Apalachicola-Chattahoochee-Flint River Basin Focus Area WaterSMART

Environmental Flows Component

- Environmental flows defined as “the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihood and well-being that depend on these ecosystems”

Brisbane Declaration

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Ecological responses to changes in flow regimes?

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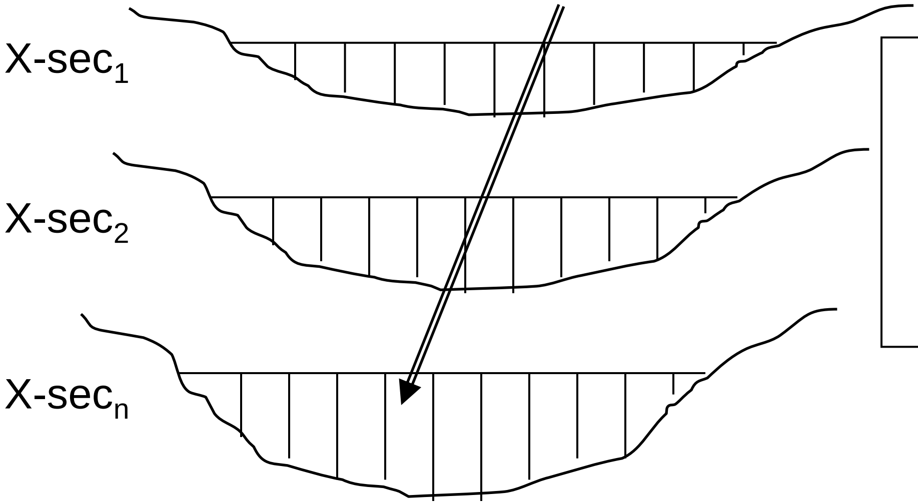
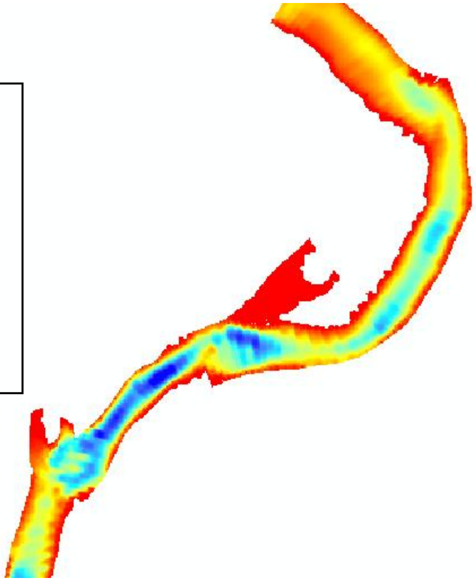


Model depth, velocity in relation to flow

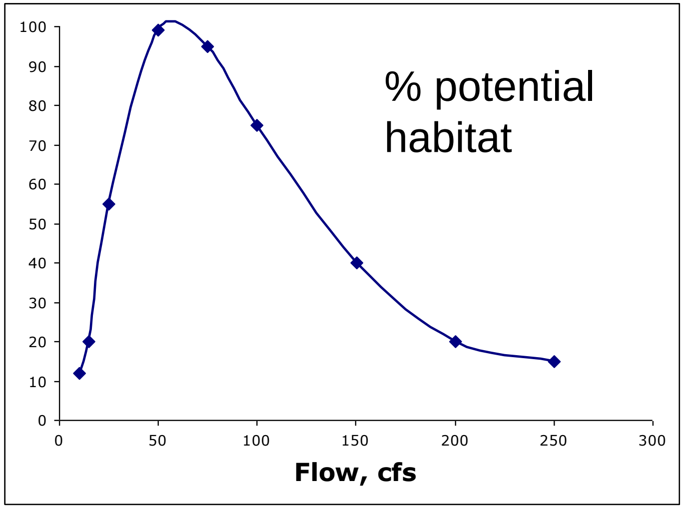


1-Dimensional model

2-Dimensional model

Incremental analyses:

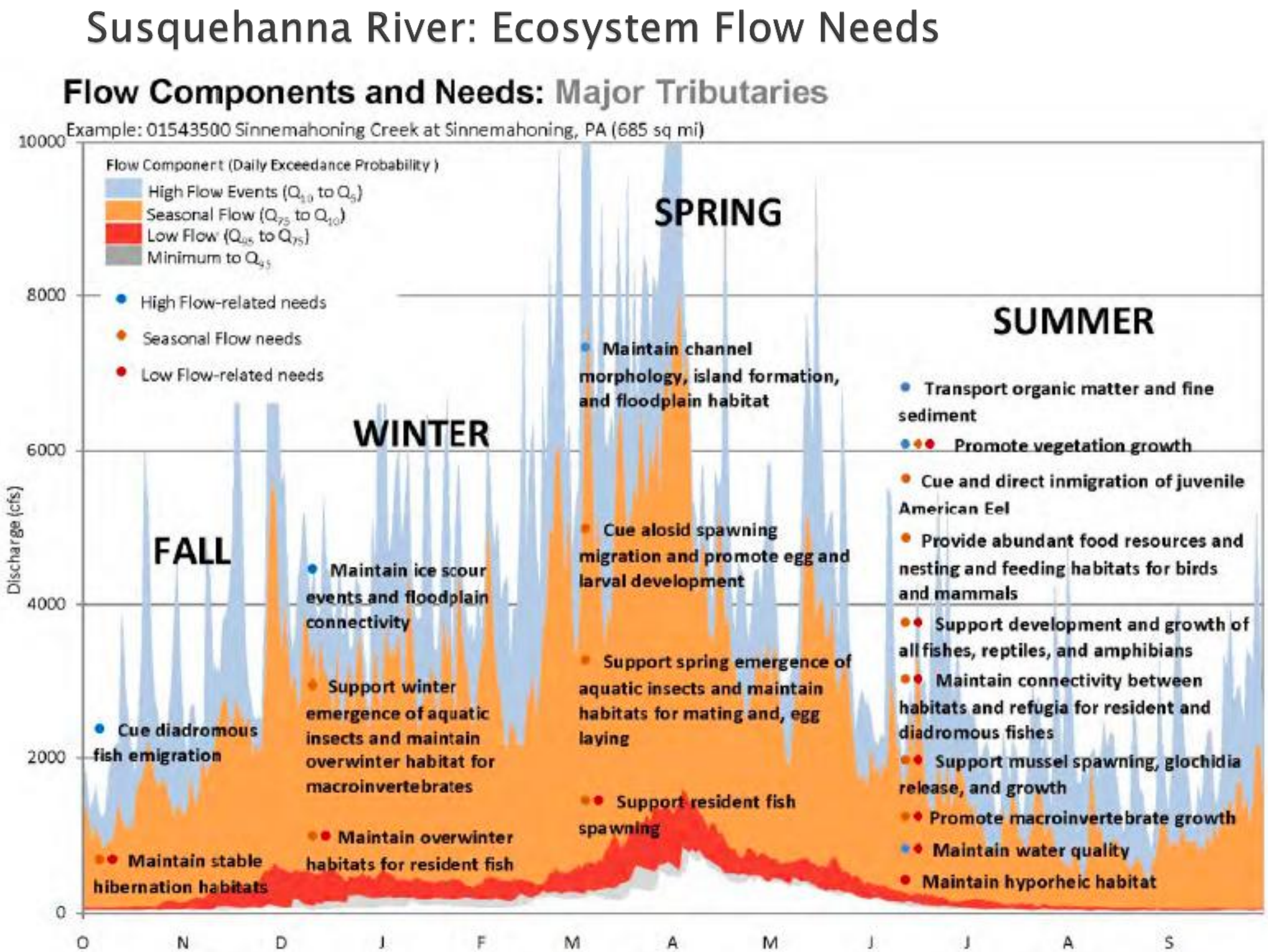
Habitat availability in relation to flow – *Site specific*



Conceptual models: flow-ecology relations

Multiple considerations:

- Fishes
- Insects
- Mussels
- Crayfishes
- Reptiles
- Amphibians
- Vegetation
- Birds
- Mammals
- Channel processes
- Water quality



DePhilip and Moberg. 2010. Ecosystem flow recommendations for the Susquehanna River Basin, *The Nature Conservancy.*

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Conceptual models: flow-ecology relations

Susquehanna River: Ecosystem Flow Needs

Recommendations:

• Aim to maintain natural variability & protect ecological functions

High flows

For all streams and rivers

- Maintain magnitude and frequency of 20-yr (large) flood
- Maintain magnitude and frequency of 5-yr (small) flood
- Maintain magnitude and frequency of 1 to 2-yr high flow (bankfull) event
- Limit the change to the monthly Q10 to less than 10%
- Maintain the long-term frequency of high pulse events during summer and fall

Seasonal flows

For all streams and rivers

- Maintain the long-term monthly median between the 45th and 55th percentiles
- Limit change to "typical monthly range" to less than 20%

Low flows

For all streams and rivers with drainage areas greater than 50 square miles

- Limit change to "monthly low flow range" to less than 10%
- Maintain the long-term monthly Q95

For headwater streams with drainage areas less than 50 square miles

- Maintain the long-term "monthly low flow range"
- Maintain the long-term monthly Q75

DePhilip and Moberg. 2010. Ecosystem flow recommendations for the Susquehanna River Basin, *The Nature Conservancy.*

The ELOHA idea:

- We can use existing data & knowledge to identify predictable ecological responses to flow alteration
  - Provide a scientific basis for developing regional environmental flow standards

Arthington et al., 2006, "The challenge of providing environmental flow rules to sustain river ecosystems", Ecological Applications 16(4), 1311-1318.

Poff et al., 2010, "The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards", Freshwater Biology 55, 147-170.

ELOHA: a framework

- Start with regional hydrologic models
- Identify stream types expected to respond differently to flow alteration
- ***Model ecological responses to flow alteration*** **for each stream type**
- Use ecological models with socially-determined objectives to decide on flow requirements
- Monitor outcomes, improve models, repeat

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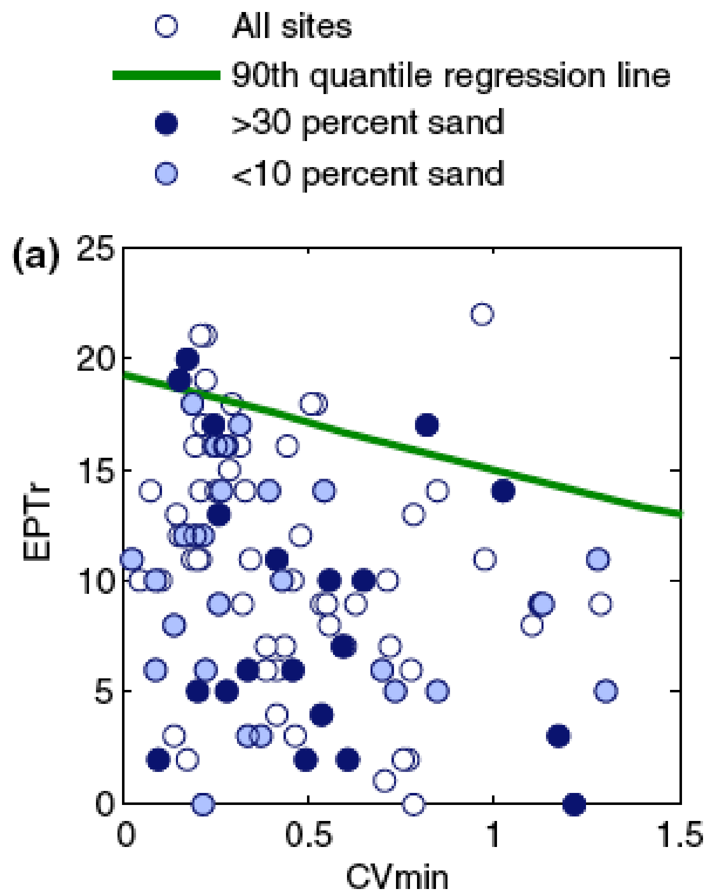
Challenge!

• Flow regime is one of many factors influencing ecological condition at a point in time

Result:
Noisy “flow-ecology” data



Ephemeroptera, Plecoptera, Trichoptera species richnes vs. CV of annual min flows
Sites from 11 Western US states

Konrad et al. 2008. Assessing streamflow characteristics as limiting factors on benthic invertebrate assemblages in streams across the western United States. *Freshwater Biology 53: 1983-1998*

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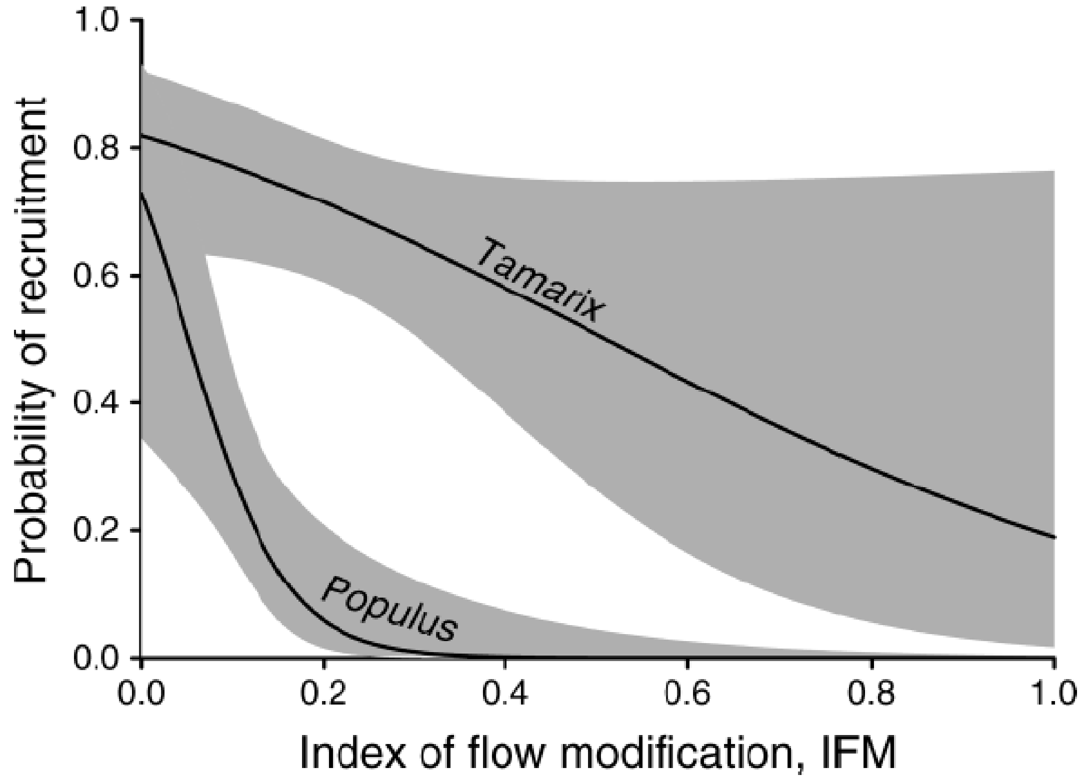
Communities are dynamic

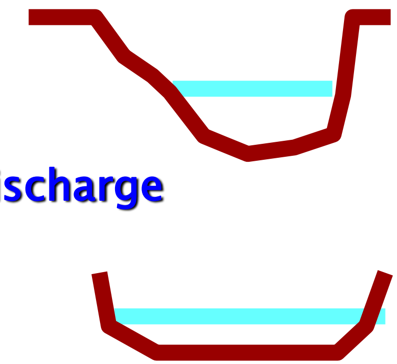
Community conditions vary through time.

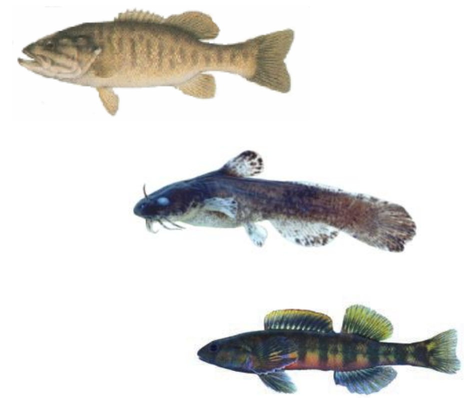
May expect more precise relations between flow and *directly-affected processes*

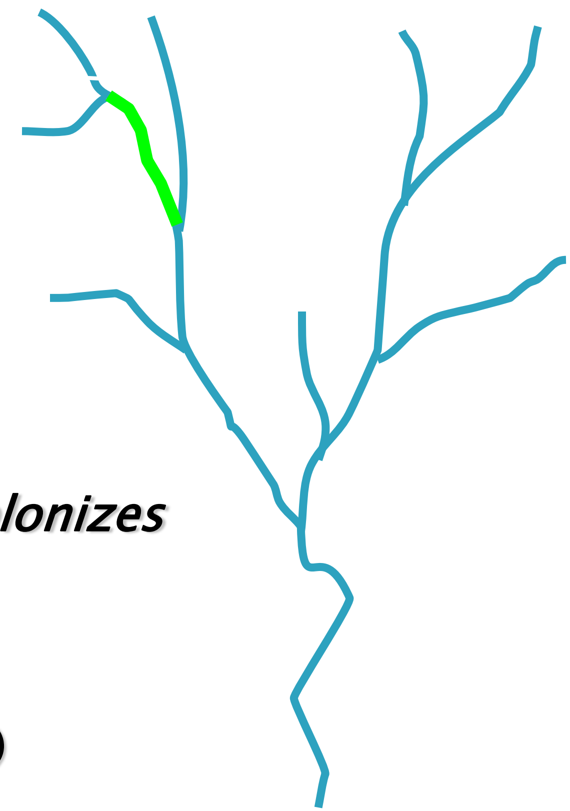


D. M. Merritt and N. L. Poff. 2010. Shifting dominance of riparian *Populus* and *Tamarix* along gradients of flow alteration in western North American rivers. *Ecol. Appl. 20:135-152.*

USGS *Water Availability for Ecosystems*
Metapopulation response to flow variation: occupancy of stream segments







Probability a species ***persists, reproduces, or colonizes***
In a given year depends on:

- Species traits
- Channel type and stream size
- Location in the drainage network (connectivity)
- The seasonal flow regime in that year

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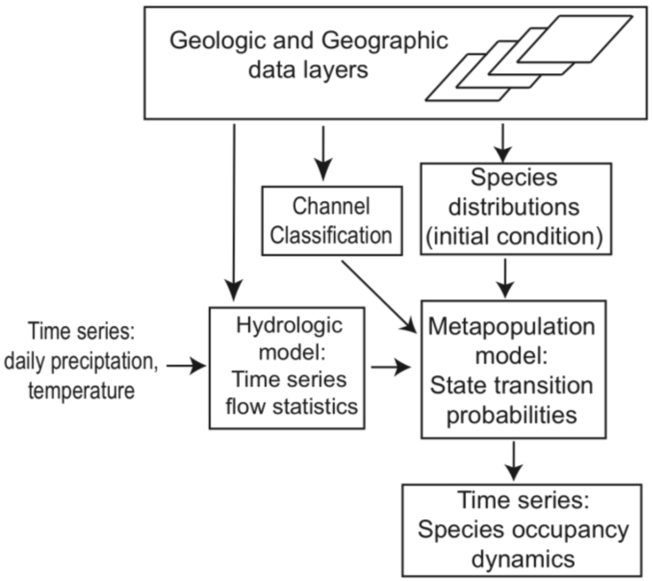
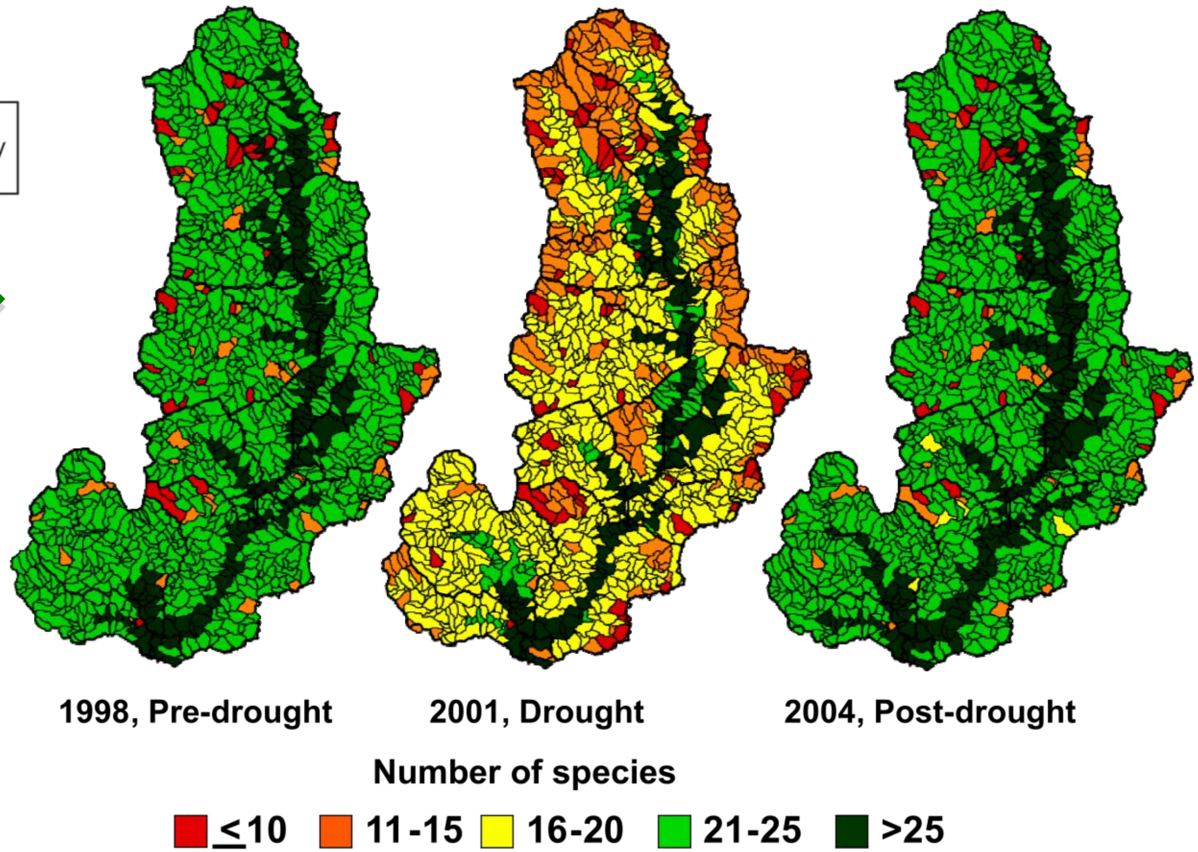
Seasonal time-step, metapopulation simulation of changes in fish species richness in relation to flow

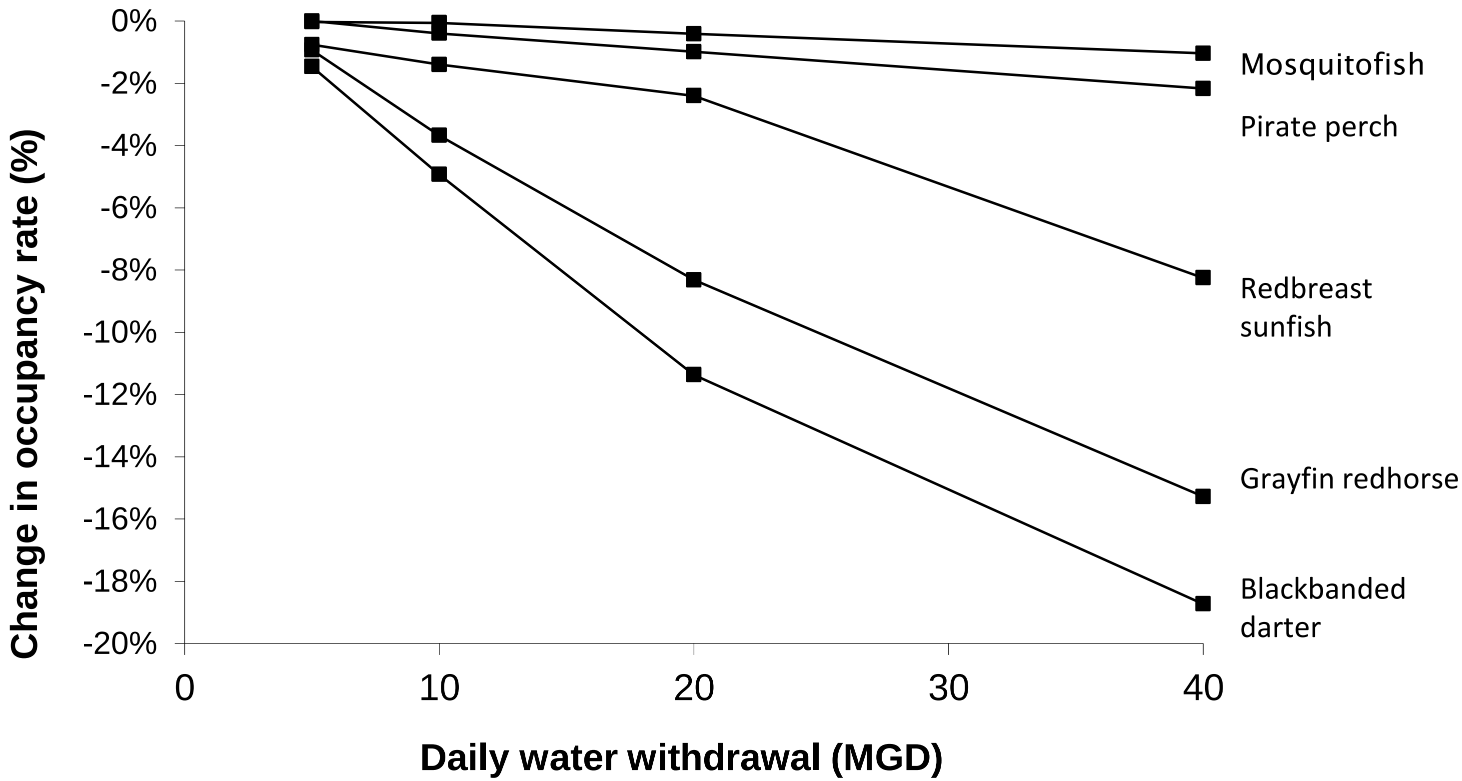


Flow statistics
- Median seasonal Q
- CV seasonal Q
- Seasonal 10-d min Q
- Seasonal 10-max Q
- Min 10-d SD of flow



Simulated stream fish responses to withdrawals in Potato Creek basin

Change in species-specific occupancy with increasing withdrawal levels



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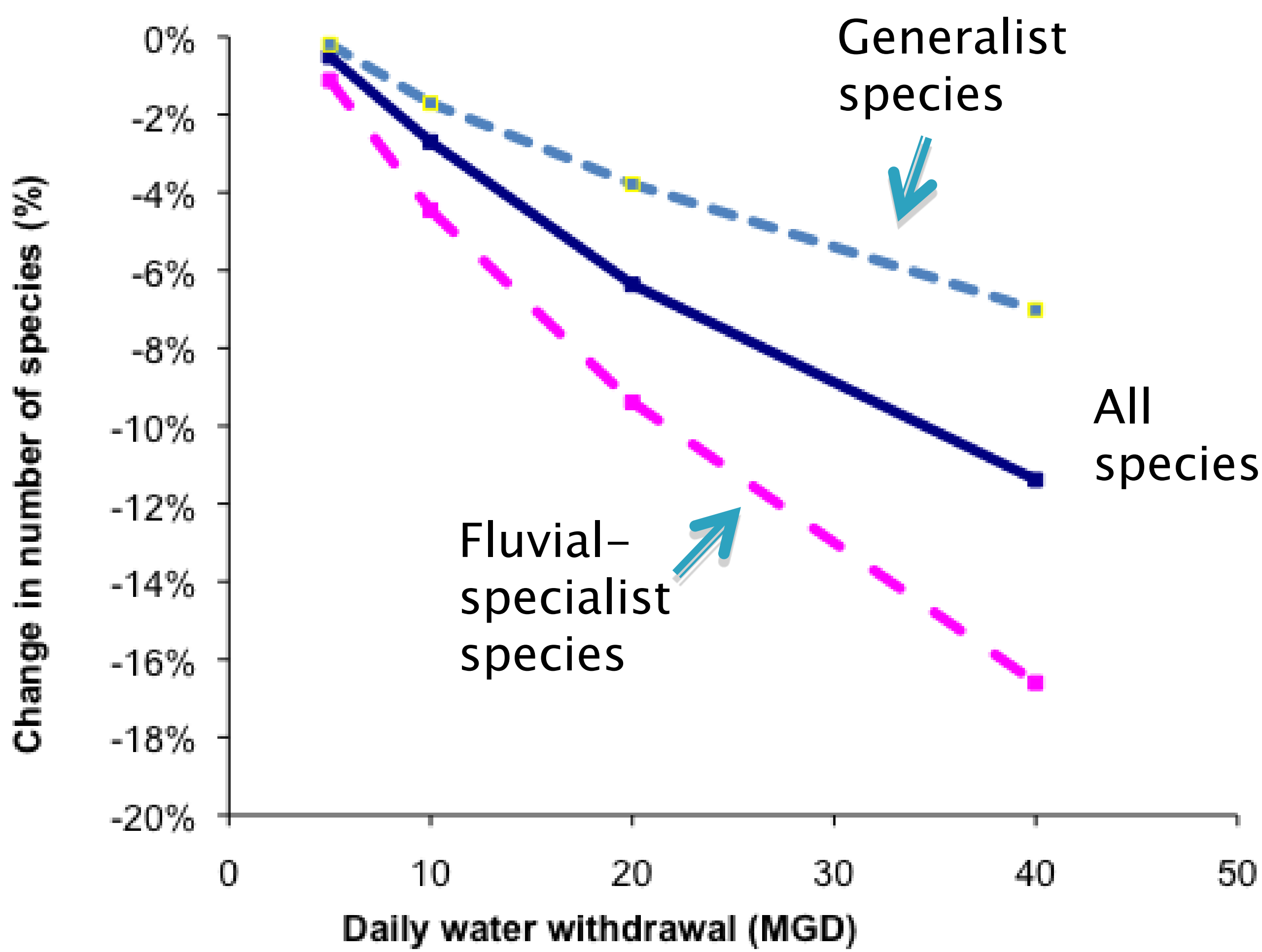

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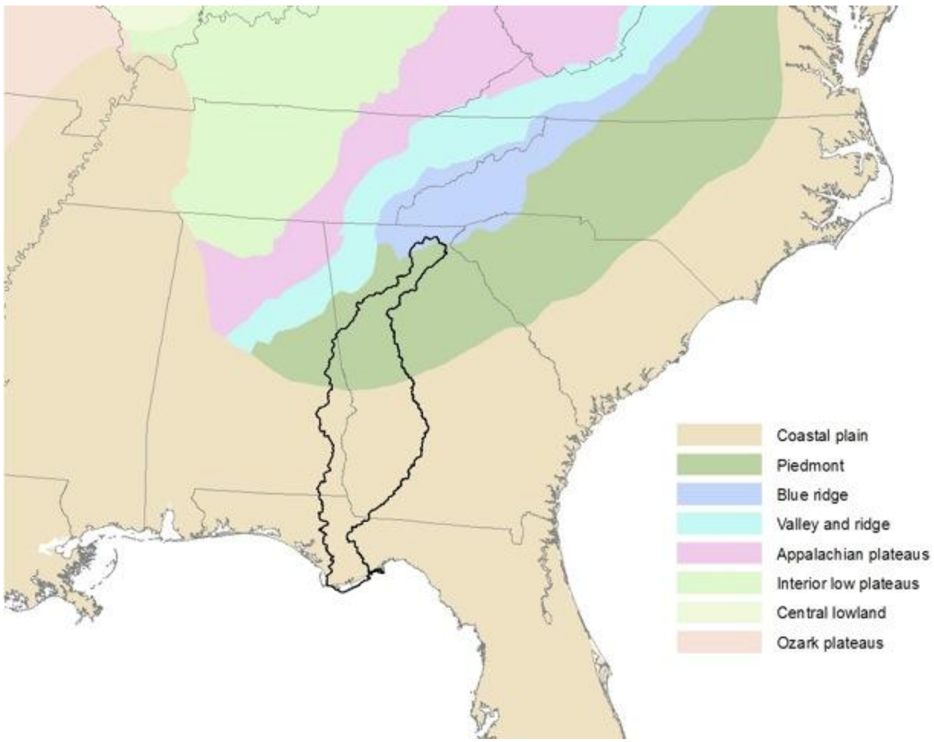
Apalachicola-Chattahoochee-Flint basin (ACF)

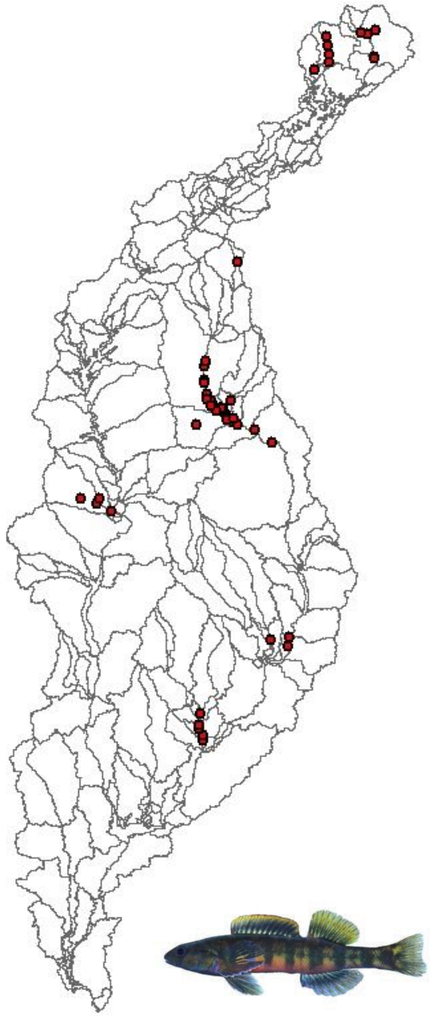


- 51,000 sq km
- Blue Ridge,
  Piedmont,
  Coastal Plain

- ca. 110 fish species
  (10 endemic species)

- ca. 27 extant freshwater mussel species
  (6 federally listed)

Apalachicola-Chattahoochee-Flint basin (ACF)



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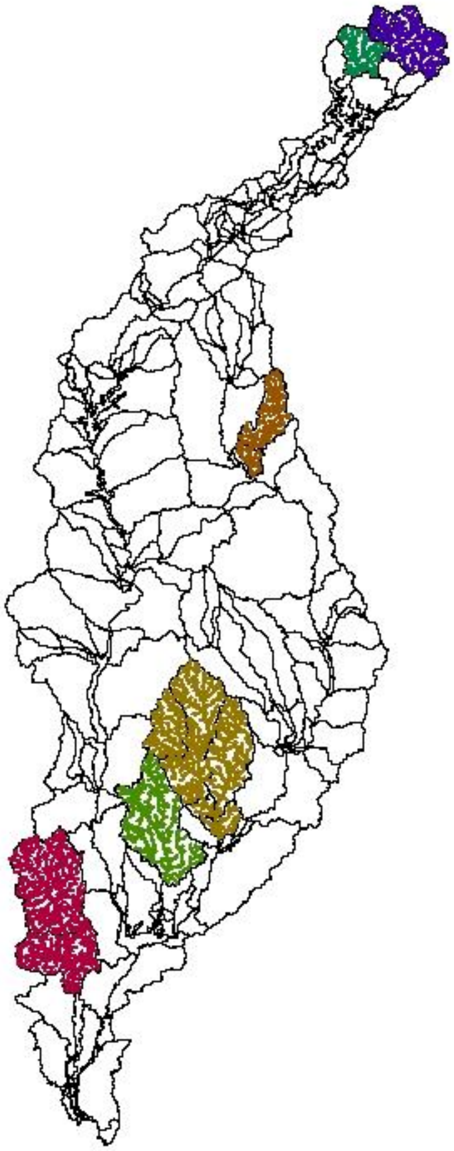
WaterSMART ACF – Environmental Flows Component

- Fine-resolution PRMS models for 6 sub-basins in 3 physiographic regions
- WaterSMART activities:
  - Current conditions flow model
  - Sample fishes and mussels to estimate meta/population dynamics in differing physiographies
  - Update model parameters
  - Simulate biota responses to flow alteration scenarios



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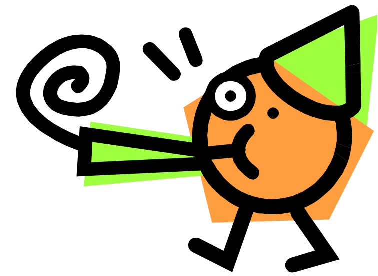
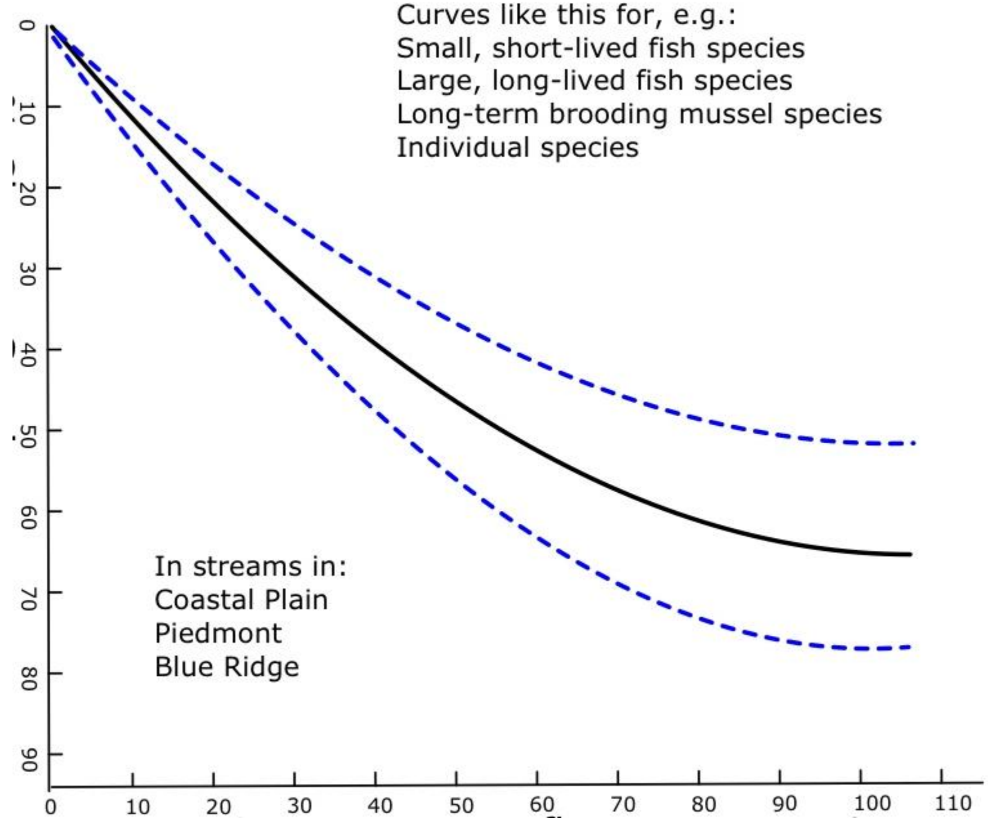
Potential product:

- Simulated flow-ecological response curves for species groups & stream types

- Guidance for monitoring to reduce uncertainties



% Change in species occurrence

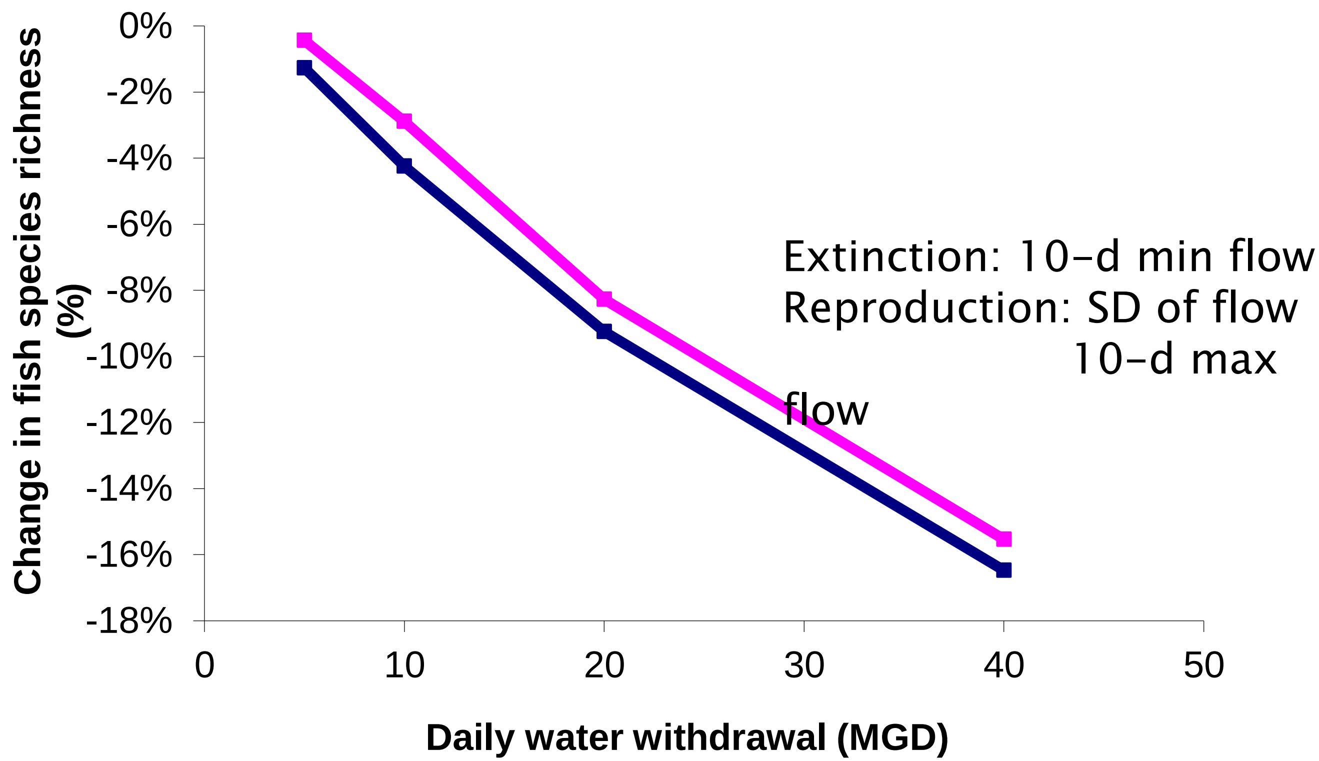


% Change in flow component
(e.g., summer minimum, spring maximum)

- Can evaluate model outcomes sensitivity to assumptions regarding mechanisms

Stream fish metapopulation model

Change in species richness with increasing withdrawal levels



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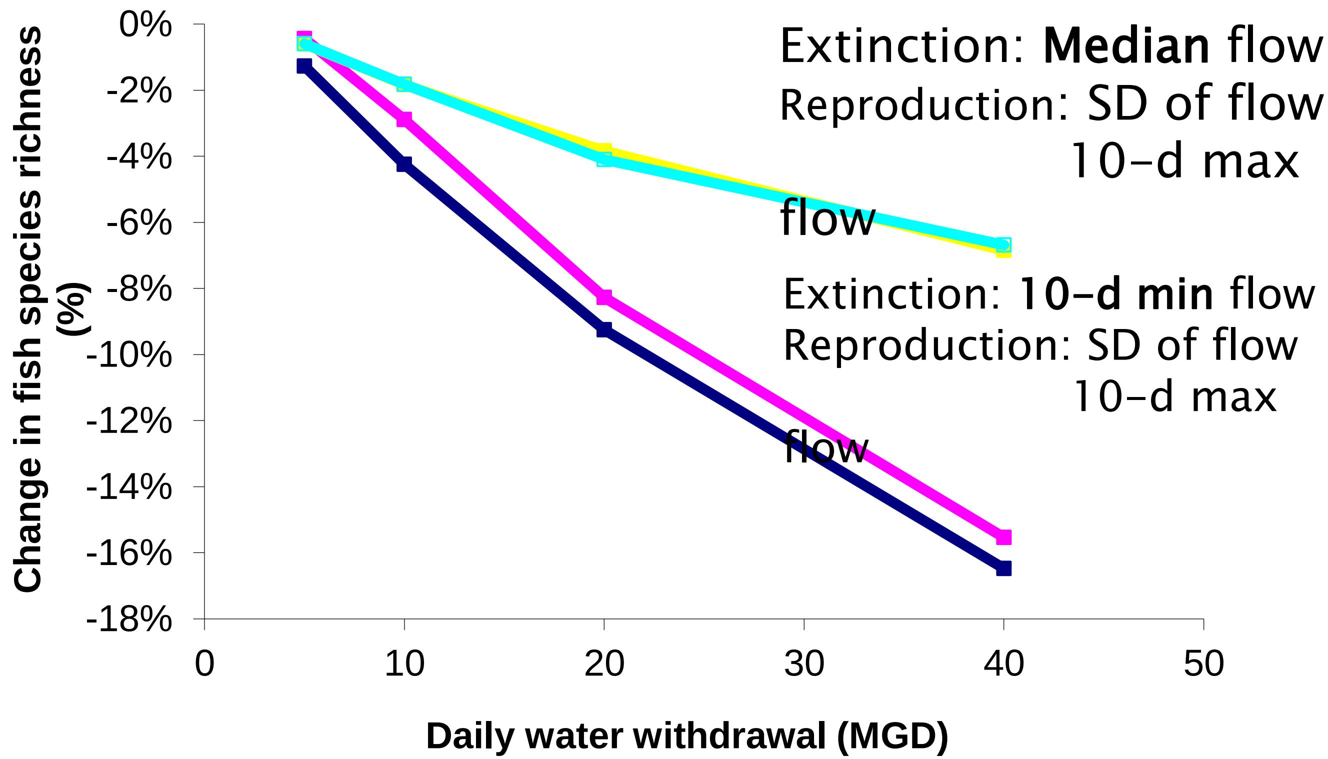

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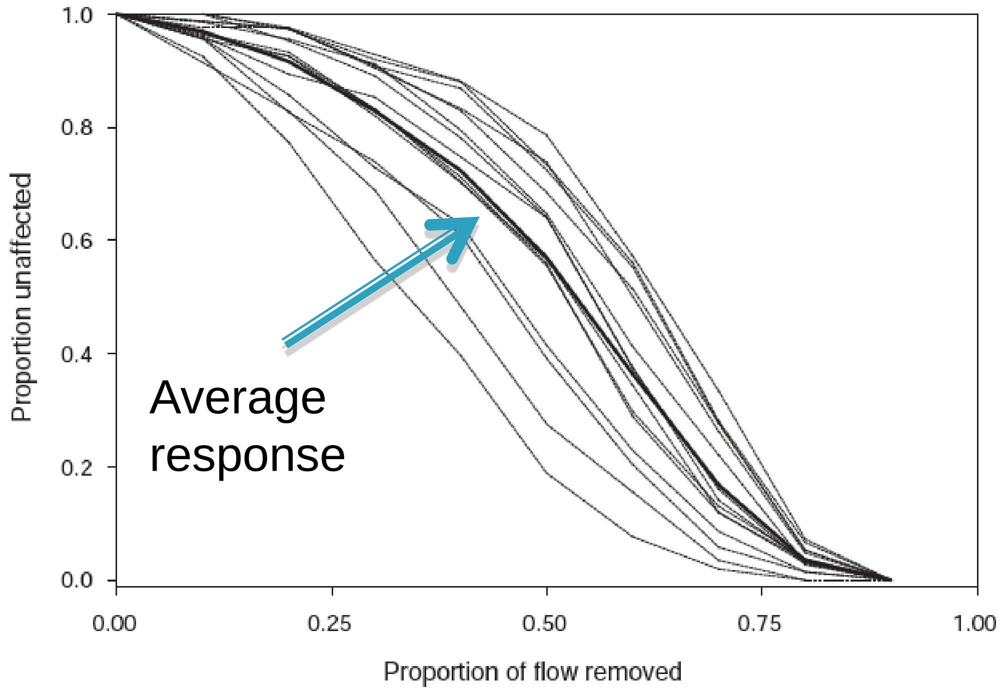
Michigan *Water Withdrawal Assessment Tool*

- Predict fish assemblage responses to decreased base flows, differing stream types, statewide

Decline in "Characteristic species" abundance metric vs. base flow reduction, simulated in 15 representative "large, warm" river reaches



Zorn et al, 2008. A regional-scale habitat suitability model to assess the effects of flow reduction on fish assemblages in Michigan streams. Michigan Department of Natural Resources, Fisheries Research Report 2089, Ann Arbor.

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Michigan *Water Withdrawal Assessment Tool*

Result: Projections of fish assemblage responses to flow reduction

Zorn et al, 2008. A regional-scale habitat suitability model to assess the effects of flow reduction on fish assemblages in Michigan streams. Michigan Department of Natural Resources, Fisheries Research Report 2089, Ann Arbor.