Flow-Ecology Relationships

Lower Savannah-Salkehatchie River RBC: August, 2024
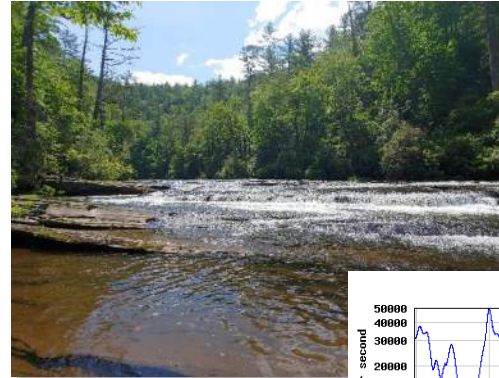
Drs. Brandon Peoples, Luke Bower, and Joe Mruzek
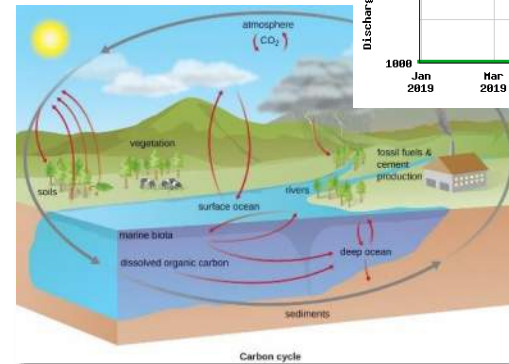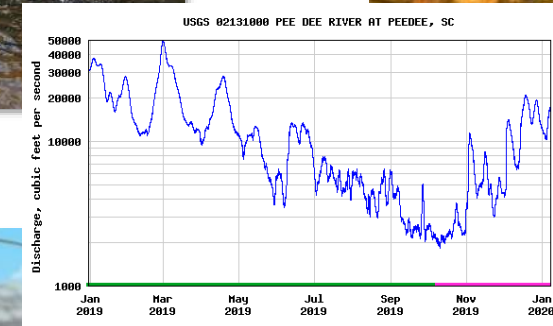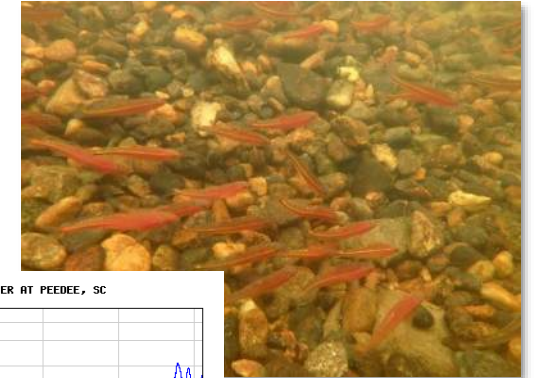
Flow-Ecology Relationships

- In stream flow is critical for aquatic communities

- "Master variable"

Water quality

Organisms

Energy cycling

Physical habitat

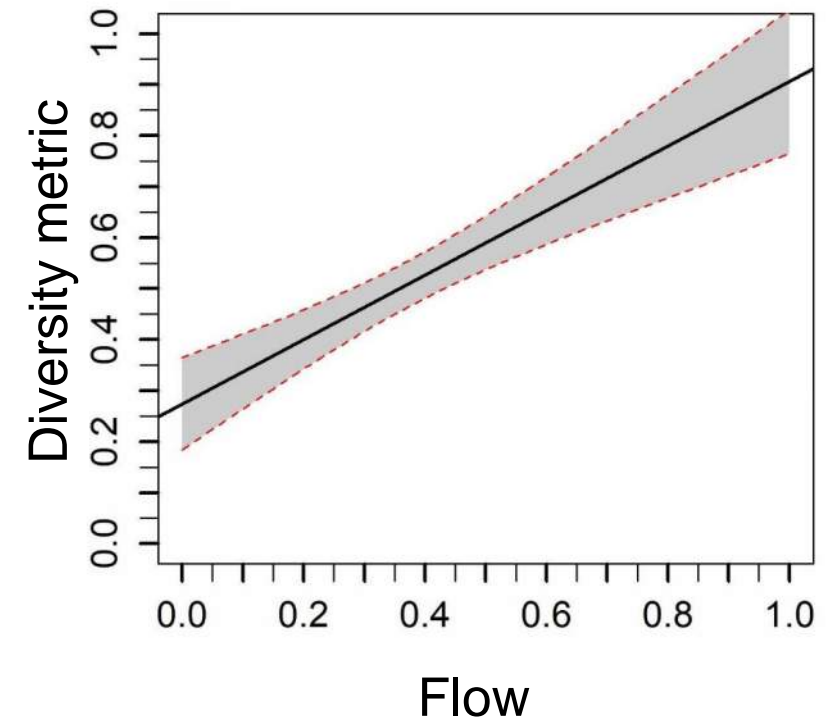# Quantifying flow–ecology relationships across flow regime class and ecoregions in South Carolina

Luke M. Bower [a,*], Brandon K. Peoples [b], Michele C. Eddy [c], Mark C. Scott [d]
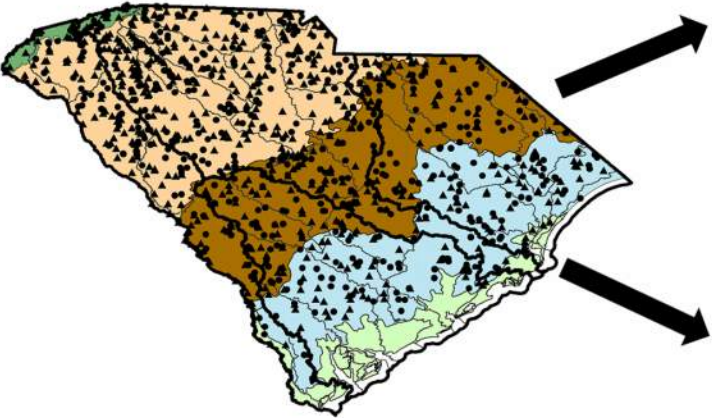
- **Goal: to provide insight on the potential response of organisms to the alternate water withdrawal scenarios produced by SWAM.**
  - We aim to put the SWAM results into a biological context in aquatic communities
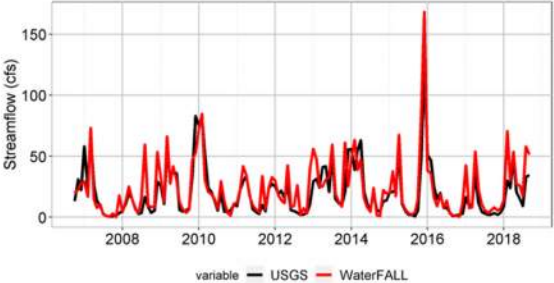
How will this work? Step 1

Timing, magnitude, frequency, and duration

Hydrologic data

Biological data

Fishes

Benthic macroinvertebrates
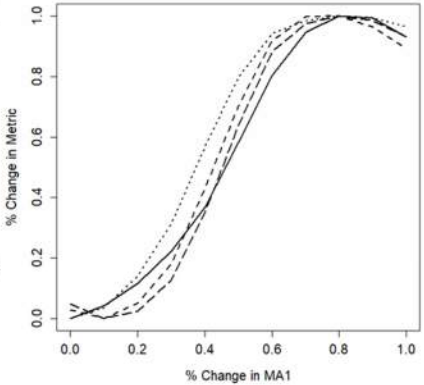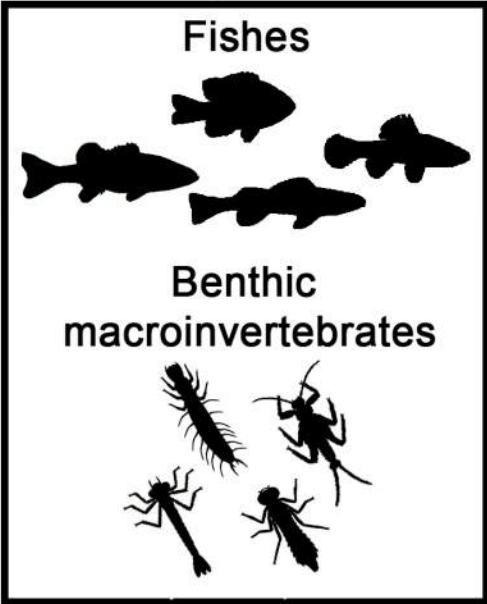
Flow-ecology relationships

1) All flow regime components affect aquatic organism

2) Relationships differ across stream classes

How will this work? Step 2
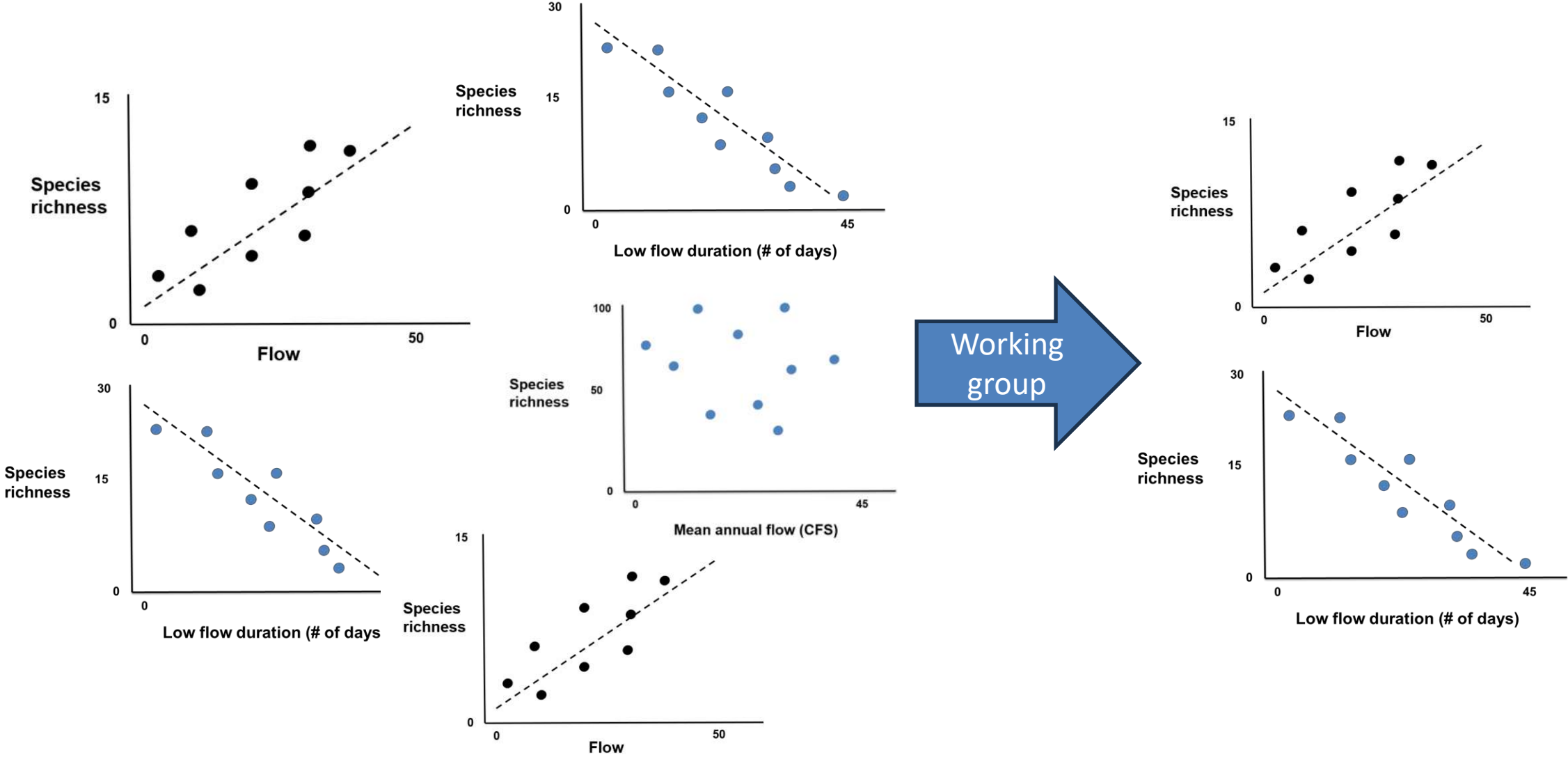
How will this work? Step 3

Selected relationships
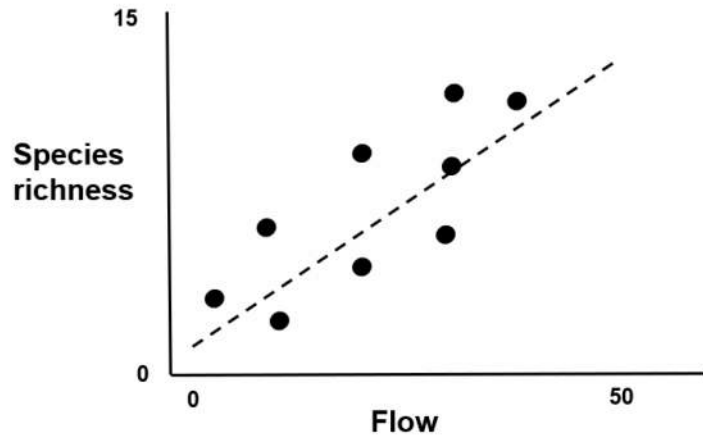
View SWAM results in a biological context

Scenario	Loss of species	Risk
MD	15%	Med
HD	25%	High

SWAM results

Scenario	Current	Predicted	% Change
MD	100	80	20%
HD	100	60	40%
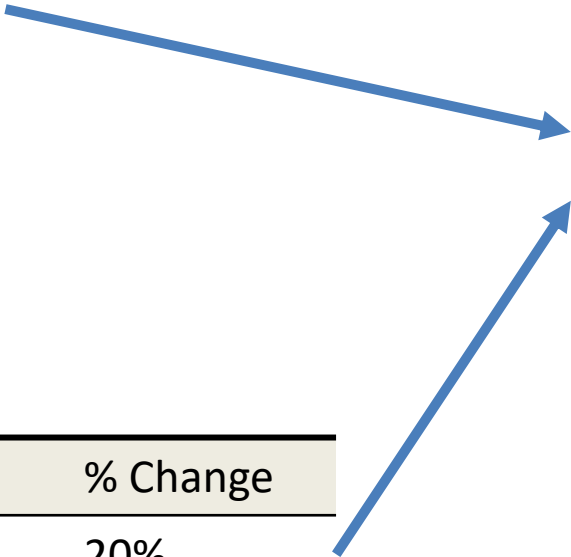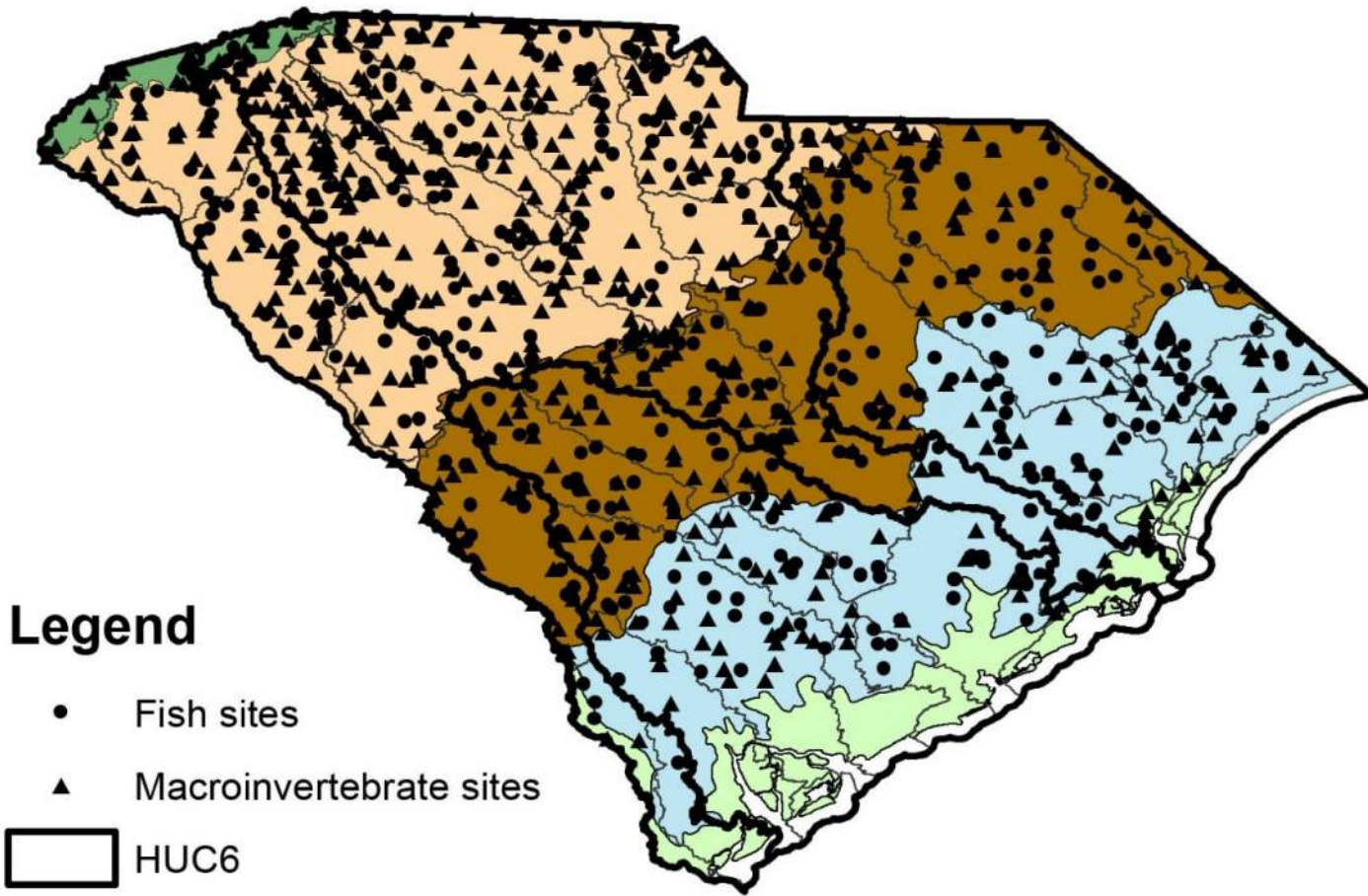
Biological Data:

Legend
- ● Fish sites
- ▲ Macroinvertebrate sites
- ▢ HUC6
- ▢ HUC8
- ▢ Blue Ridge
- ▢ Southern Coastal Plain
- ▢ Southeastern Plain
- ▢ Middle Atlantic Coastal Plain
- ▢ Piedmont

- 492 Fish sites (streams & rivers)
  - DNR
  - 8 biological response metrics

- 530 aquatic insect sites
  - DHEC
  - 6 biological response metrics

Characterizing aquatic diversity

- **Species richness:** number of species
- **Shannon's Diversity:** Accounts for <u>percentages</u>

Tolerant species
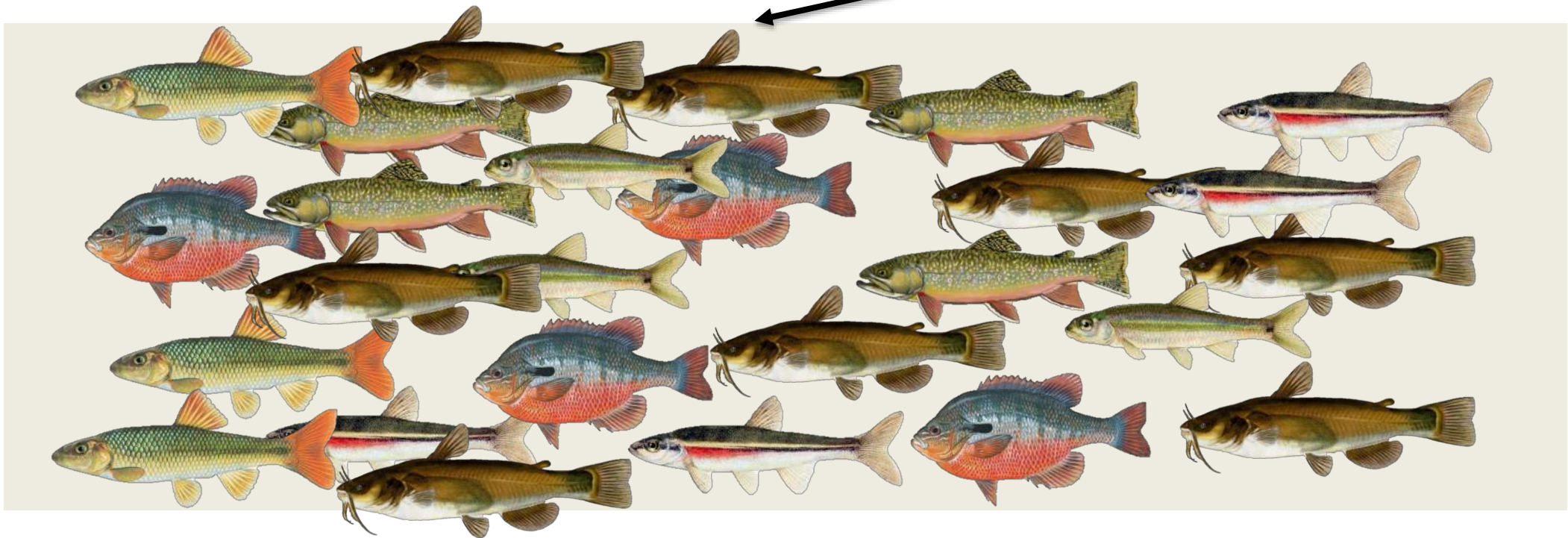
Diverse biota = healthy ecosystem

How can we use these relationships?

- Defining biological response limits
  - zones low, medium, and high change in the biological condition of streams along flow gradients
  - Searching for areas along flow gradients that induce changes in the biological metric

- Predicting responses
  - If we alter flow by X amount what will be the biological response?

Mean daily flow (MA1): biological response limits

- Lines defined by working group

- Performance measure
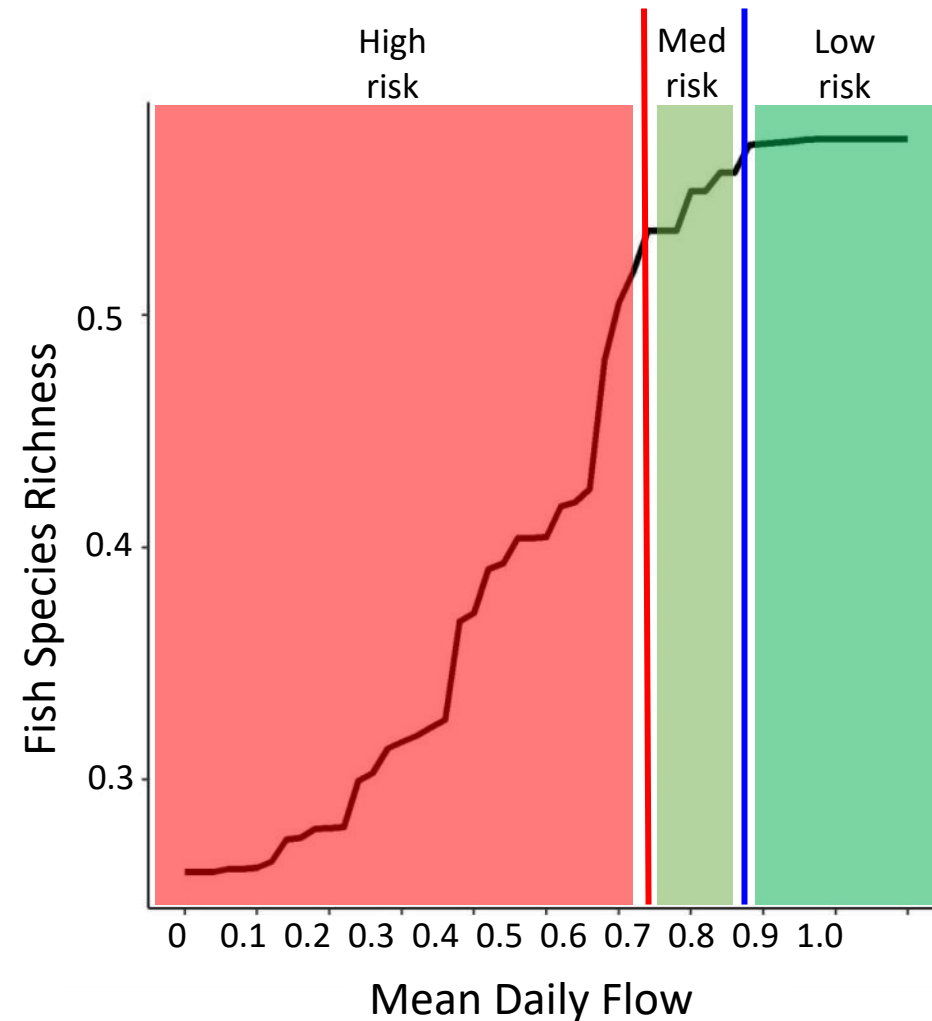
Mean daily flow (MA1): predictions

$$y = 0.2745 + x*0.63099 \pm e$$
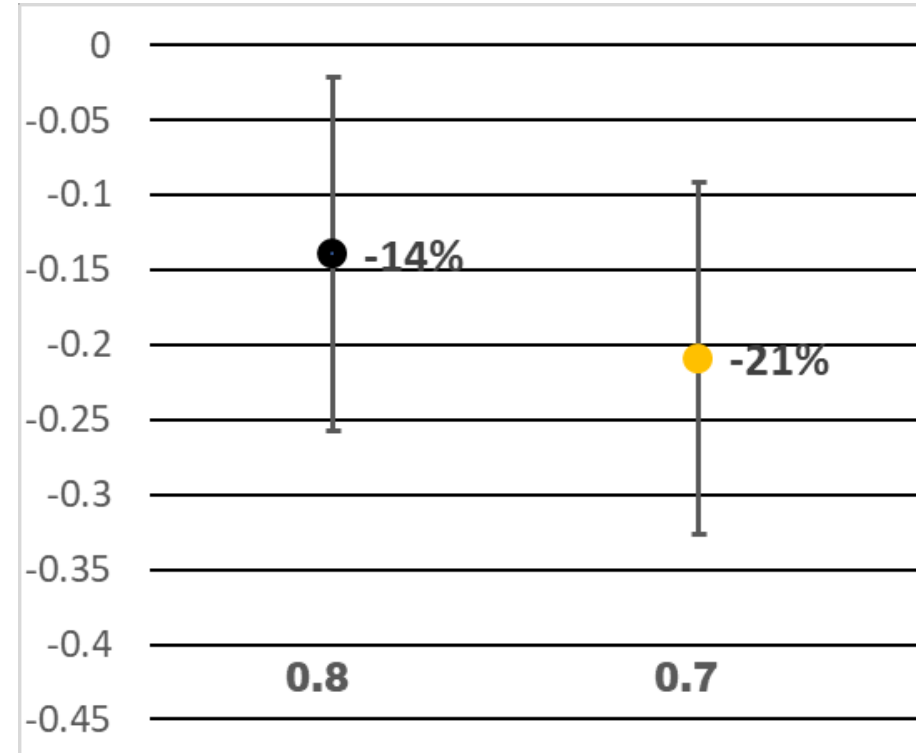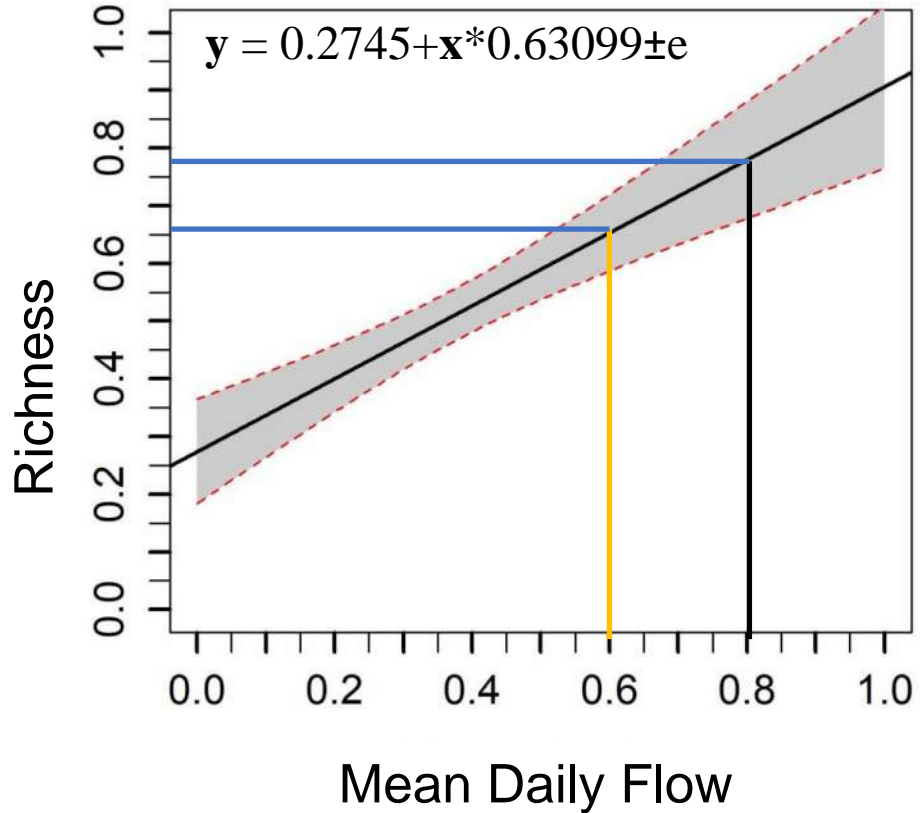
Scenario	Current	Predicted	% Change
MD	100	80	20%
HD	100	60	40%

Key to Understanding the Results of the Surface Water Modeling Scenarios:

Mean daily flow (MA1): N. Pacolet near Fingerville

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	320	368.91	15.4%	Richness	Low
MD 2070	320	283.39	-11.3%	Richness	Low
HD 2070	320	257.78	-19.4%	Richness	Low
P&R	320	227.65	-28.8%	Richness	Med

Current Use Scenario
Mean Daily Flow

Scenario
Mean Daily Flows

% Changes for each scenario are relative to the Current Use Scenario

Colored lines correspond to scenario results shown in the table

Dashed red and blue lines separate the low medium and high risk zones

Key to Understanding the Results of the Surface Water Modeling Scenarios:

95% Confidence Interval

Mean daily flow (MA1): N. Pacolet near Fingerville

Scenario	Current	Predicted	% change	Bio Metric	Change in Bio	95ci
UIF	320	368.91	15.4%	Richness	12.7%	7
MD 2070	320	283.39	-11.3%	Richness	-9.3%	7
HD 2070	320	257.78	-19.4%	Richness	-15.9%	7
P&R	320	227.65	-28.8%	Richness	-23.6%	7
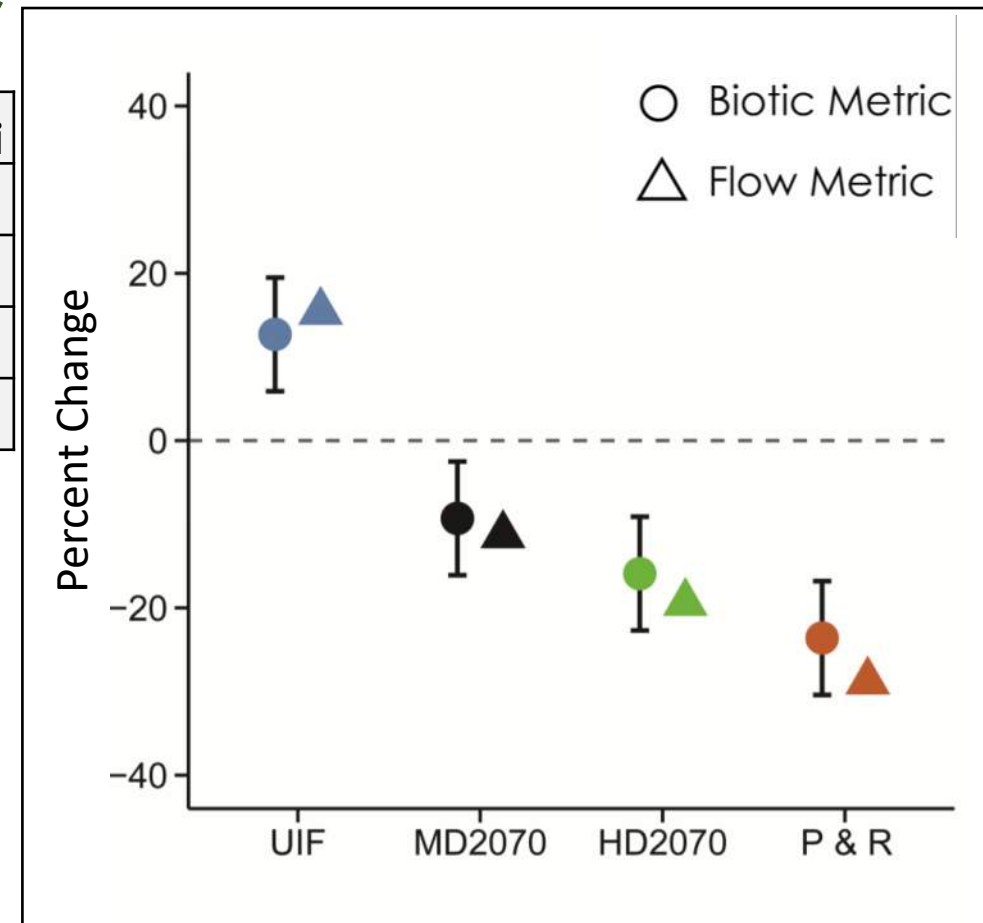
Current Use Scenario Mean Daily Flow

Scenario Mean Daily Flows

% Changes for each scenario are relative to the Current Use Scenario

Ecoregions

- Piedmont: Rolling hills

- Southeastern plains: Flatter, well drained sandy soils

- Middle Atlantic Coastal Plains

Savannah & Salkehatchie River Basins
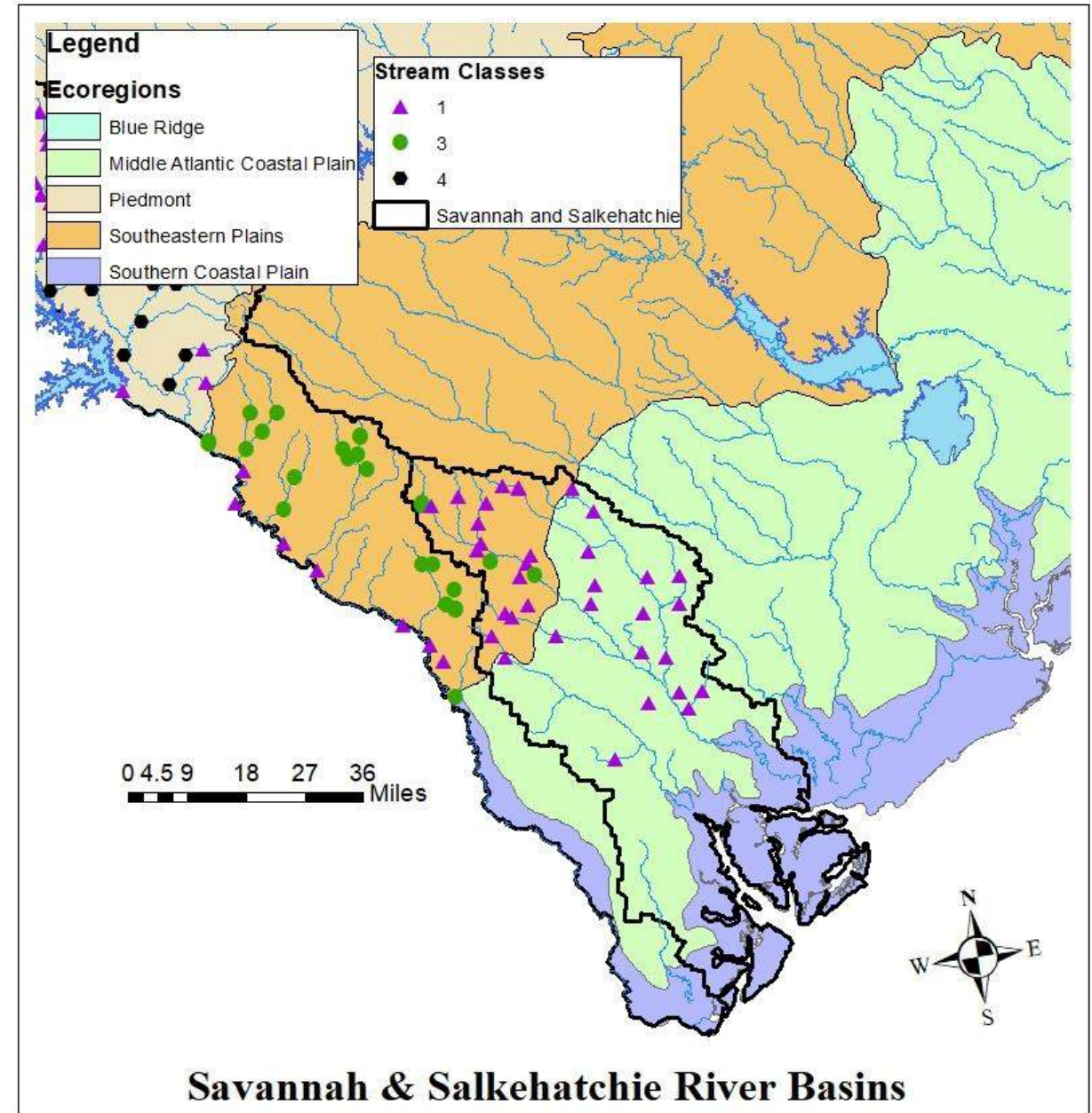
Stream Classes
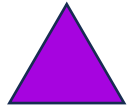
- 1: Perennial runoff: moderately stabile flow and distinct seasonal extremes

- 3: Stable baseflow: high precipitation, sustained high baseflows, and moderately high run-off

- 4: Perennial flashy: moderately stabile flow with high flow variability

Legend

Ecoregions
- Blue Ridge
- Middle Atlantic Coastal Plain
- Piedmont
- Southeastern Plains
- Southern Coastal Plain

Stream Classes
- ▲ 1
- ● 3
- ⬡ 4
- ☐ Savannah and Salkehatchie

0 4.5 9   18   27   36
Miles

Savannah & Salkehatchie River Basins
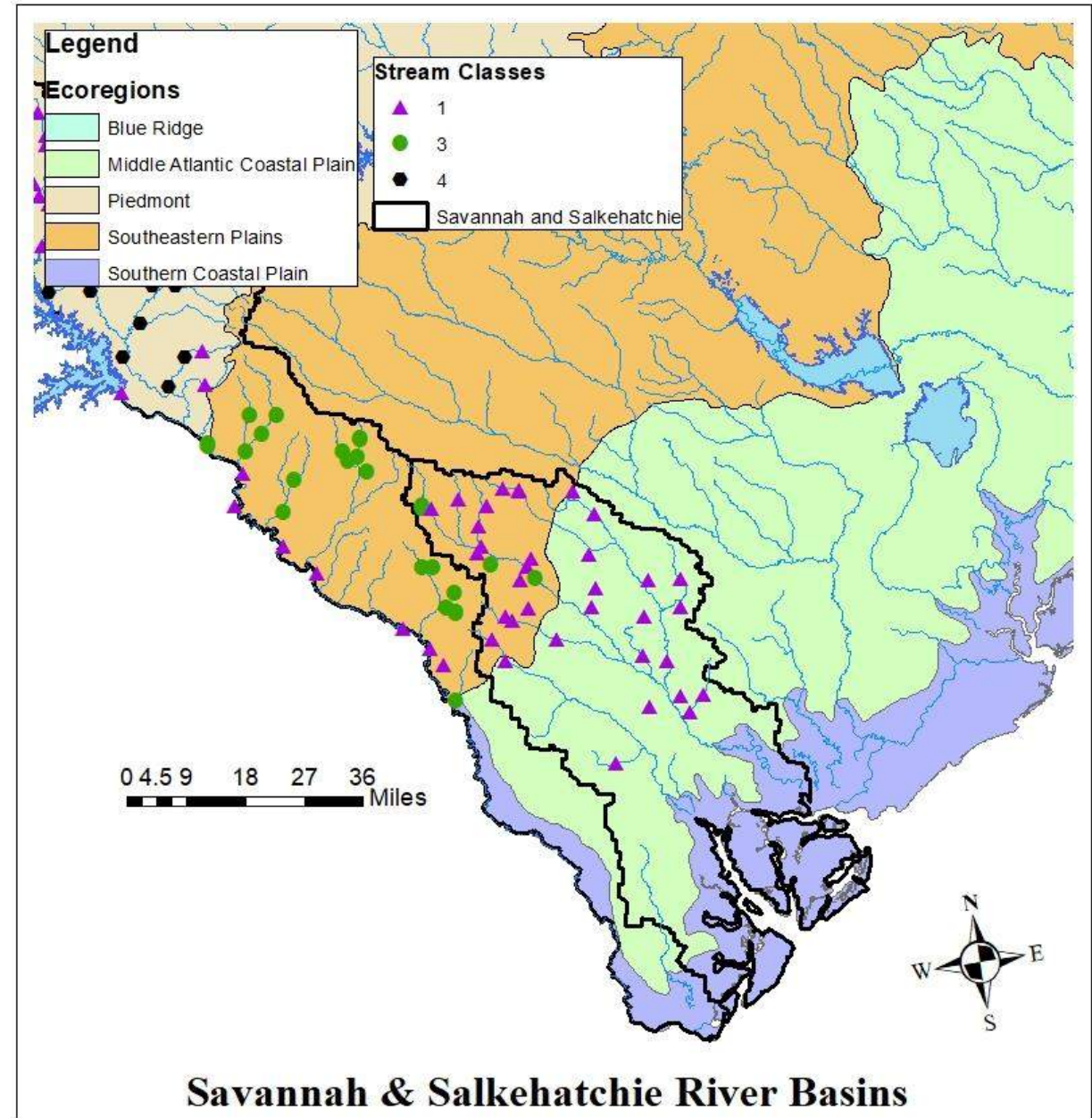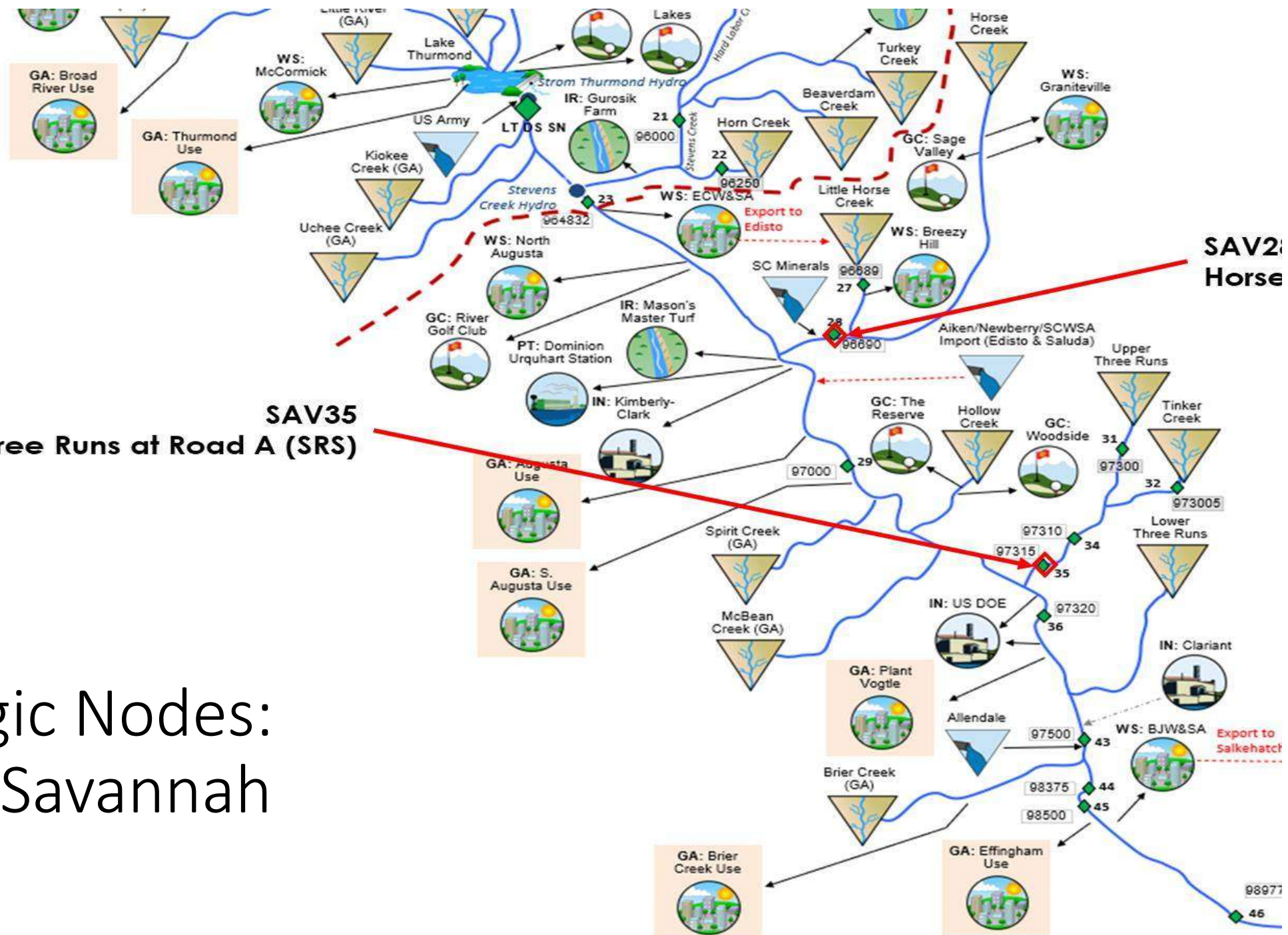
Strategic Nodes: Lower Savannah
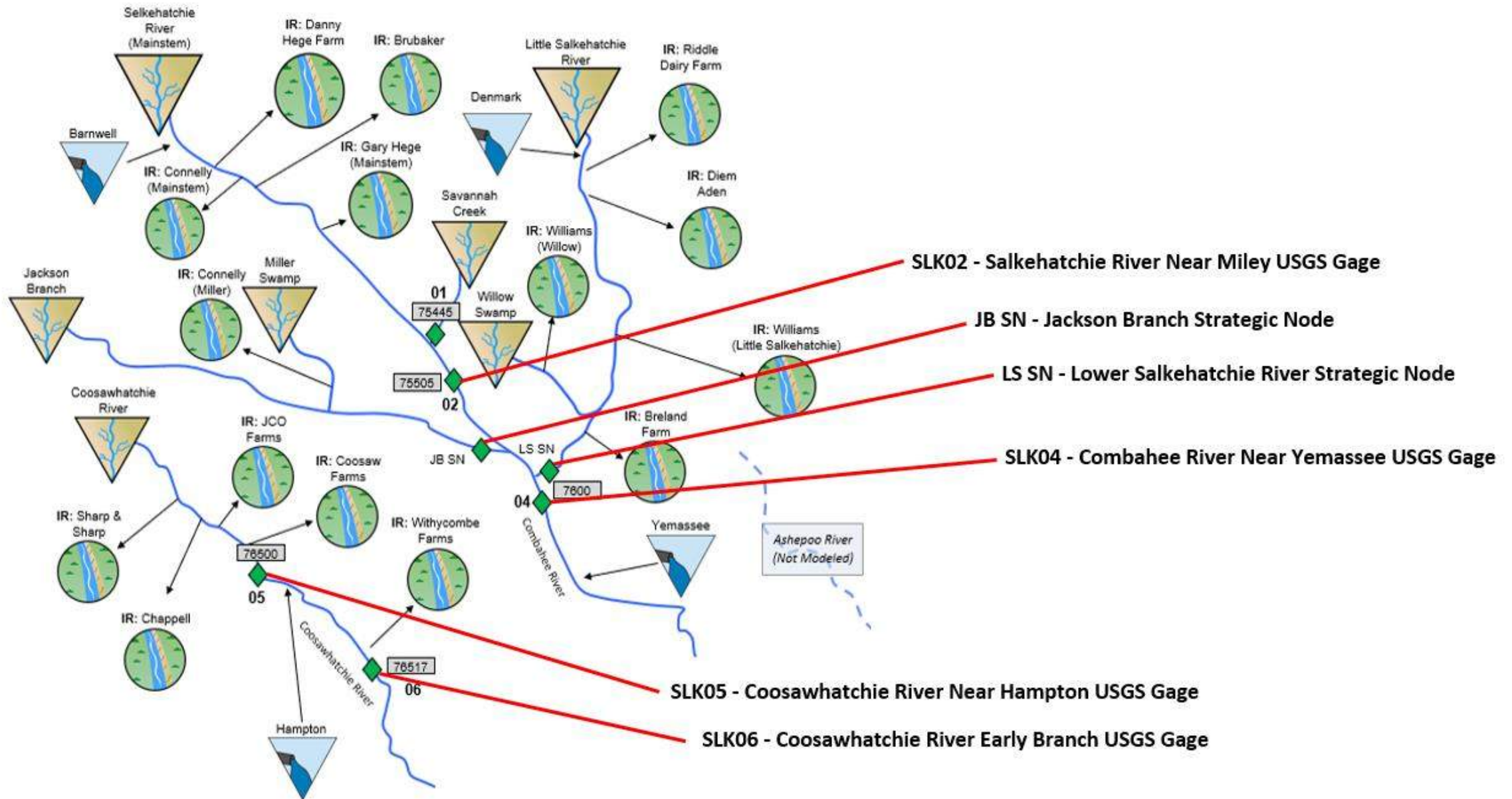
Strategic Nodes: Salkehatchie

Selected Metrics: Lower Savannah

	Performance Recommendations and Risk Ranges		
Stream Type:	**Southeastern Stable Baseflow**		
	Low	**Med**	**High**
Flow Metric			
Mean Daily Flow (FR)	>0.75	0.52-0.75	<0.52
Low Flow Duration (FR)	<0.13	0.13-0.40	>0.40

FR=Fish Species Richness: The number of fish species found in a stream or river reach

SAV28 Horse Creek: MA1-Richness

Scenario	Current	Predicted	% Flow	Bio Metric	% Bio	SE
UIF	185.669	198.503	6.912	Richness	5.28	10.3
MD 2070	185.669	183.168	-1.347	Richness	-1.03	10.3
HD 2070	185.669	168.678	-9.151	Richness	-6.99	10.3
P&R	185.669	120.457	-35.123	Richness	-26.84	10.3

SAV28 Horse Creek: MA1-Richness
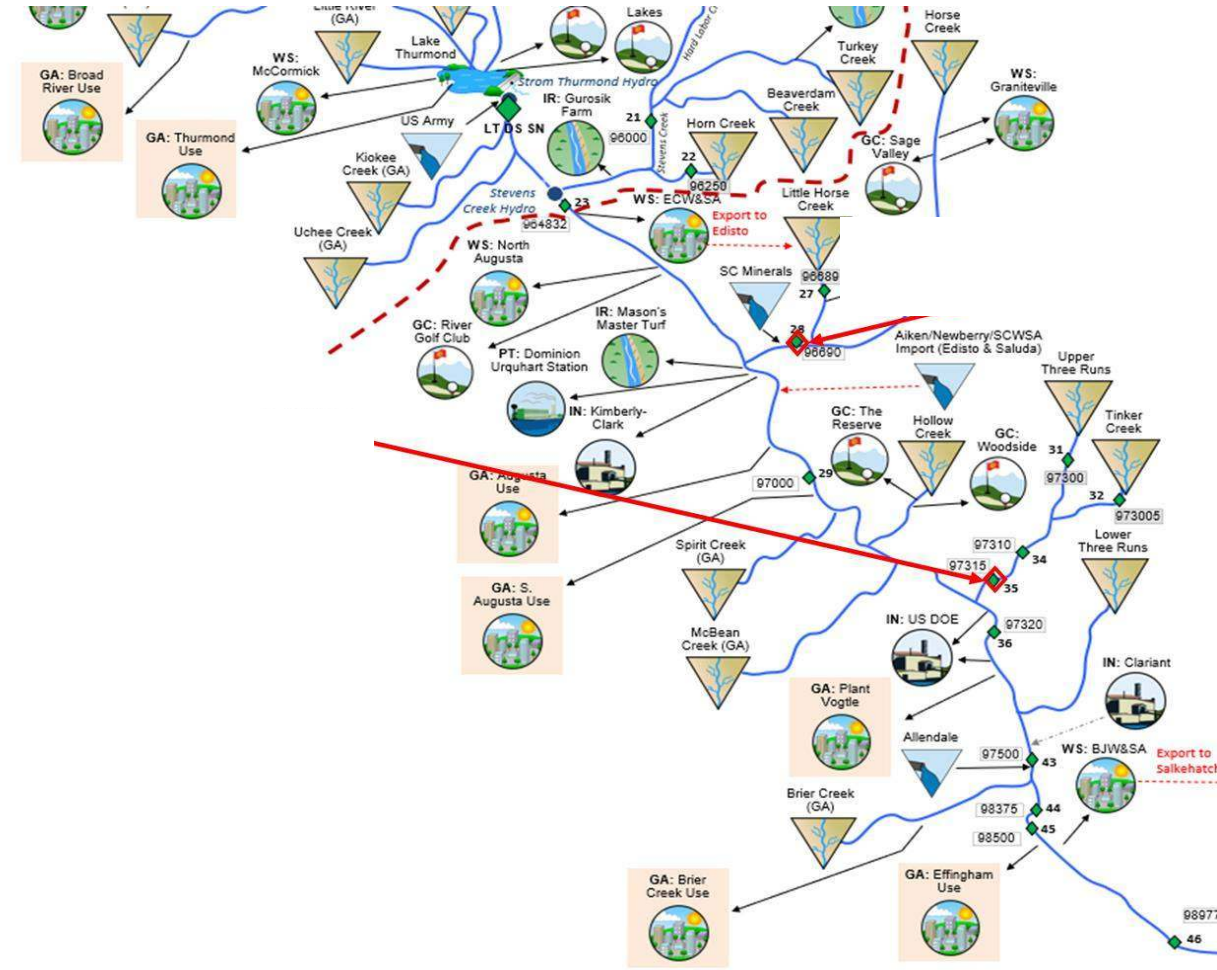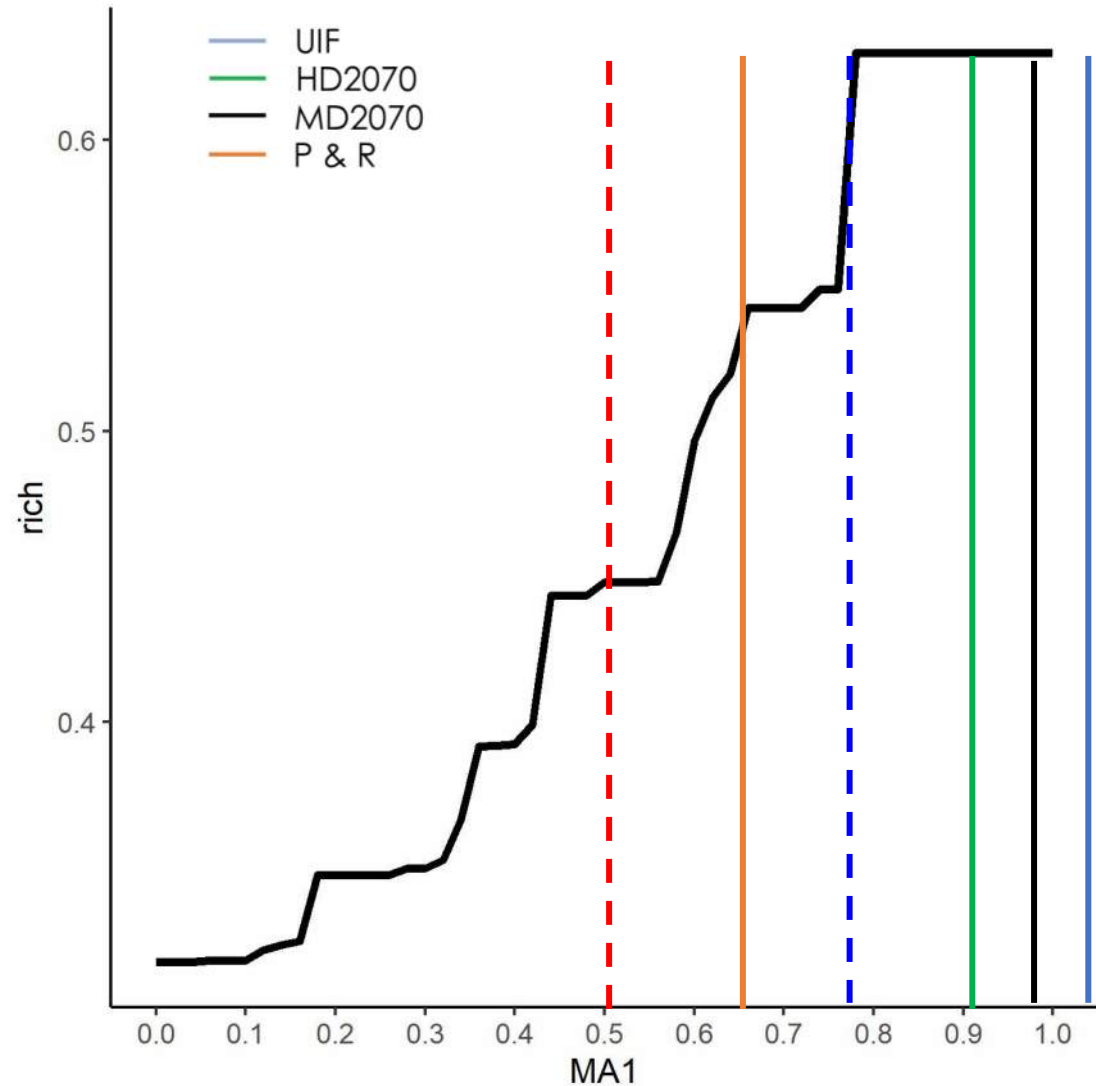
Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	185.669	198.503	6.912	Richness	Low
MD 2070	185.669	183.168	-1.347	Richness	Low
HD 2070	185.669	168.678	-9.151	Richness	Low
P&R	185.669	120.457	-35.123	Richness	Low

SWAP-listed fishes in Lower Sav/Salk Basin

Savannah Darter

Bluebarred Pygmy Sunfish

Blackbanded sunfish

Carolina Pygmy Sunfish

Christmas Darter

Robust Redhorse

Bluespotted Sunfish

Everglades Pygmy Sunfish

Bridle Shiner

What this info *is*

- **Guidance based on best available data and analysis tools**

- **Based on models with compounding statistical uncertainty**

What this info *is not*

- **Arbitrary recommendations from 'expert advice'**

- **Perfect.**
- **More data = less uncertainty**
- **Changing climate & land cover = more uncertainty**

Flow Chart

Gauge Data

Community Data

Estimate Flow metrics

+ Uncertainty

Estimate Flow-Ecology Relationships

+ Uncertainty

Forecast Future Flows

+ Uncertainty

+ Uncertainty
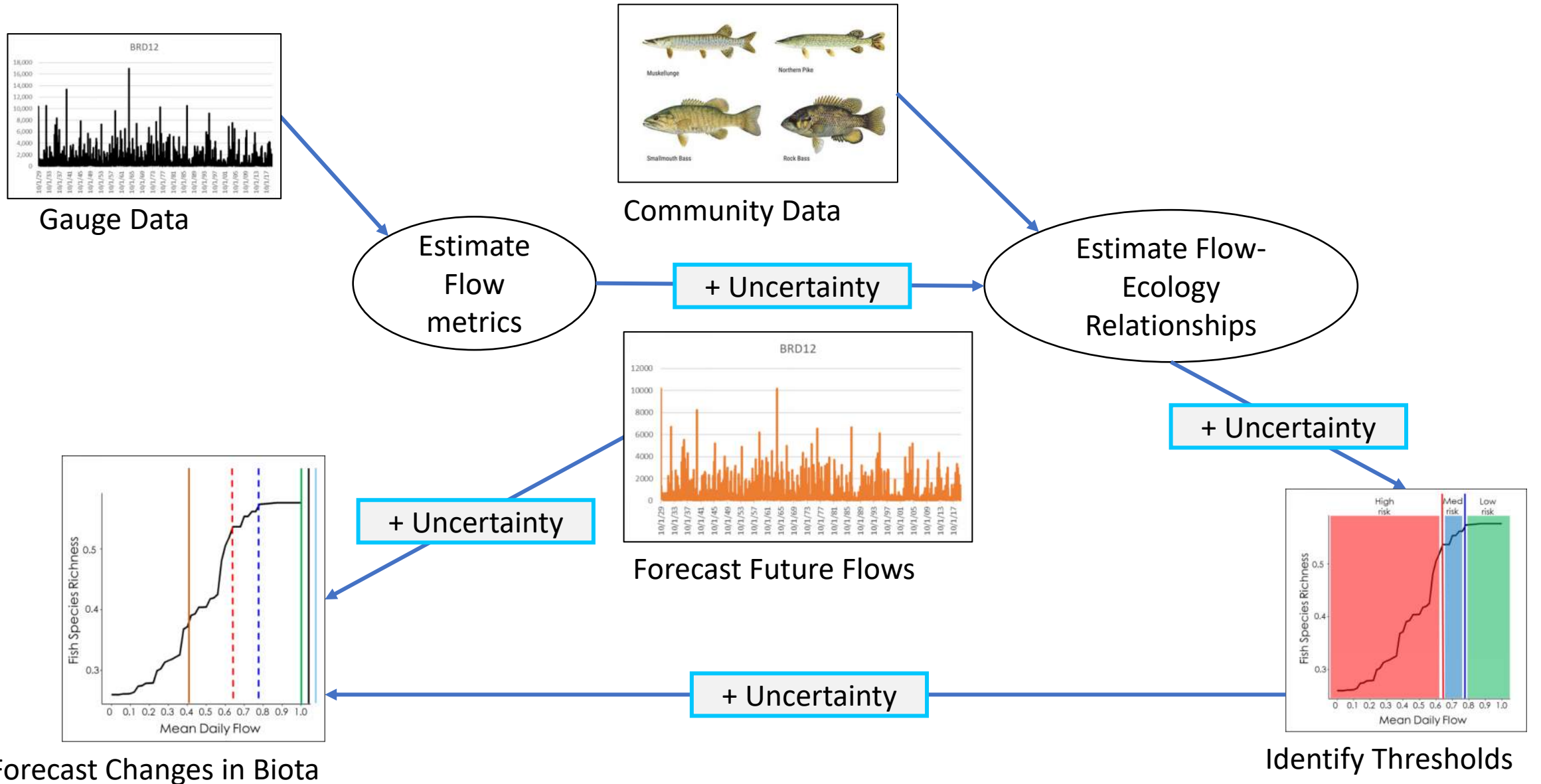
Identify Thresholds

Forecast Changes in Biota

What this info *is*

- **Guidance based on best available data and analysis tools**

- **Based on models with compounding statistical uncertainty**

- **Representative of overall (30-year) flow regime characteristics**
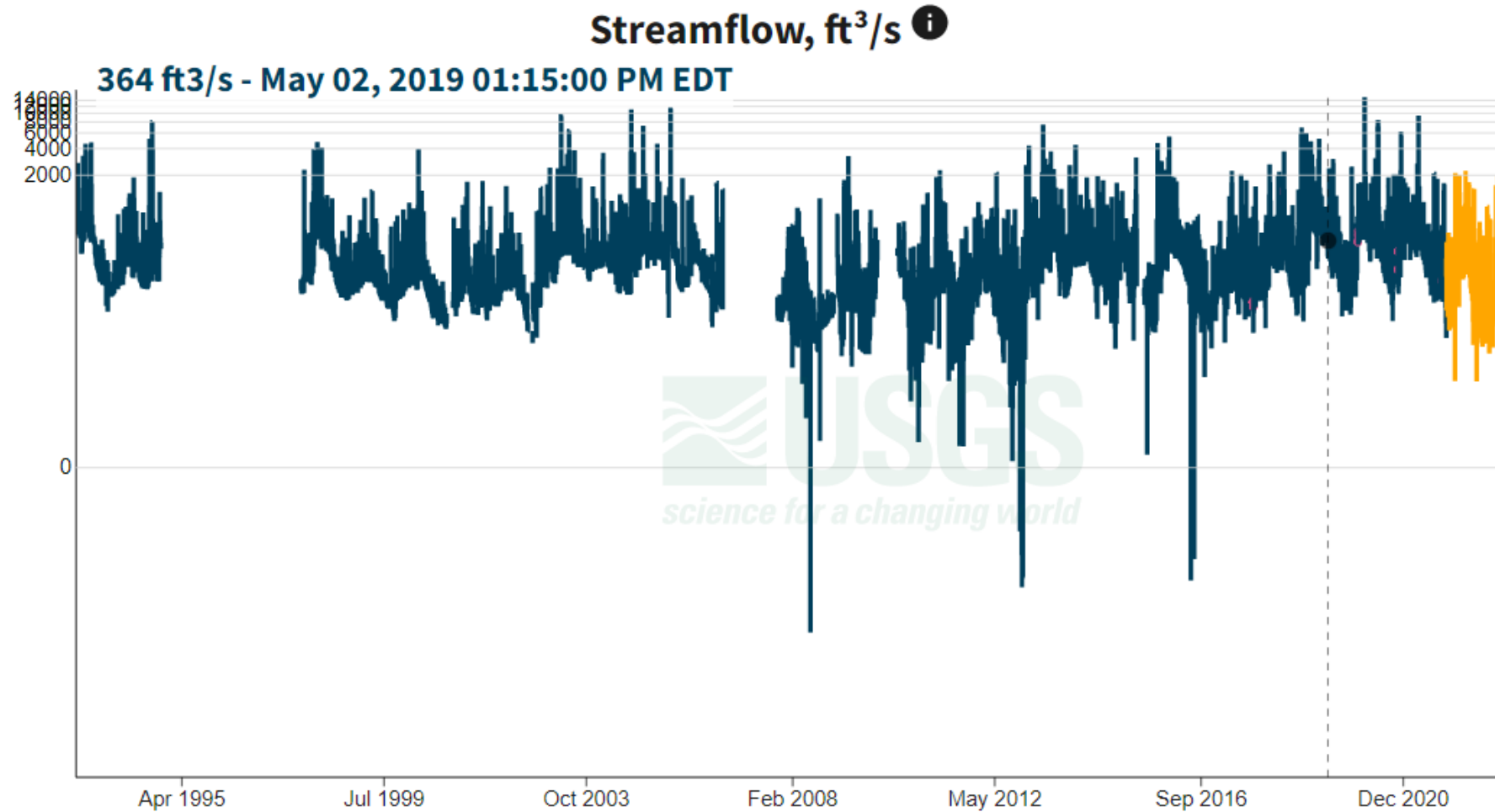
What this info *is not*

- **Arbitrary recommendations from 'expert advice'**

- **Perfect.**
- **More data = less uncertainty**
- **Changing climate & land cover = more uncertanty**

- **One-time withdrawal thresholds**

PACOLET RIVER NEAR FINGERVILLE, SC

ⓘ

Monitoring location 02155500 is associated with a STREAM in SPARTANBURG COUNTY, SOUTH CAROLINA. Current conditions of DISCHARGE, GAGE HEIGHT, MEAN WATER VELOCITY FOR DISCHARGE COMPUTATION, and MORE are available. Water data back to 1903 are available online.

Streamflow, ft³/s ⓘ

364 ft3/s - May 02, 2019 01:15:00 PM EDT

What this info _is_

- **Guidance based on best available data and analysis tools**

- **Based on models with compounding statistical uncertainty**

- **Representative of overall (30-year) flow regime characteristics**

- **Applicable to streams and small rivers (~86% of all SC waters)**

- **Relationships between organisms and flow**

What this info _is not_

- **Arbitrary recommendations from 'expert advice'**

- **Perfect.**
- **More data = less uncertainty**
- **Changing climate & land cover = more uncertanty**

- **One-time withdrawal thresholds**

- **Applicable to large rivers and reservoirs**

- **Parsing out other factors that affect organisms**
- **Land use affects flow, etc.**

Results summary

- Most scenarios showed little to no change for fish Richness and Shannon's diversity

- Full demand scenario could result in species loss

- Report to follow

Questions

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