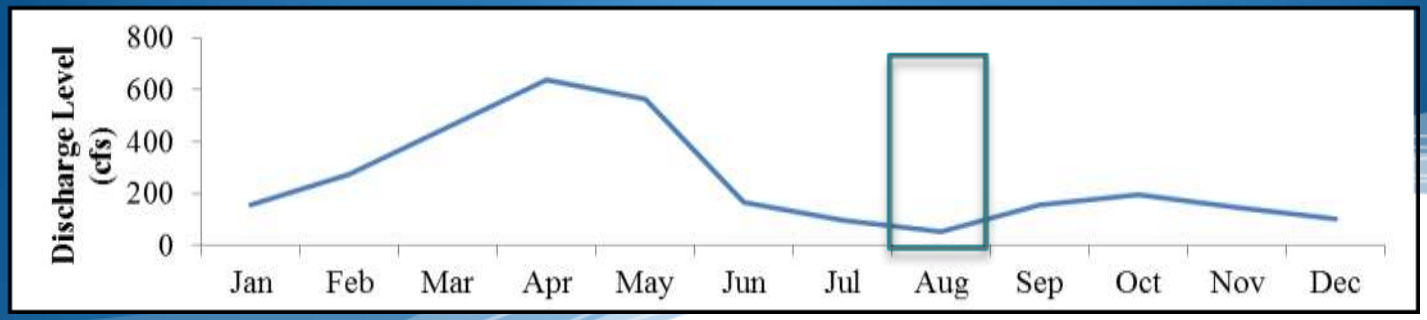
- Months of March-May (5 year average)
- Showed a marked increase in all streams
- Standard deviation was used for the variation

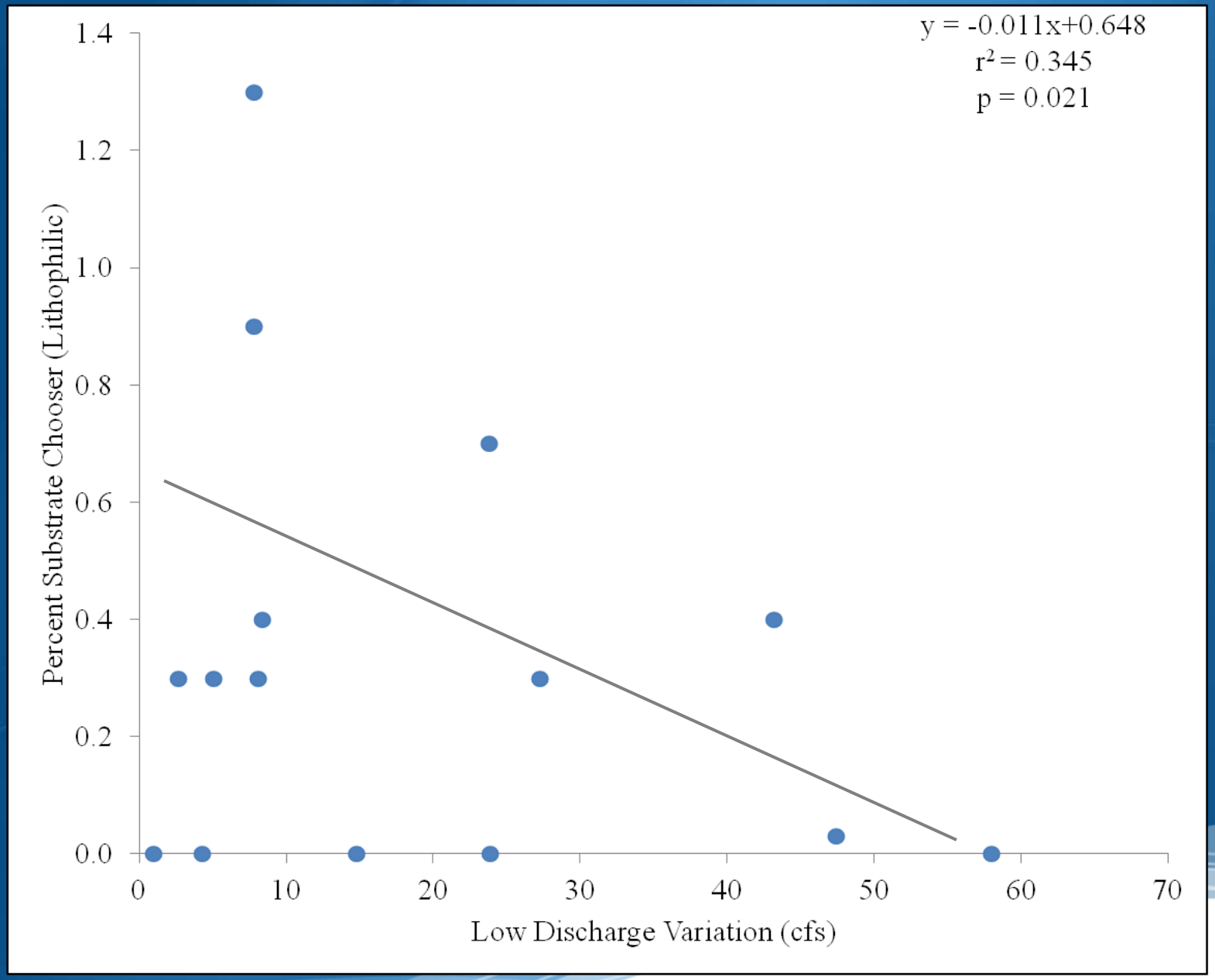



y = -0.014x+22.873
r² = 0.331
p = 0.025
Percent Percidae
High Discharge Variation (cfs)
0
5
10
15
20
25
30
35
40
45
0
200
400
600
800
1000
1200
1400
1600

Low Discharge Variation

- Month of August (4 year average)
- Showed a marked decrease in all streams
- Standard deviation was used for the variation




y = -0.011x+0.648
r² = 0.345
p = 0.021
Percent Substrate Chooser (Lithophilic)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
Low Discharge Variation (cfs)

Discussion: HDI

- High HDI values lead to a fish community that is tolerant
- Would expect to see a decline in the more sensitive fish species and substrate chooser (lithophilic) species

Discussion: High Discharge

- Overall, Percidae, was the only variable significantly influenced by high variability in the high discharge time of year

Discussion: Low Discharge

- Overall, the substrate chooser (lithophilic) reproductive guild was the only variable significantly influenced by low discharge high variability

Conclusion

- HDI
- By understanding the ecological changes brought about by disturbance, we can have a better understand on how to proceed with water and land usage in the future

Future Work

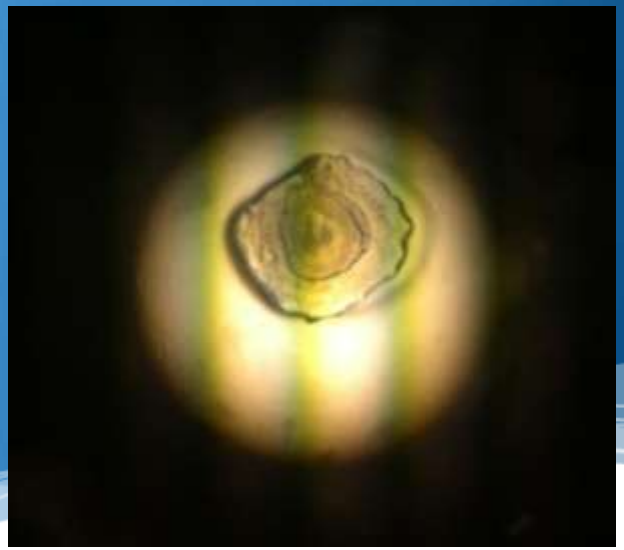
- More sampling during the summer 2013
- Continuous monitoring of streams with various HDI values

Future Work

- Incorporation of other stream characteristics into the HDI and biotic interaction model
  - Geomorph
  - Macro- & Microinvertebrate
  - Water quality

Future Work

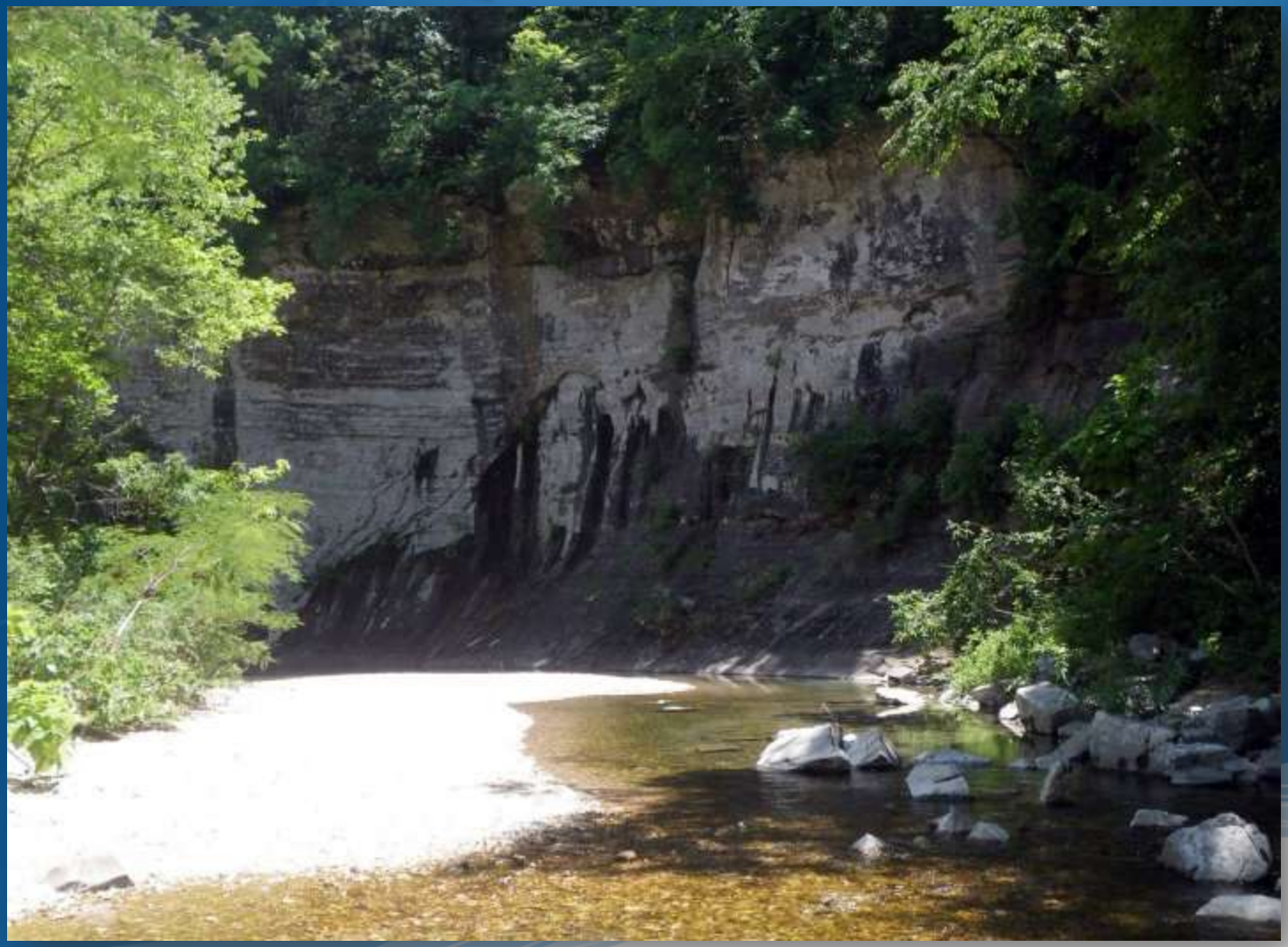
- Look at how flow levels influence spawning times
  - Orangethroat Darter
  - Central Stoneroller
  - Cardinal Shiner



Acknowledgements

- Arkansas Tech University
- Arkansas Game and Fish Commission
- USGS Cooperative Unit, Fayetteville
- Dr. Scott Longing
- Tyler Williams
- Keith Waters
- U of A student workers

Questions



The Arkansas Method of Instream Flow Reservation: Is There a Method to this Madness?

Presented at AR Water Plan Meeting
Fish and Wildlife Working Group
AGFC Central AR Nature Center
Little Rock, AR
27 March 2013

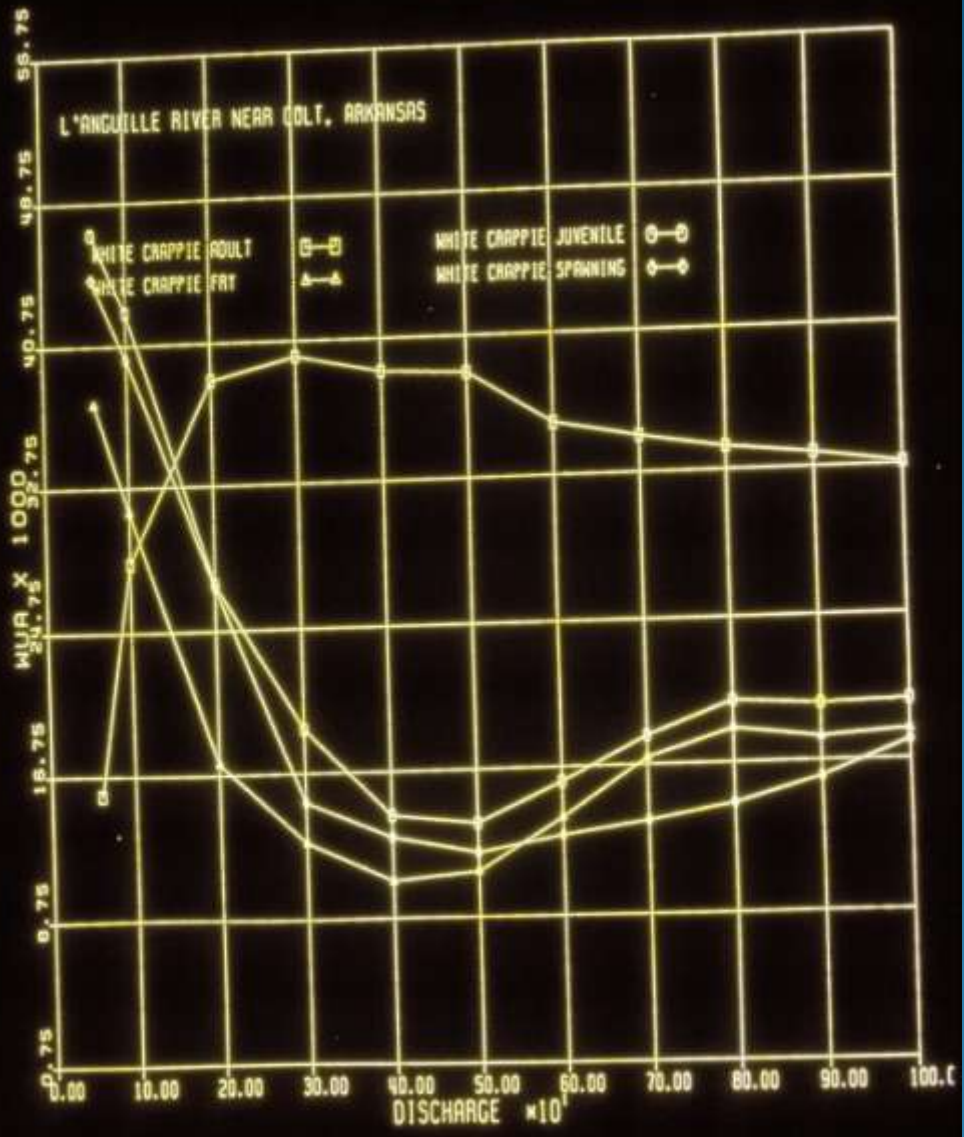
Steve Filipek
Arkansas Game & Fish Commission

Arkansas has World Record Fisheries – 40 lb. 4 oz. Brown Trout

In 2011, fishing in Arkansas worth over $700,000,000. Hunting worth over $1 billion to the economy of Arkansas

Background Information

- In preparation for the work on the 1990 Arkansas water plan, AGFC personnel began taking IFIM/PHABSIM courses thru the USFWS office in Ft. Collins, CO
- Instream Flow Incremental Methodology/Physical Habitat Simulation studies are very time/labor consumptive not to mention very costly &, at the time, mainly modeled on salmonid ecosystems
- AGFC was contacted and 56 instream flow values for various streams/rivers were requested w/in one year
- After approx 40 instream flow methods were reviewed, AGFC & ADEQ staff decided to hybridize a single transect method and a modified Tennant Method to be more applicable to Arkansas' climate/hydrology
- The resultant "Arkansas Method" was based on some field work, some desk top work and 80 years of field work/fish experience


L'ANGUILLE RIVER NEAR COLT, ARKANSAS
WHITE CRAPPIE ADULT
WHITE CRAPPIE FRY
WHITE CRAPPIE JUVENILE
WHITE CRAPPIE SPAWNING
WUA X 1000
DISCHARGE ×10
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
0.75
16.75
24.75
32.75
40.75
48.75
56.75

Office "DeskTop" Work

- Stage-discharge relationships, obtained from the USGS office in Little Rock, were tabulated for various river sites
- Exceedence values at different percentages were obtained from USGS
- Temperature data was obtained for the Ouachita River near Felsenthal and plotted by week of the water year
- The water year was categorized into 3 seasons and flow percentages based on the function of the stream during that season, field transect surveys, and the literature for flushing flow rates

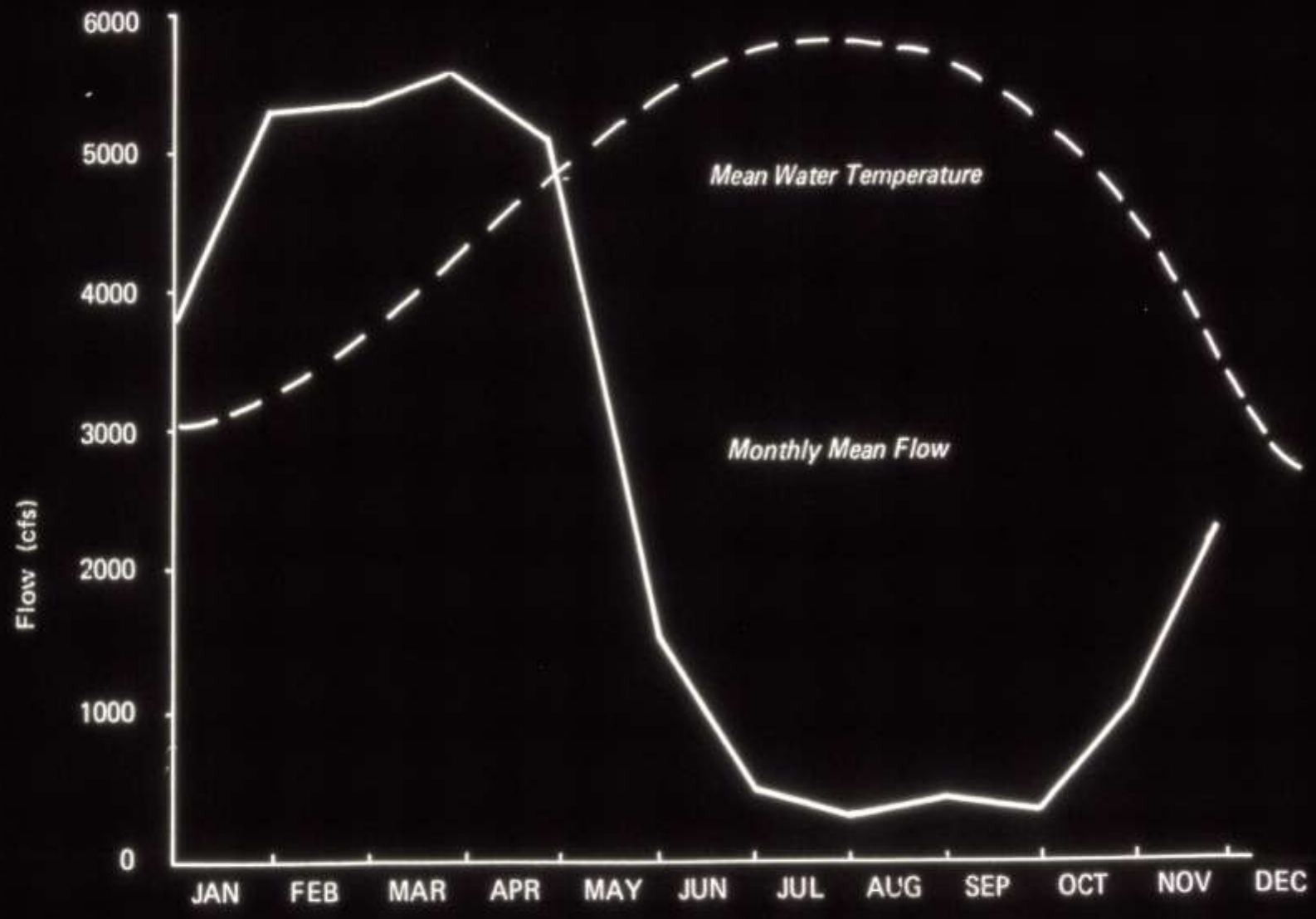


Fig. 2 Monthly mean flows and mean relative water temperatures for the Saline River near Rye, Ark.

Field Work

- AGFC/ADEQ staff conducted single transect surveys at several streams in Arkansas to identify depth, wetted perimeter, and discharge relationships near USGS gaging stations
- In addition, if recent USGS transect data existed for a stream near the gaging station, (if a stage-discharge relationship was current for the location) that data was utilized as well
- These streams included the Saline River, the L'Anguille River, and Bayou Bartholomew
- In order to visualize what different flows would look like, AGFC obtained a key to the flow gage boxes in the state so that they could photograph different flow levels at different elevations (stages) to show the relationships between flow, elevation (stage) and wetted perimeter for numerous streams throughout the state

Transect surveys – wetted perimeter

Fish & Wildlife
Instream Flows

Overbank flooding helpful to ducks, fish and farmers

Physical/Chemical/Biological Seasons of Ark Method - 1

Time of Year	November thru March
Flow Recommendation	60% of the Mean Monthly Flow (MMF)
Physical/Chemical/Biological processes involved	Clean and Recharge
Normal Conditions	High average monthly flows Low water temperatures High dissolved oxygen content
Function and/or Response	Flushing of accumulated sediment & cleaning of septic wastes Spawning areas cleaned & rebuilt by upstream gravel & other substrate Recharge of groundwater (aquifers)
Limiting Factors	Reduced flows during this period cause: Decreased benthic production due to accumulated sediments on substrate. Decrease in success of early fish spawners due to reduced flushing. Decrease in aquifer recharge.

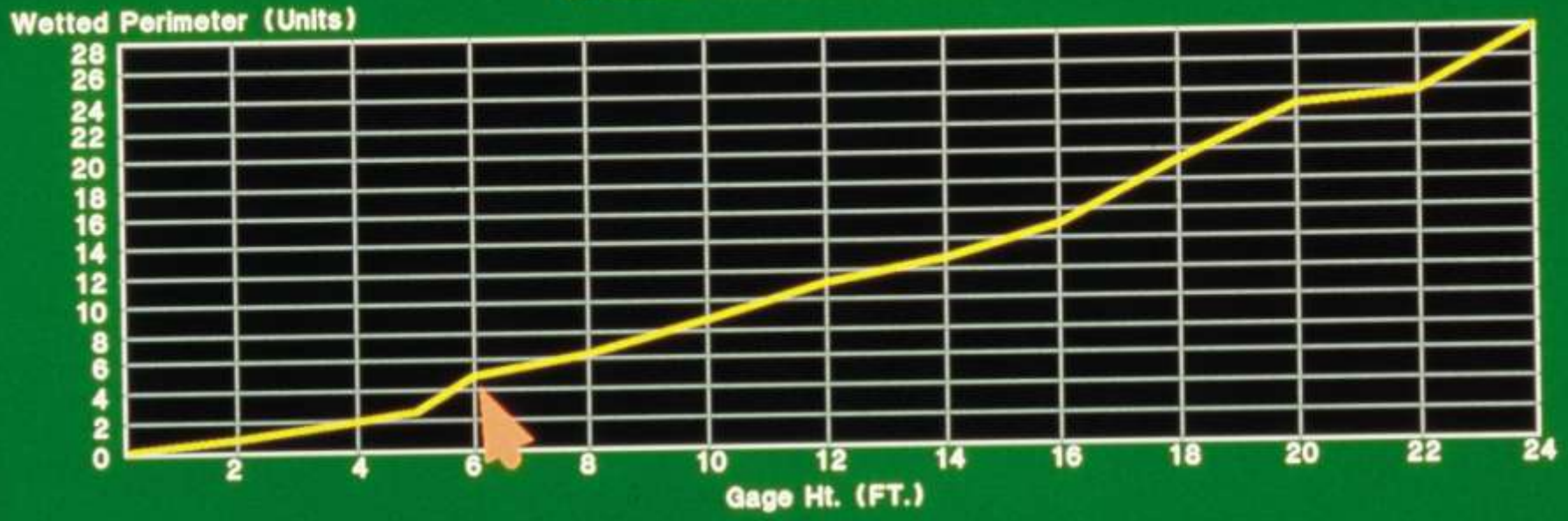
Critical Life Stages

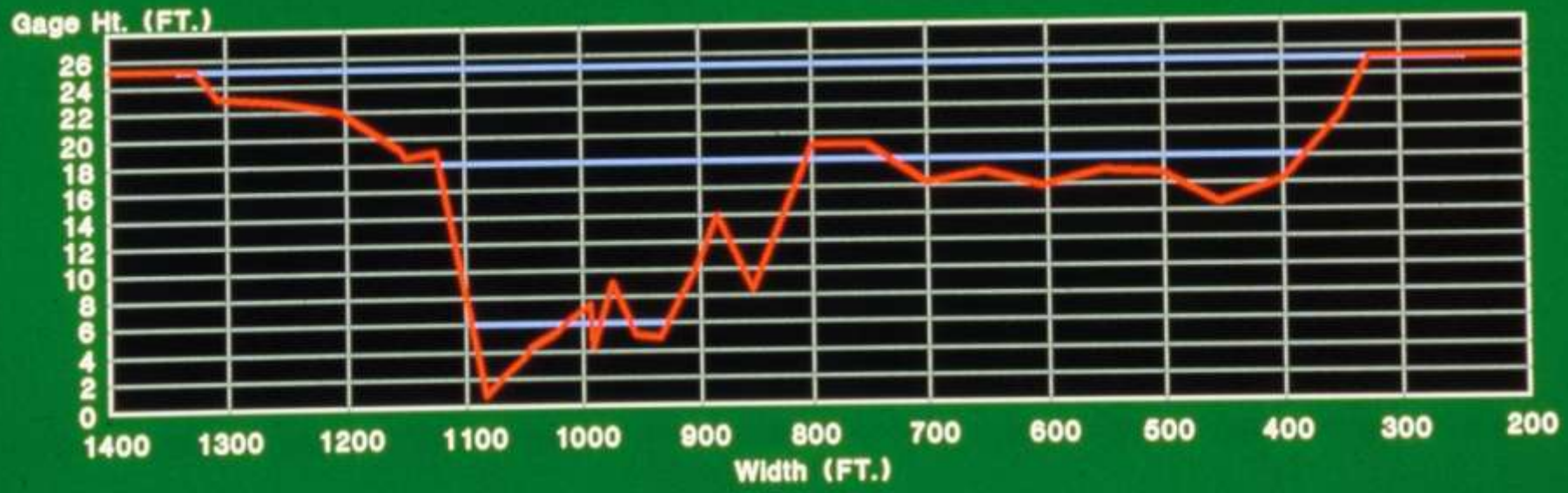
Endangered Species Concerns

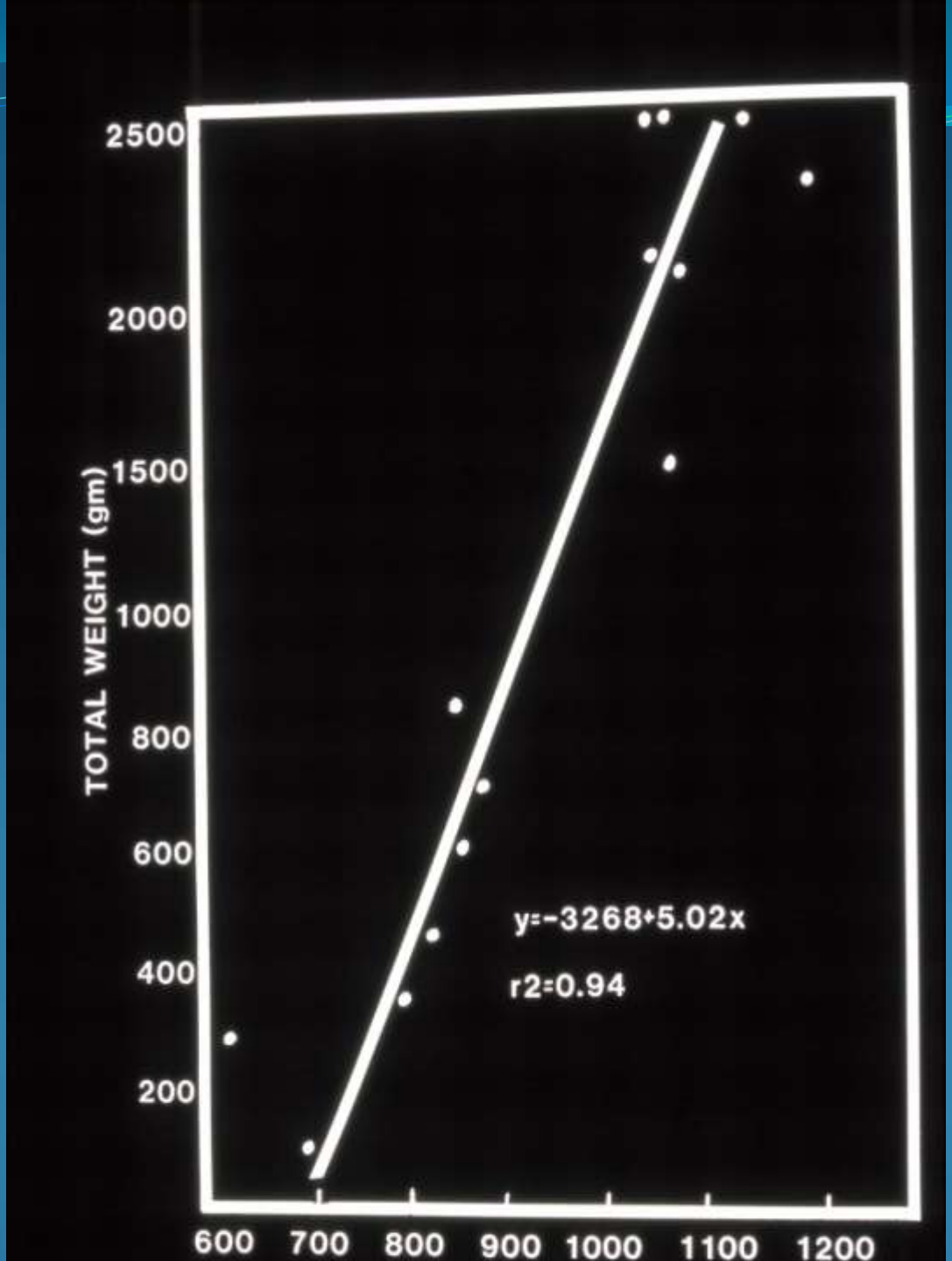
Physical/Chemical/Biological Seasons of Ark Method - 2

Time of Year	April thru June
Flow Recommendation	70% of the Mean Monthly Flow (MMF)
Physical/Chemical/Biological processes involved	Spawning
Normal Conditions	High average monthly flows Increasing (preferred) water temps High DO content especially intragravel
Function and/or Response	Hi flows & increasing water temps & photoperiod cues spawning response in fish: 1) upriver migrations, 2) in channel, 3) in flooded overbank areas. Feeding also activated by higher temps and flows
Limiting Factors	Reduced flows cause decrease in spawning, egg and fry survival & overall reproductive success of important sport and nongame fishes Weak year classes of sport, commercial, nongame and endangered fish species

SALINE RIVER AT RYE






TOTAL WEIGHT (gm)
2500
2000
1500
1000
800
600
400
200
600
700
800
900
1000
1100
1200
y=-3268+5.02x
r2=0.94

Physical/Chemical/Biological Seasons of Ark Method - 3

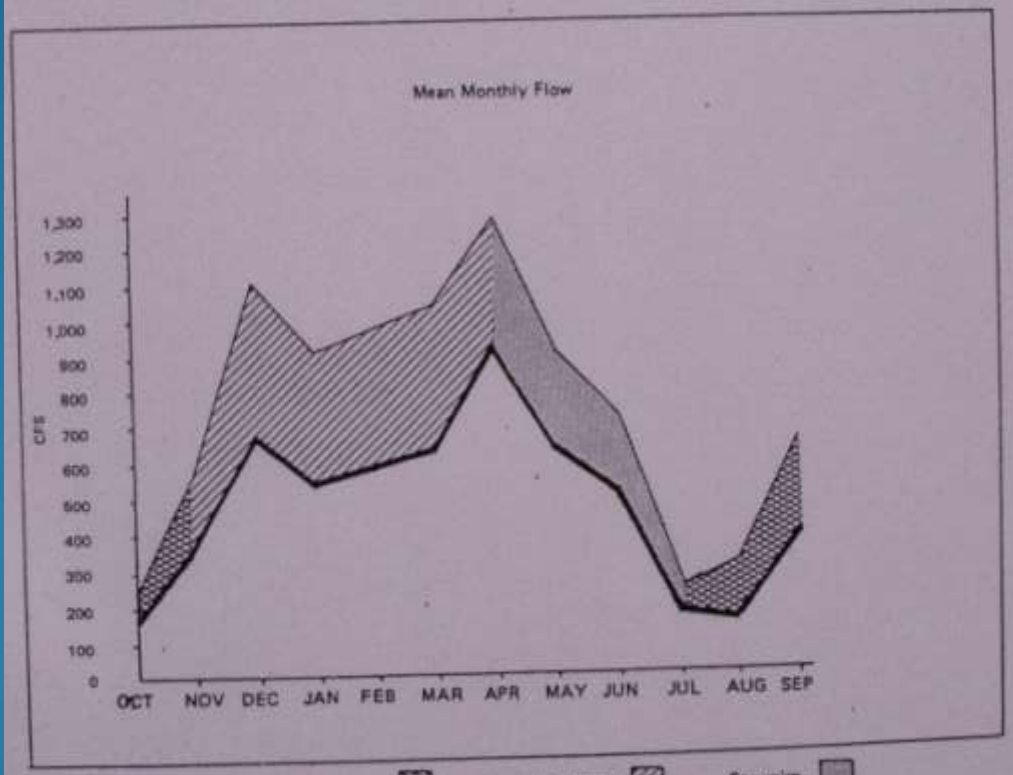
Time of Year	July thru October
Flow Recommendation	50% of the Mean Monthly Flow (MMF)
Physical/Chemical/Biological processes involved	Production
Normal Conditions	Low average monthly flows High water temperatures Low dissolved oxygen content
Function and/or Response	High water temps increase primary, secondary, and tertiary aquatic production Low flows concentrate predators (fish, otters) with prey (forage fish, invertebrates
Limiting Factors	Reduced flows = water temps increase, decreasing survival of certain fish spp. Decrease in wetted substrate = less periphyton & macroinvertebrates. Decreased dissolved oxygen due to higher water temps = fish kills. Pollutants concentrated. Decrease in groundwater.

Inadequate flows = unhealthy streams for fish, farmers & folks

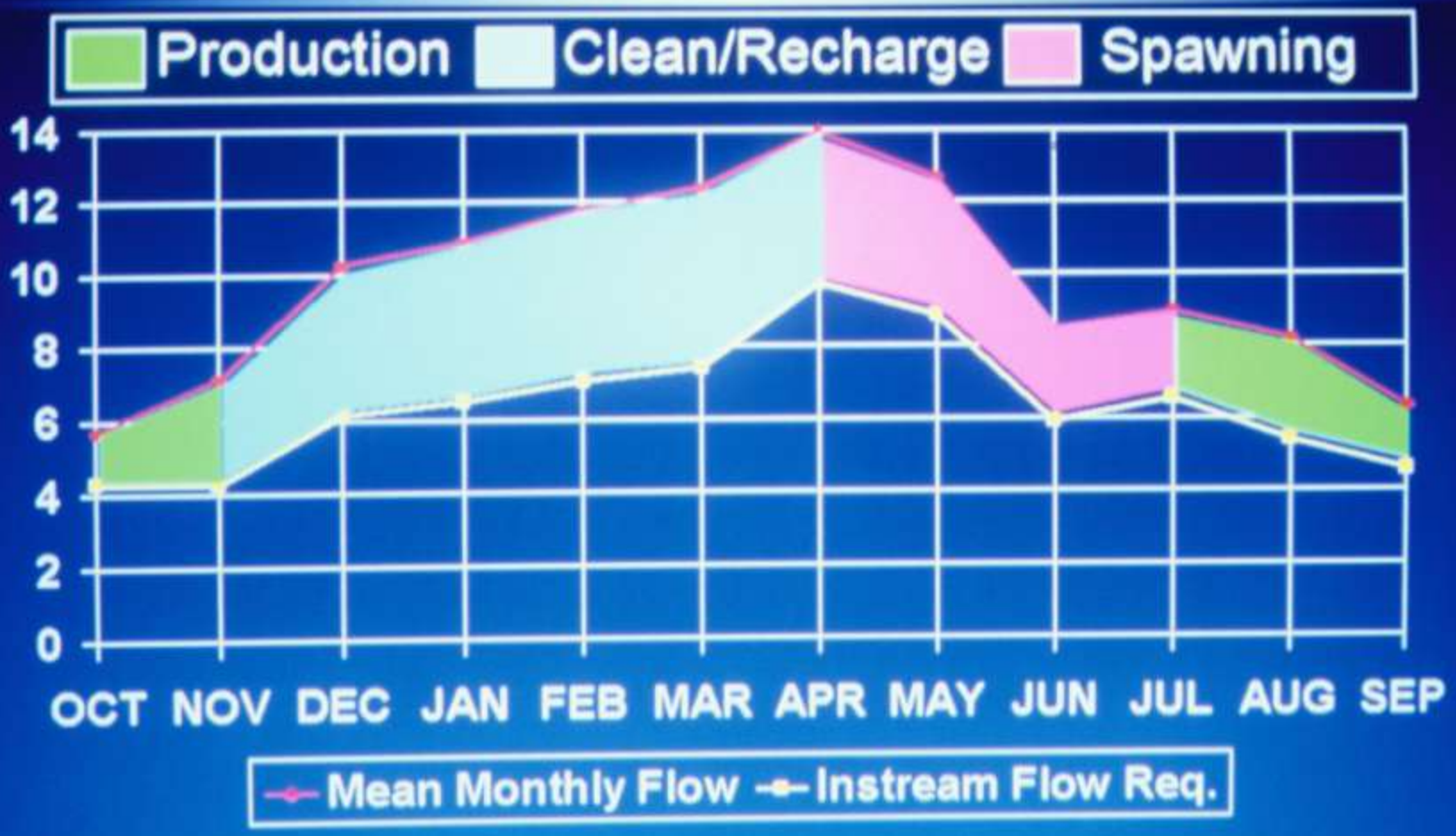
You don’t have to have one of these to negatively impact a fishery

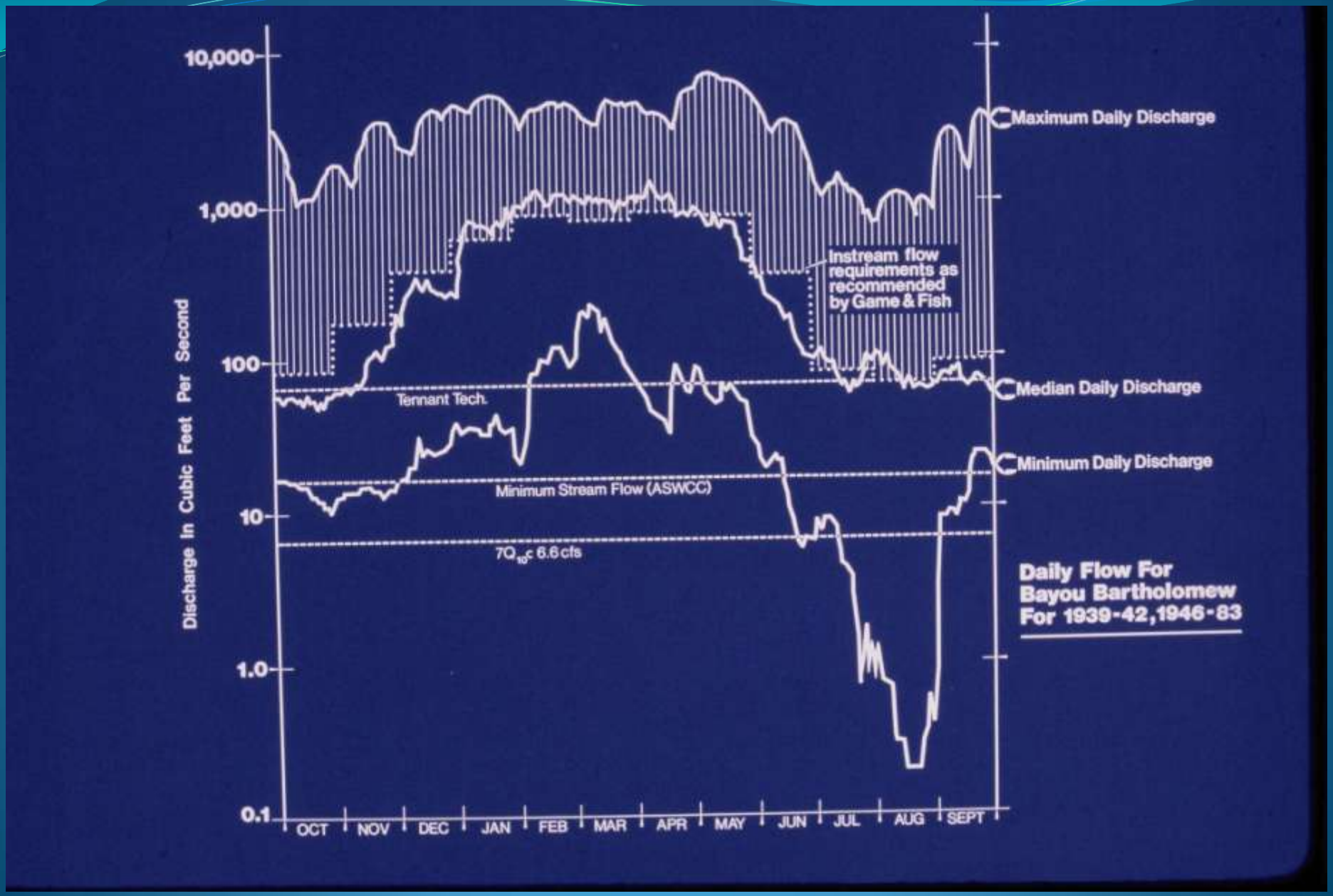
ABLE 18 Minimum Instream Flow Requirements for Fisheries by Month for the L'Anguille River near Colt, Arkansas

ONTH	MONTHLY MEAN FLOW (CFS) 1971-93	INSTREAM FLOW REQUIREMENT ARKANSAS METHOD (CFS)	INSTREAM NEEDS BY STAGE HEIGHT (FT.)
ANUARY	905	543	10.0
EBRUARY	983	590	10.4
ARCH	1,032	619	10.5
PRIL	1,295	907	11.8
AY	914	640	10.7
UNE	714	500	9.7
ULY	230	173	6.0
UGUST	315	158	5.8
EPTEMBER	669	386	8.6
CTOBER	269	174	6.0
OVEMBER	584	350	8.2
ECEMBER	1,100	660	10.8



Minimum Instream Flow Requirements for Fisheries - White River at Calico Rock, AR




10,000
1,000
100
10
1.0
0.1
Discharge In Cubic Feet Per Second
Maximum Daily Discharge
Instream flow requirements as recommended by Game & Fish
Median Daily Discharge
Tennant Tech.
Minimum Daily Discharge
Minimum Stream Flow (ASWCC)
7Q10c 6.6 cfs
Daily Flow For Bayou Bartholomew For 1939-42,1946-83
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT

A healthy fish community corresponds to a healthy human environment

White River Allocation Plan (WRAP)

3 Committees

1) Agriculture

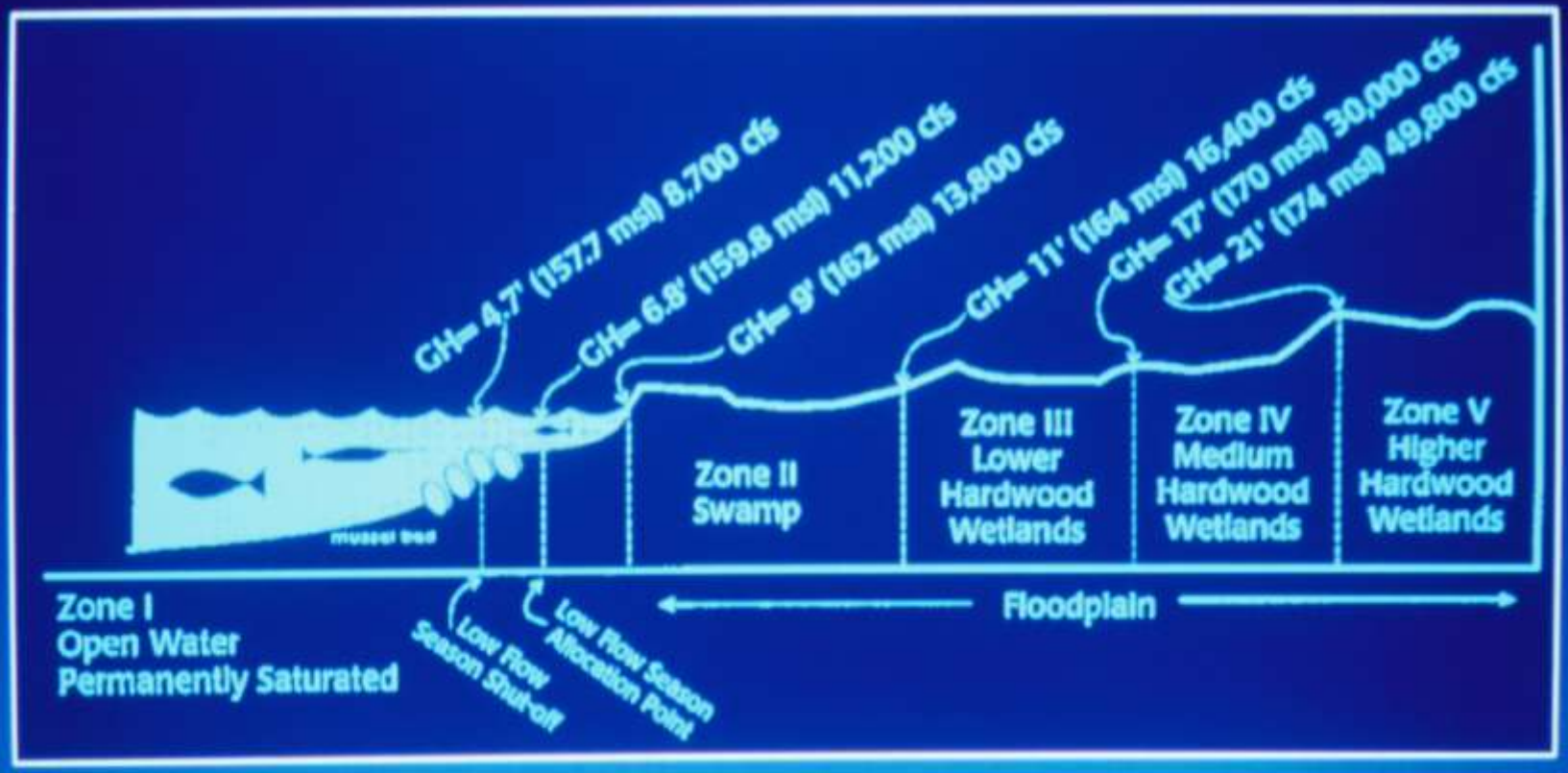
2) Navigation

3) Fish, Wildlife, Recreation & Water Qual

Implanting radiotransmitter in paddlefish, a Species of Greatest Conservation Need

30+ pound gravid female paddlefish from White River

Instream Flow Allocation Plan for White River at DeValls Bluff, AR



Allocation/Minimum Flows for the Middle White River, Newport

Season	*Allocat. Flow (cfs)*	*Allocat. Gage Ht*	*Shut-off Flow (cfs)*	*Shut-off Gage Ht*
Winter	15,000	6.6 ft.	9,000	2.9 ft.
Spring	26,000	12.1 ft.	17,000	7.7 ft.
Paddle-fish	59,000	23.6 ft.	50,000	21.5 ft.
Summer	8,400	2.5 ft.	6,000	0.7 ft.

White River Instream Flow / Water Allocation (DeValls Bluff Gage)

- 21' → ~49,800 cfs. Restrict diversions below this level from:
  - Dec. 15 - Mar. 1 all years
  - Dec. 15 - Apr. 1 2 of 3 years
  - Dec. 15 - May 15 1 of 3 years
- 17' → ~30,000 cfs. No diversions below this level Mar. 1 - May 15 2 of 3 years.
- 11' → ~16,400 cfs. No diversions below this level Mar. 1 - June 30 2 of 3 years.
- 9' → ~13,800 cfs. No diversions below this level Mar. 1 - June 30 all years.
- 6.8' → ~11,200 cfs. Conservation measures implemented, diverters cut back Jul - Nov.
- 4.7' → ~8,700 cfs. Diversions must cease at any time.
- 0' → < 2,000 - 3,000 cfs. River has never been this low during USGS gaging.