Flow-Ecology Relationships
Saluda RBC: March, 2024

Drs. Luke Bower, Joe Mruzek, and Brandon Peoples
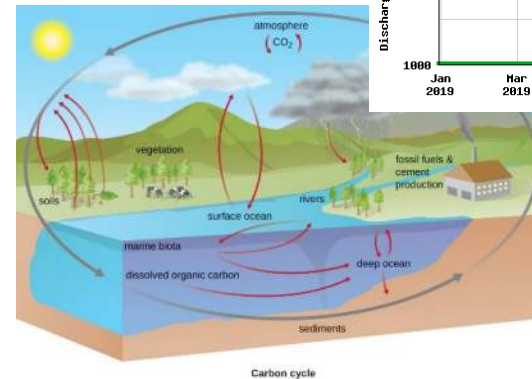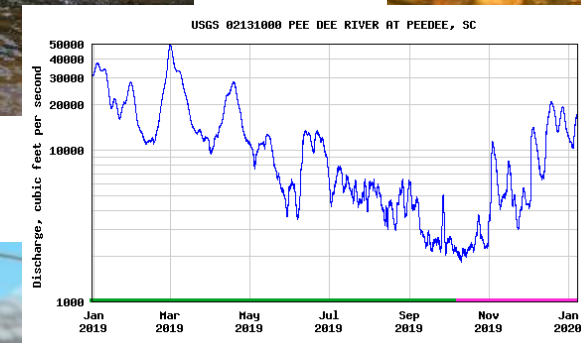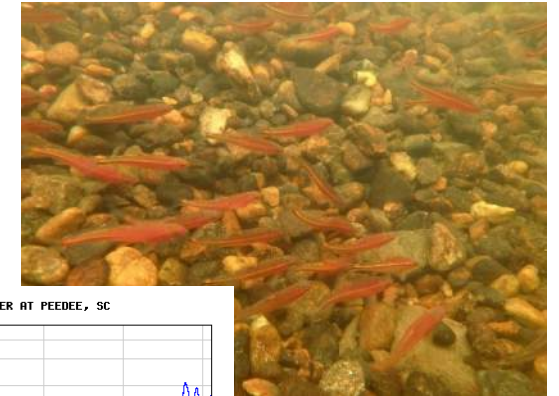
Flow-Ecology Relationships

- 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
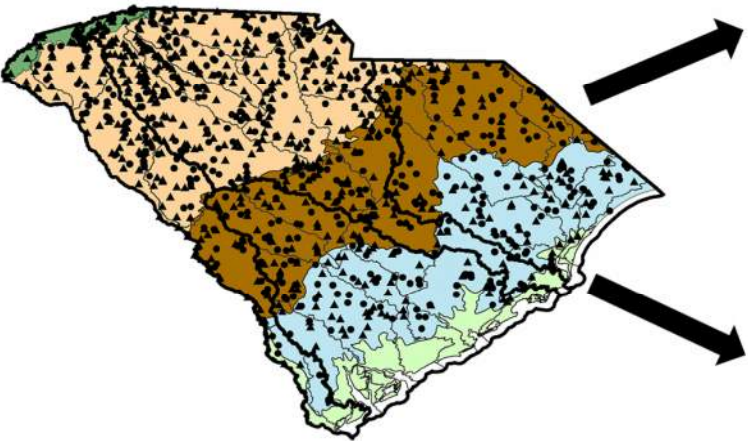
Luke M. Bower [a,*], Brandon K. Peoples [b], Michele C. Eddy [c], Mark C. Scott [d]

- Goal: to provide insight on the potential response of organisms to the alternate water withdrawal scenarios produced by SWAM.
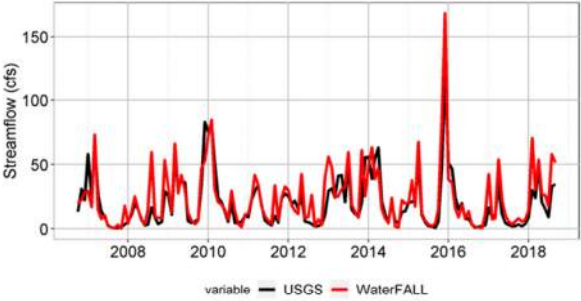 - We aim to put the SWAM results into a biological context in aquatic communities
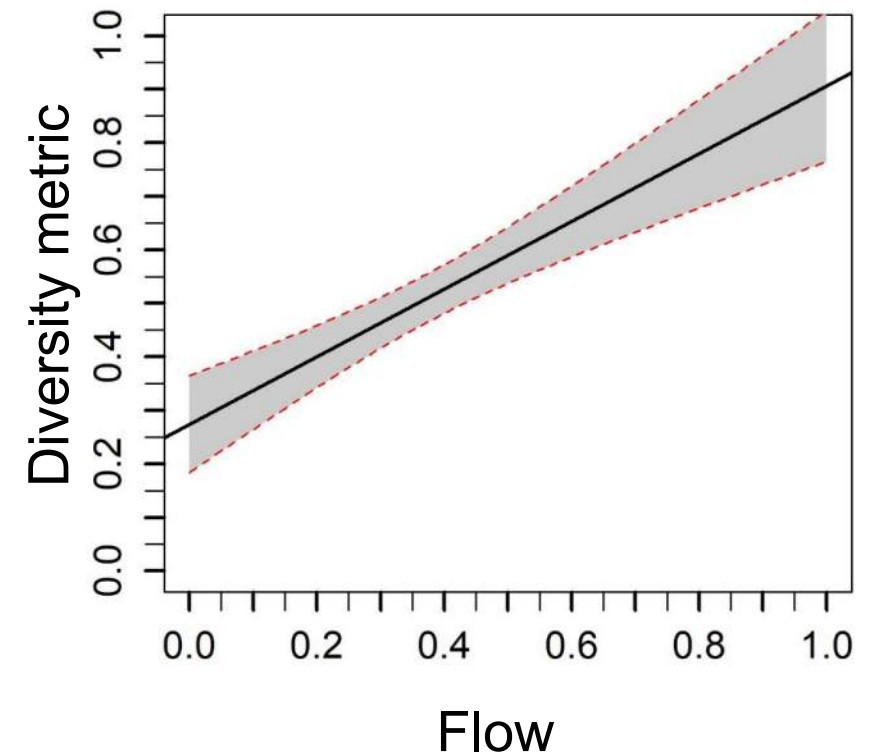
How will this work? Step 1

Timing, magnitude, frequency, rate of change, and duration

Hydrologic data

Biological data

Fishes

Benthic macroinvertebrates

Flow-ecology relationships
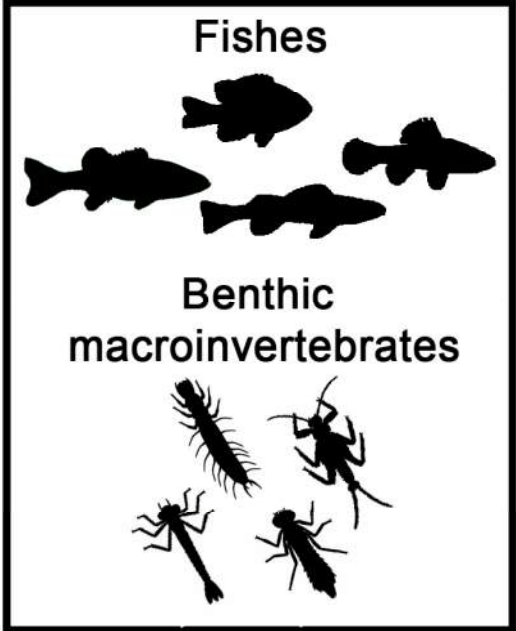
1) All flow regime components affect aquatic organism
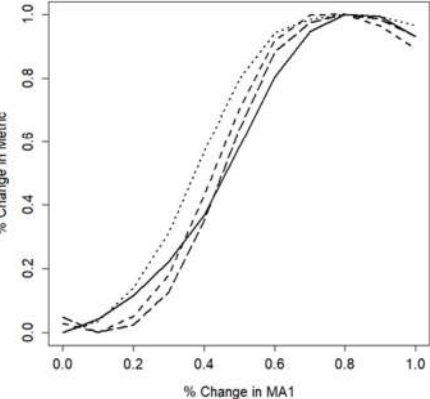
2) Relationships differ across stream classes

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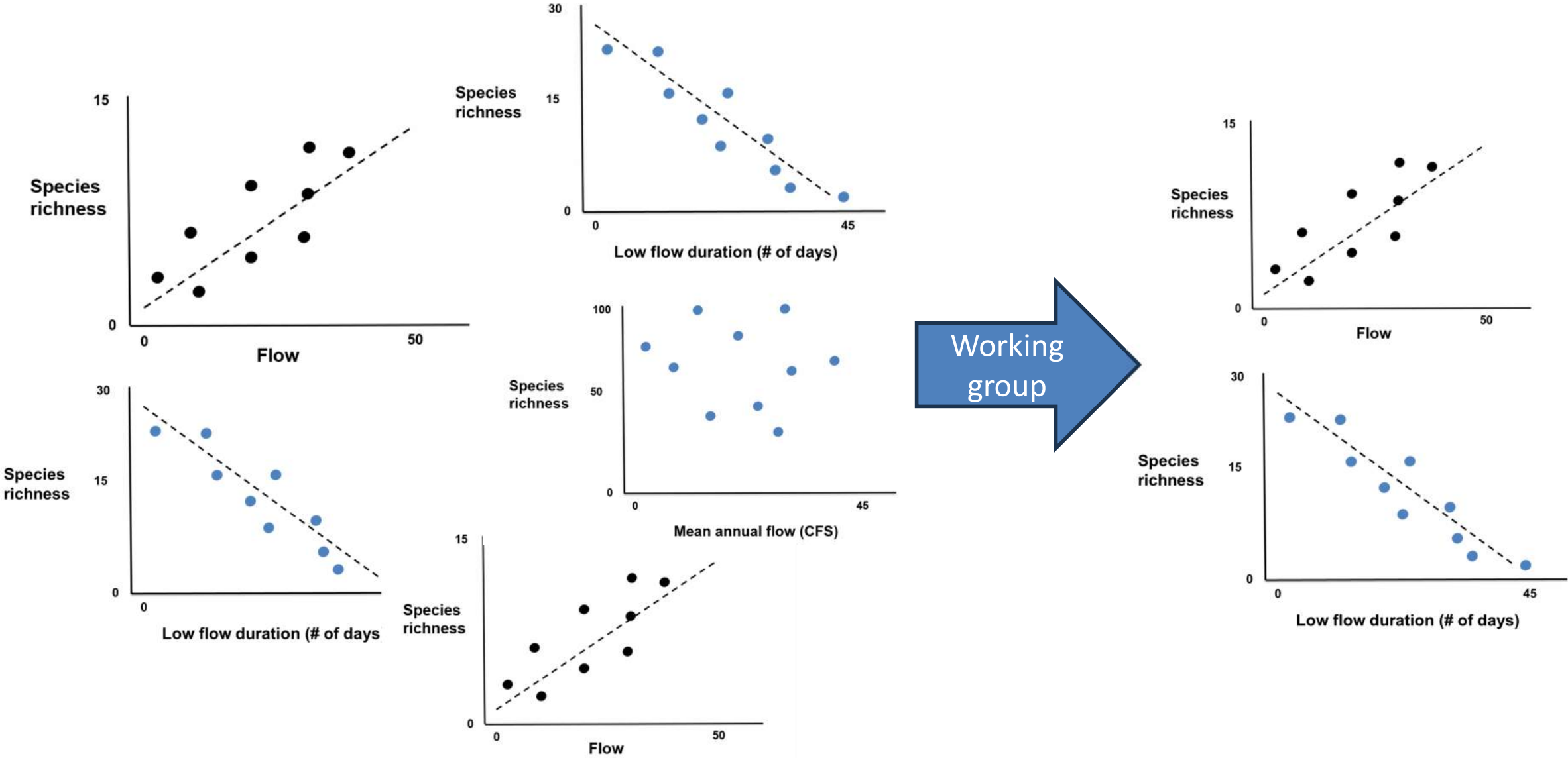
How will this work? Step 3

Selected relationships
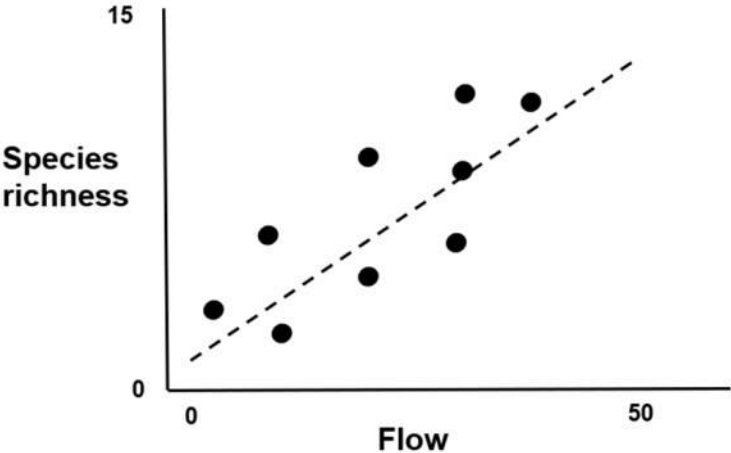
View SWAM results in a biological context

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%
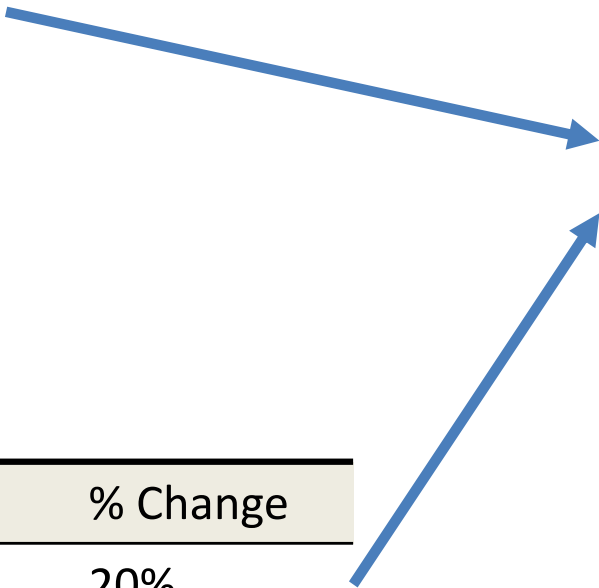
How can we use these relationships?

- 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
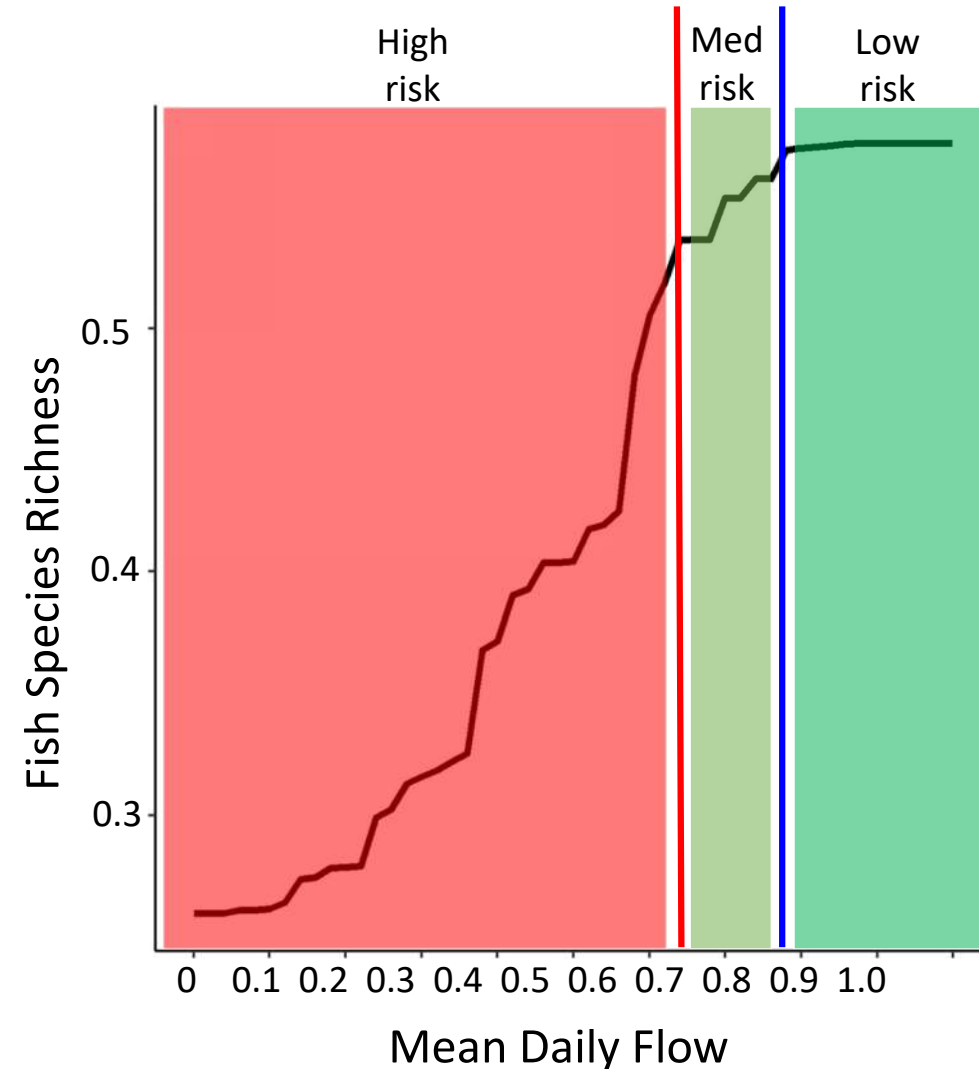
Mean daily flow (MA1): predictions

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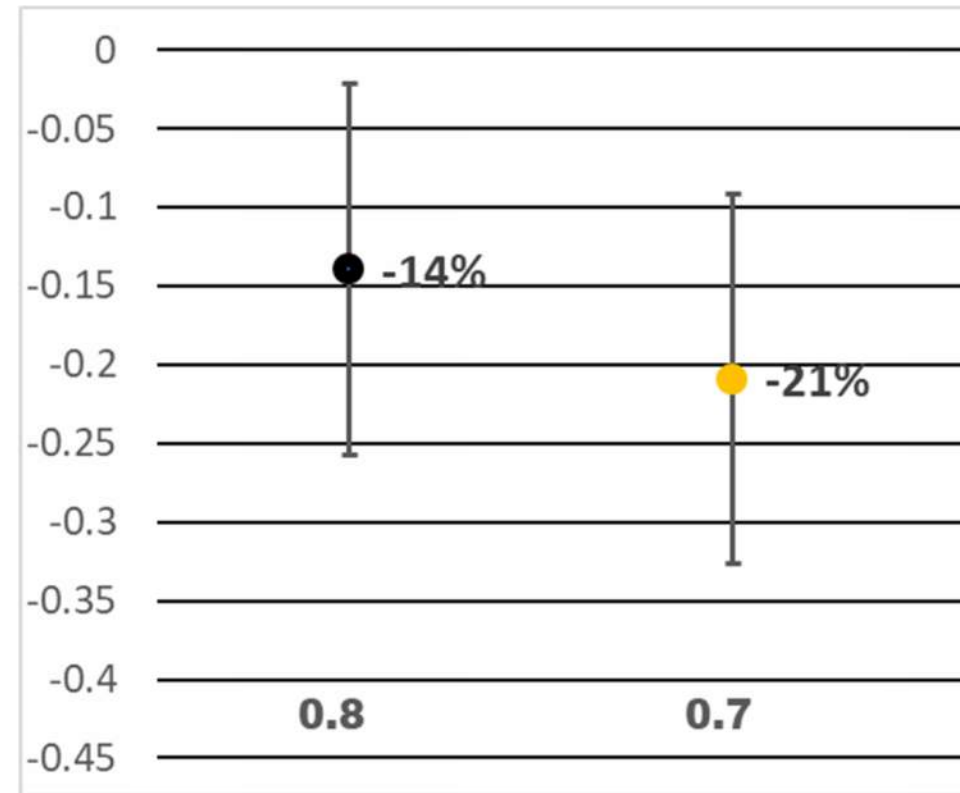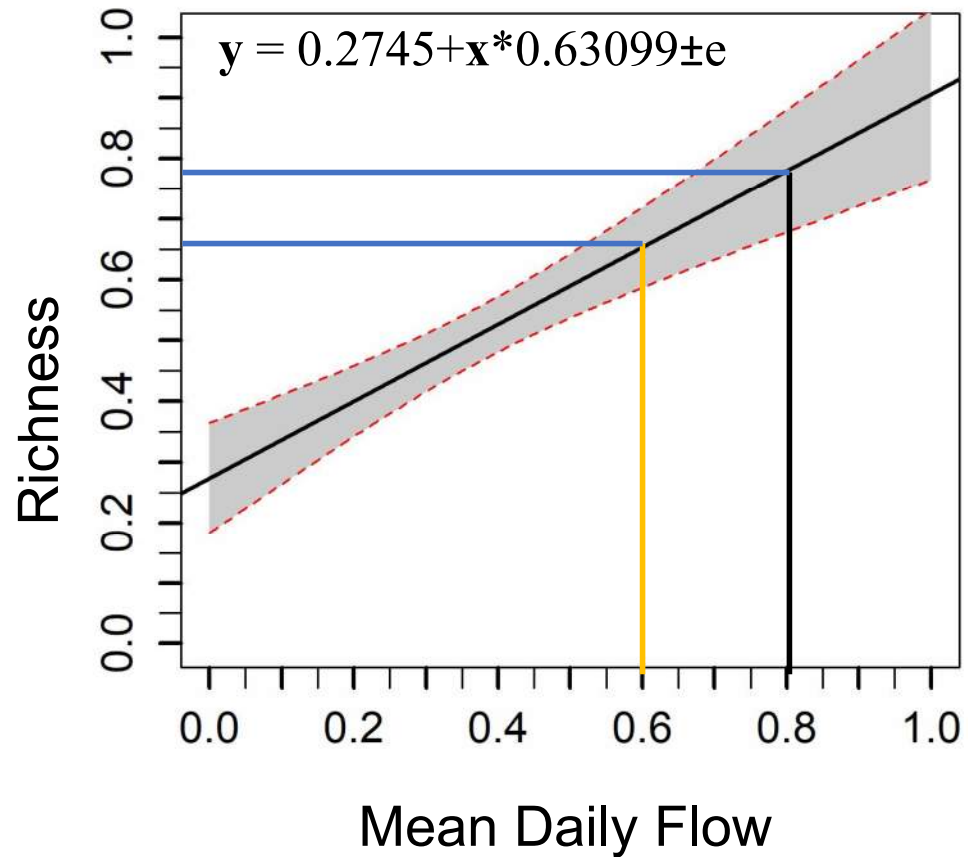
Scenario	Current	Predicted	% Change
MD	100	80	20%
HD	100	60	40%

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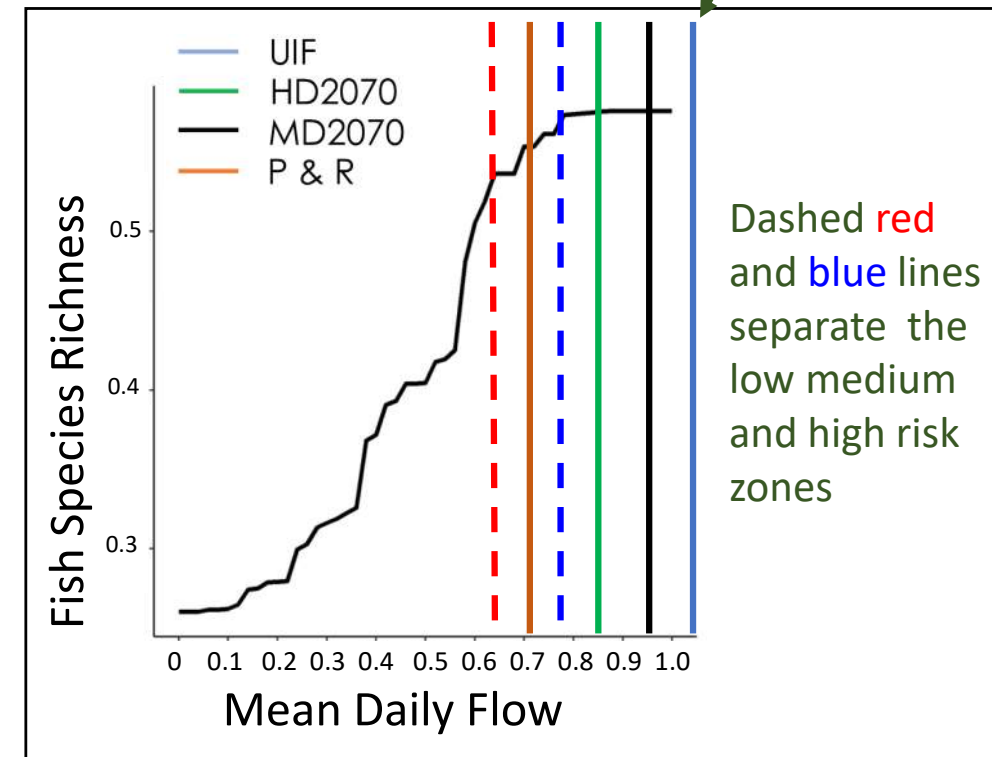
Dashed red and blue lines separate the low medium and high risk zones

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
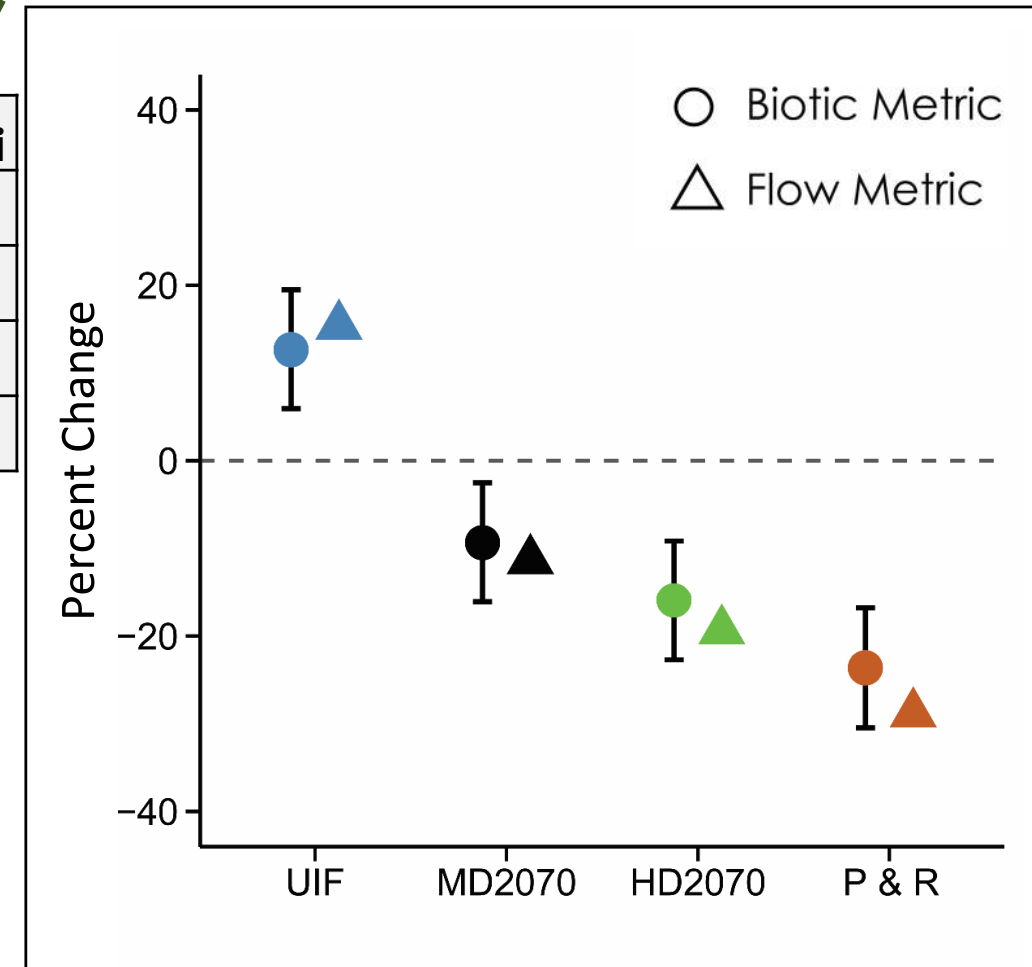
Current Use Scenario
Mean Daily Flow

Scenario
Mean Daily Flows

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

Ecoregions

- ~~Blue Ridge: Mountainous~~

- Piedmont: Rolling hills

- ~~Southeastern plains: Flatter, well drained sandy soils~~

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

Stream Class
- ▲ 1
- ● 3
- ■ 4

Saluda River Basin

0 5 10 20 30 40 Miles
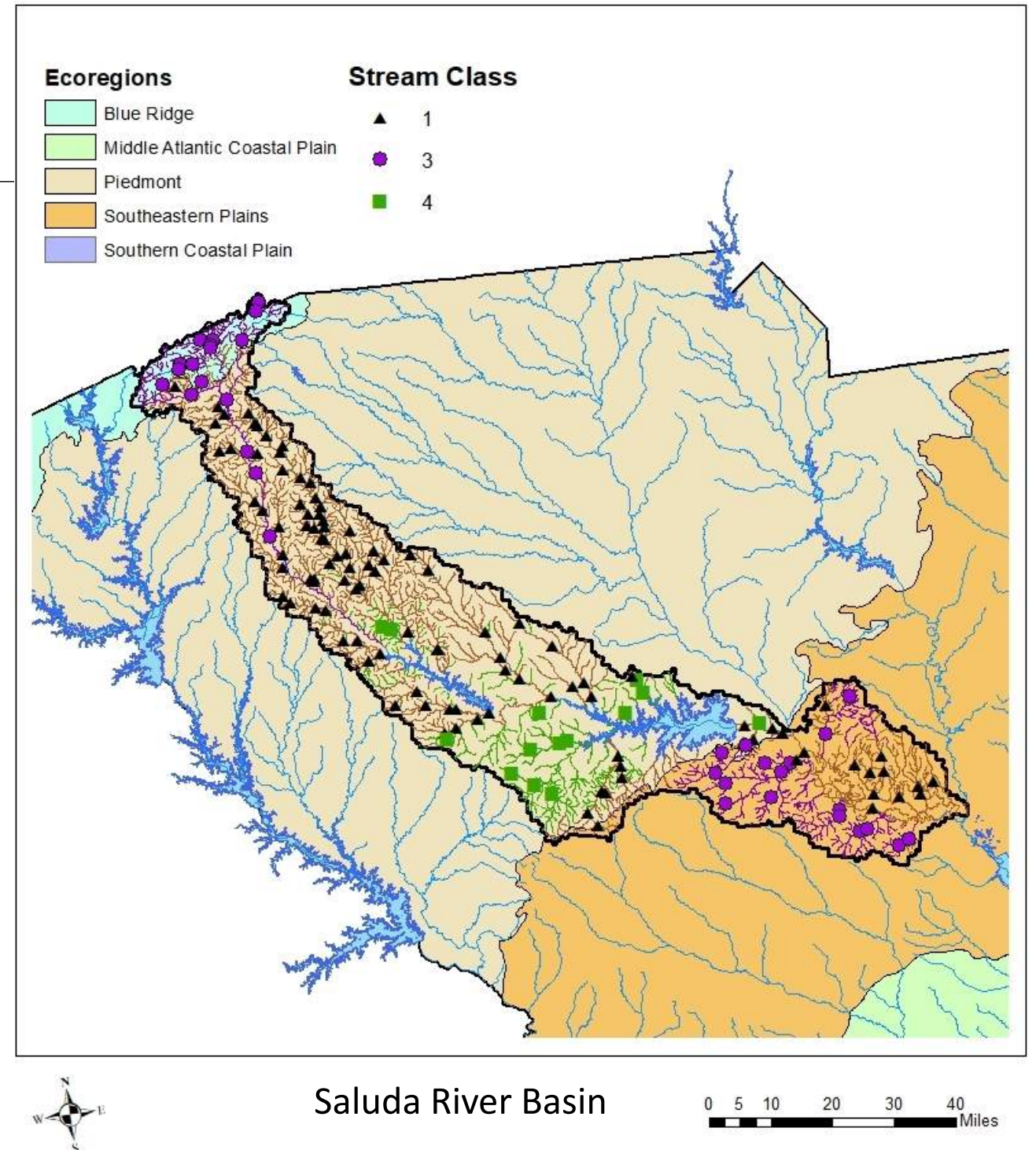
Stream Classes

- 1: Perennial runoff: moderately stable flow and distinct seasonal extremes

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

- 4: Perennial flashy: moderately stable flow with high flow variability
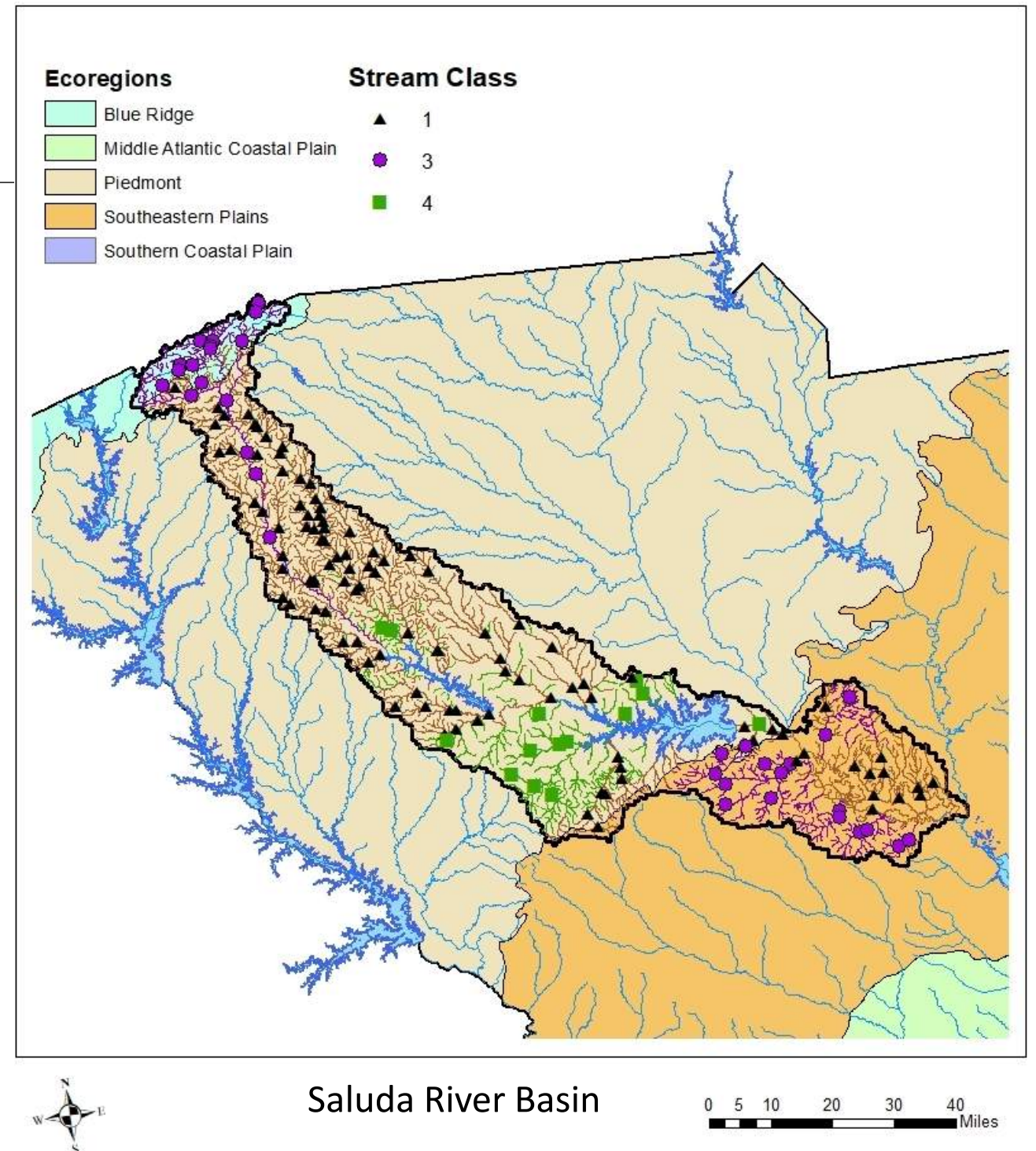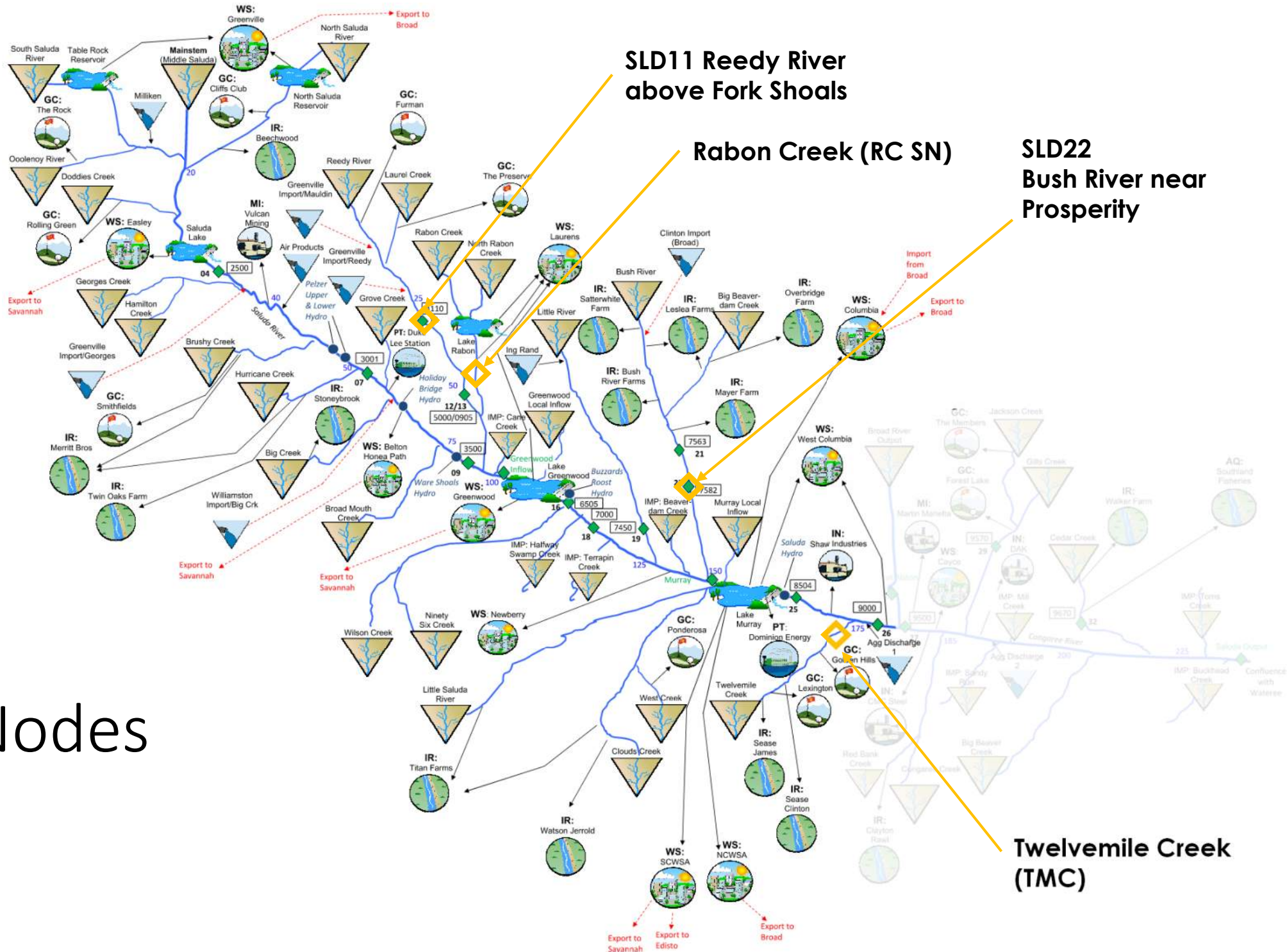
Ecorgions
- Blue Ridge
- Middle Atlantic Coastal Plain
- Piedmont
- Southeastern Plains
- Southern Coastal Plain

Stream Class
- ▲ 1
- ● 3
- ■ 4

Saluda River Basin

0 5 10 20 30 40 Miles

Strategic Nodes

Selected Metrics

	Instream Flow Performance Recommendations and Risk Ranges		
Stream Type:	Piedmont Perennial Runnoff		
	Risk Ranges		
	Low	**Med**	**High**
Flow Metric			
Mean Daily Flow (FR)	>0.78	0.64-0.78	<0.64
Calendar Day of Lowest Flow (BHF)	>327		

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

BHF=Brood hiding fishes. Brood hiders bury of place their eggs in a concealed location, but do not guard or provide any parental care.

SLD22 Bush River: MA1-Richness
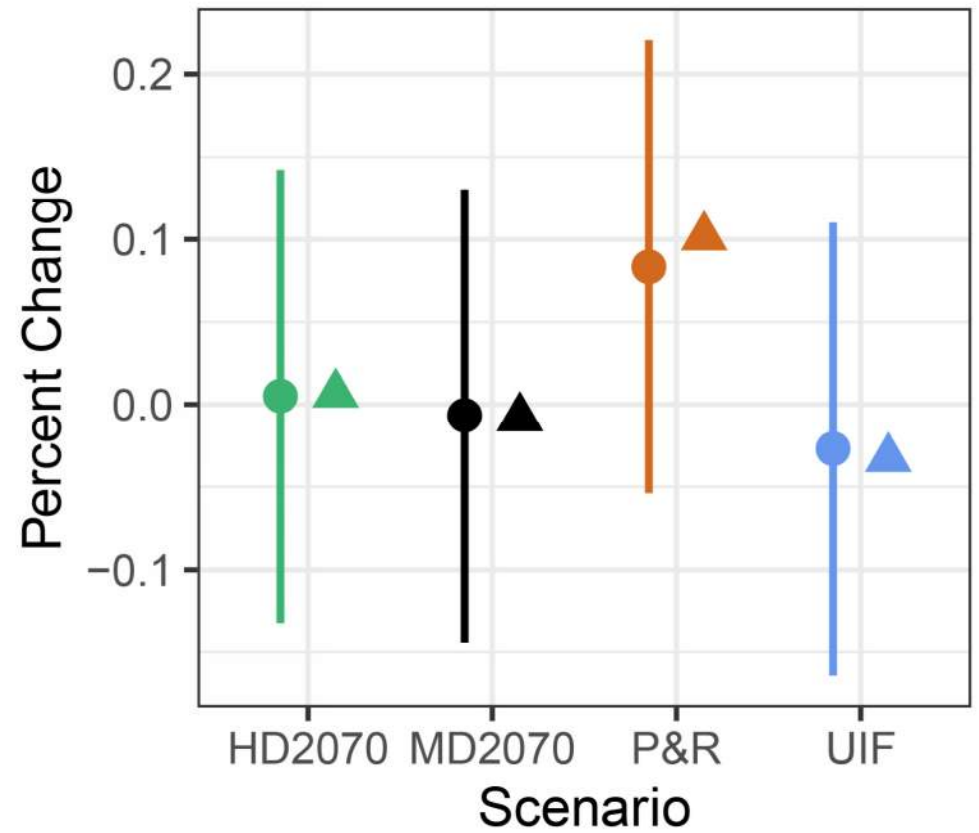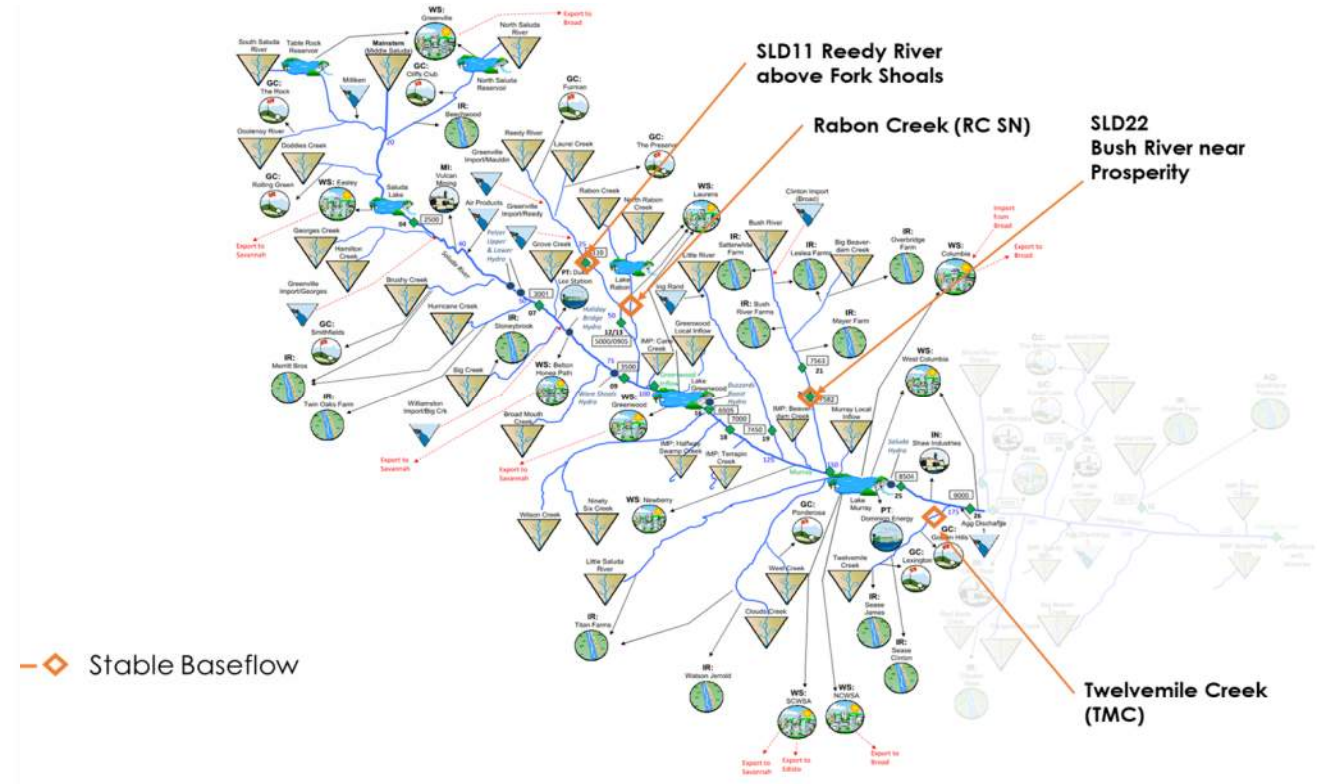
Scenario	Current	Predicted	% Flow	Bio Metric	% Bio	SE	95%
UIF	205.89	199.12	-3%	Richness	-3%	7	13.9
MD 2070	205.894	204.21	-1%	Richness	-1%	7	13.9
HD 2070	205.894	207.17	1%	Richness	1%	7	13.9
P&R	205.894	226.79	-10%	Richness	-8%	7	13.9

SLD22 Bush River : MA1-Richness

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	205.89	199.12	-3%	Richness	Low
MD 2070	205.894	204.21	-1%	Richness	Low
HD 2070	205.894	207.17	1%	Richness	Low
P&R	205.894	226.79	-10%	Richness	Low
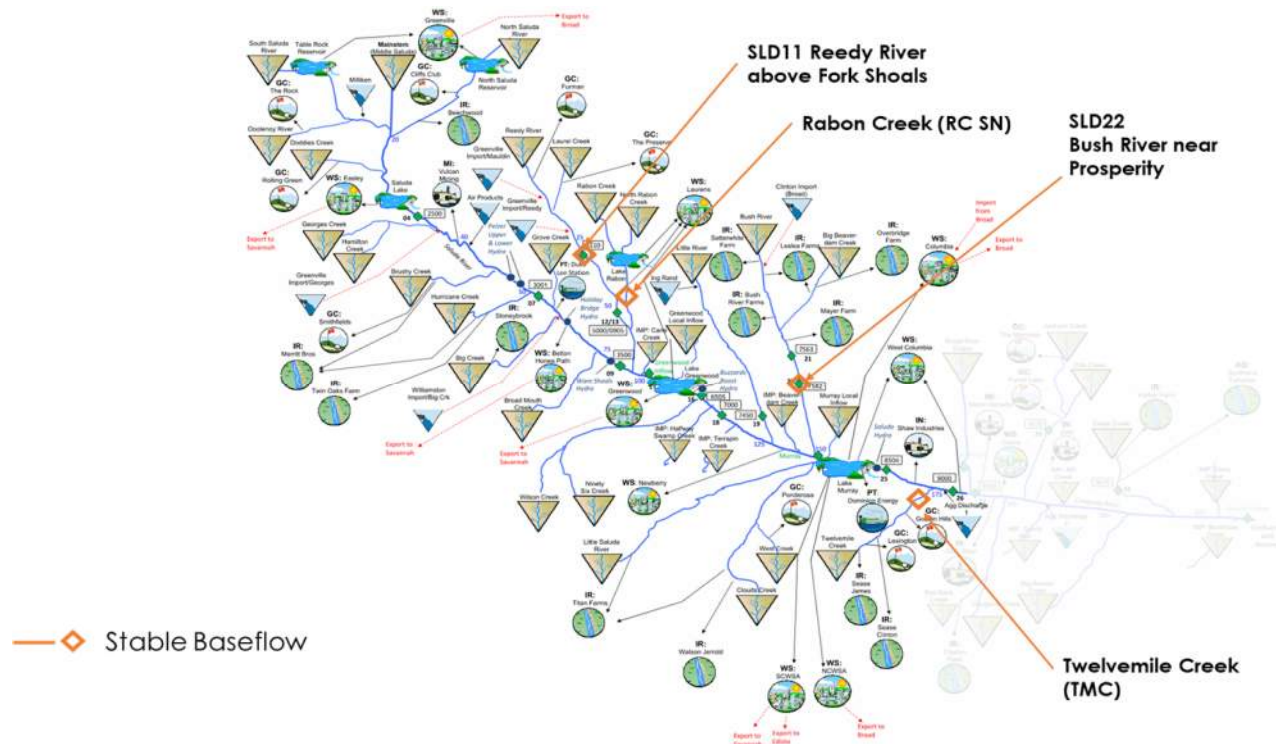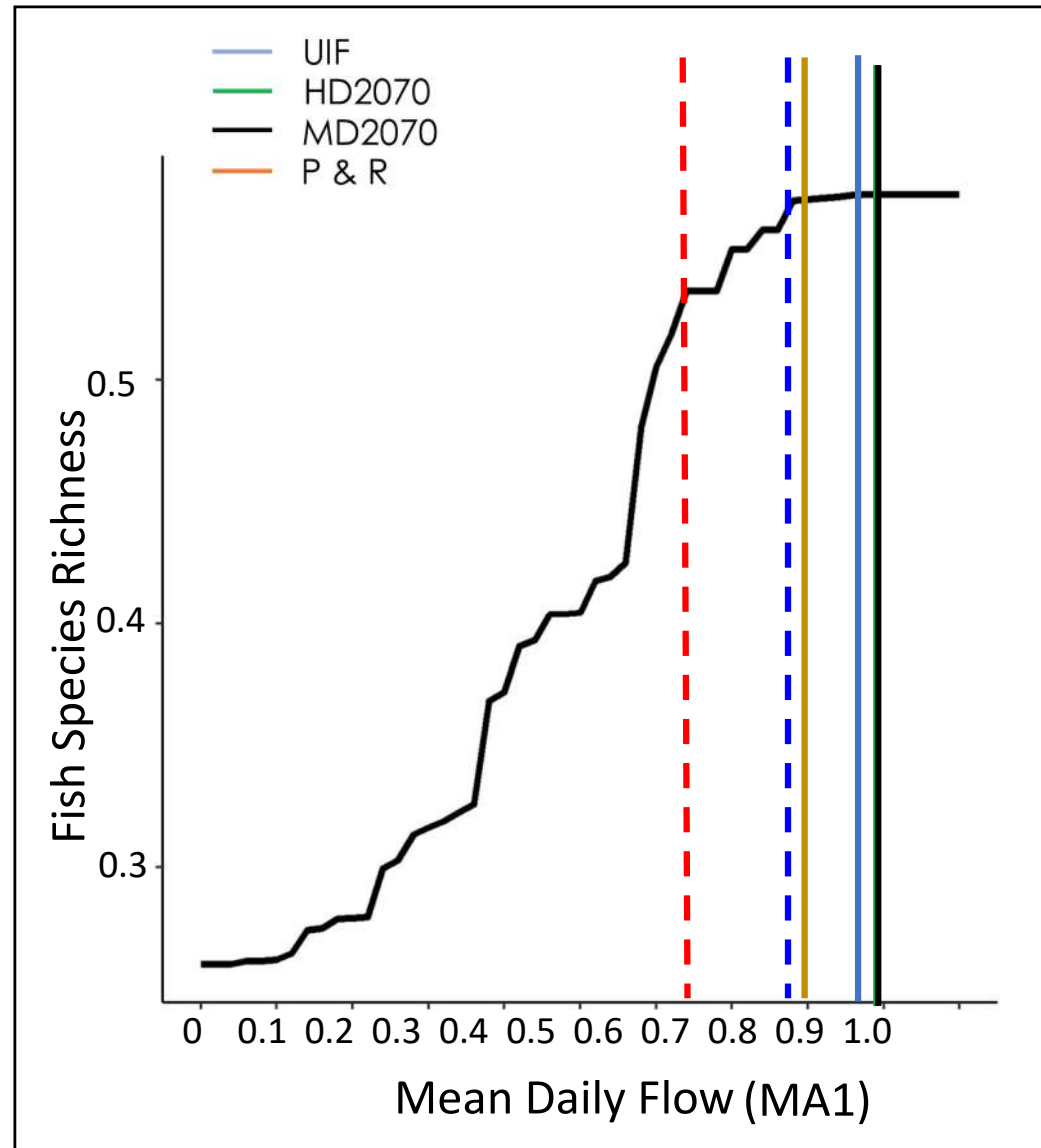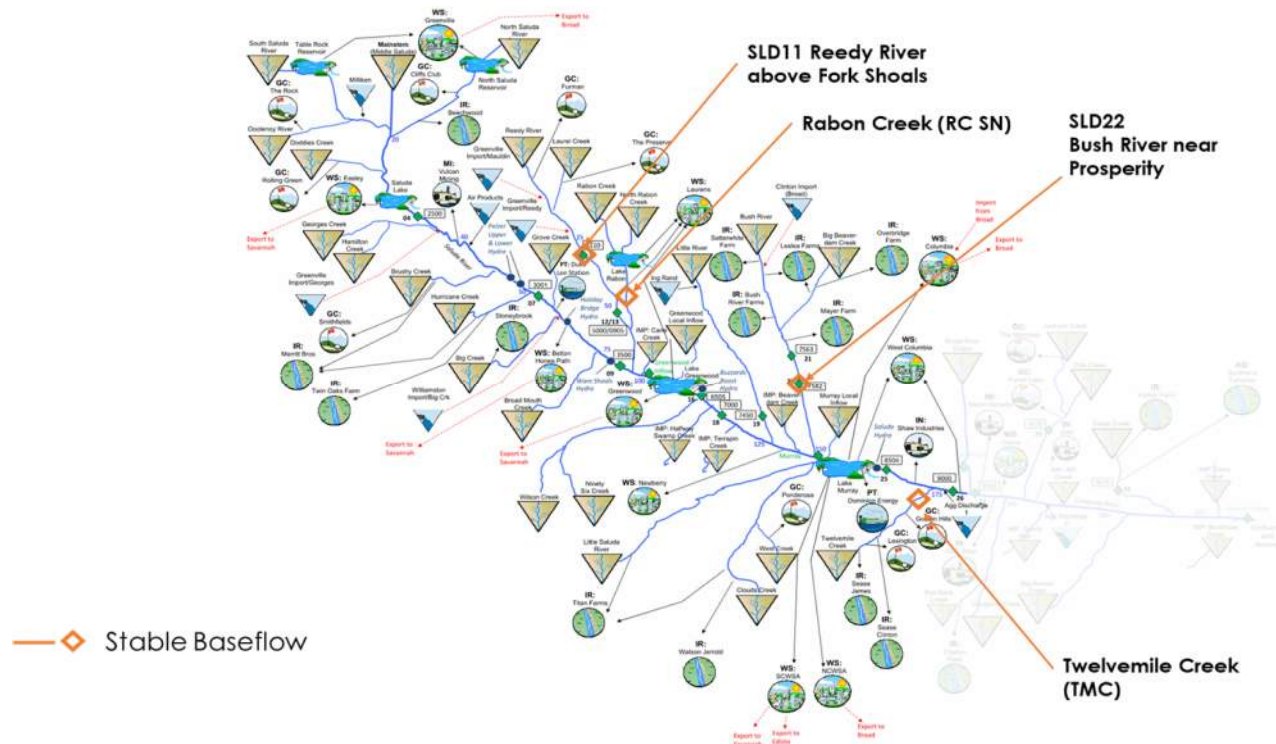
SLD22 Bush River : TL1-Brood hiding fishes

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	227	242	6%	Brood	Low
MD 2070	227	227	0%	Brood	Low
HD 2070	227	225	<-1%	Brood	Low
P&R	227	224	-1%	Brood	Low

Stable Baseflow

TL1

Brood Hiders

Timing of Low Flow
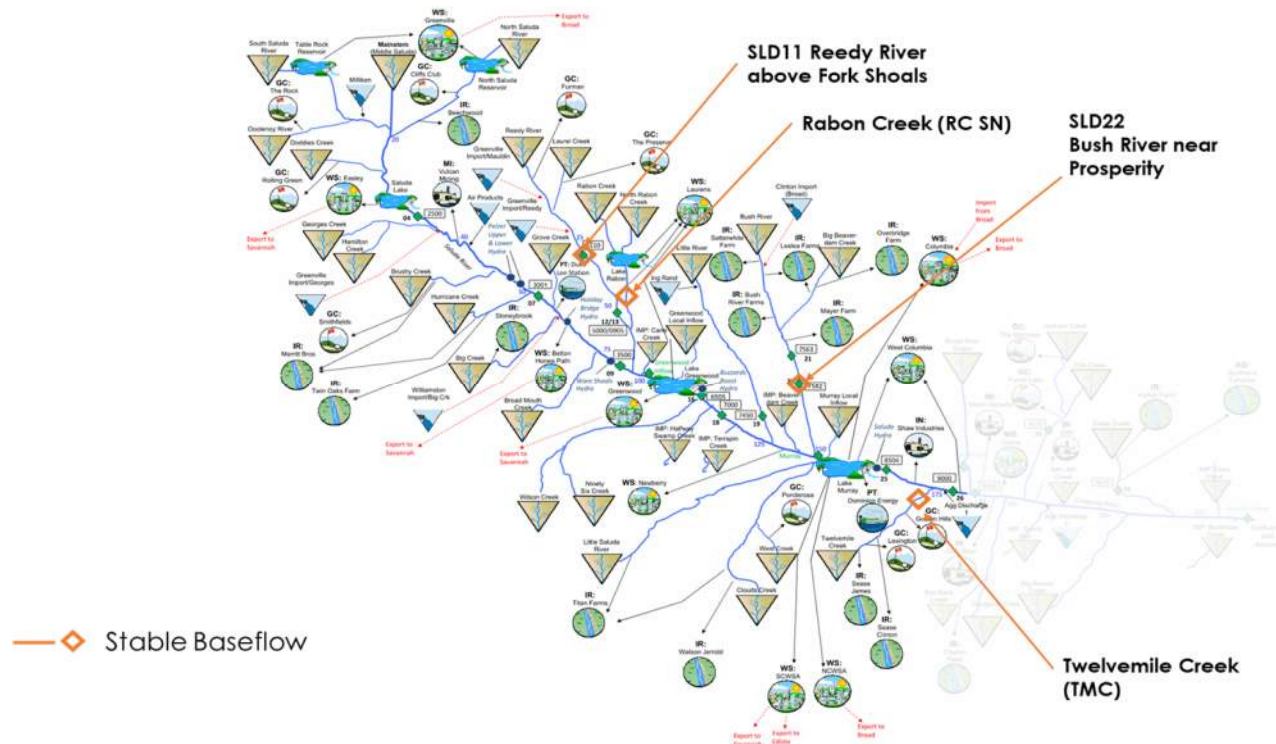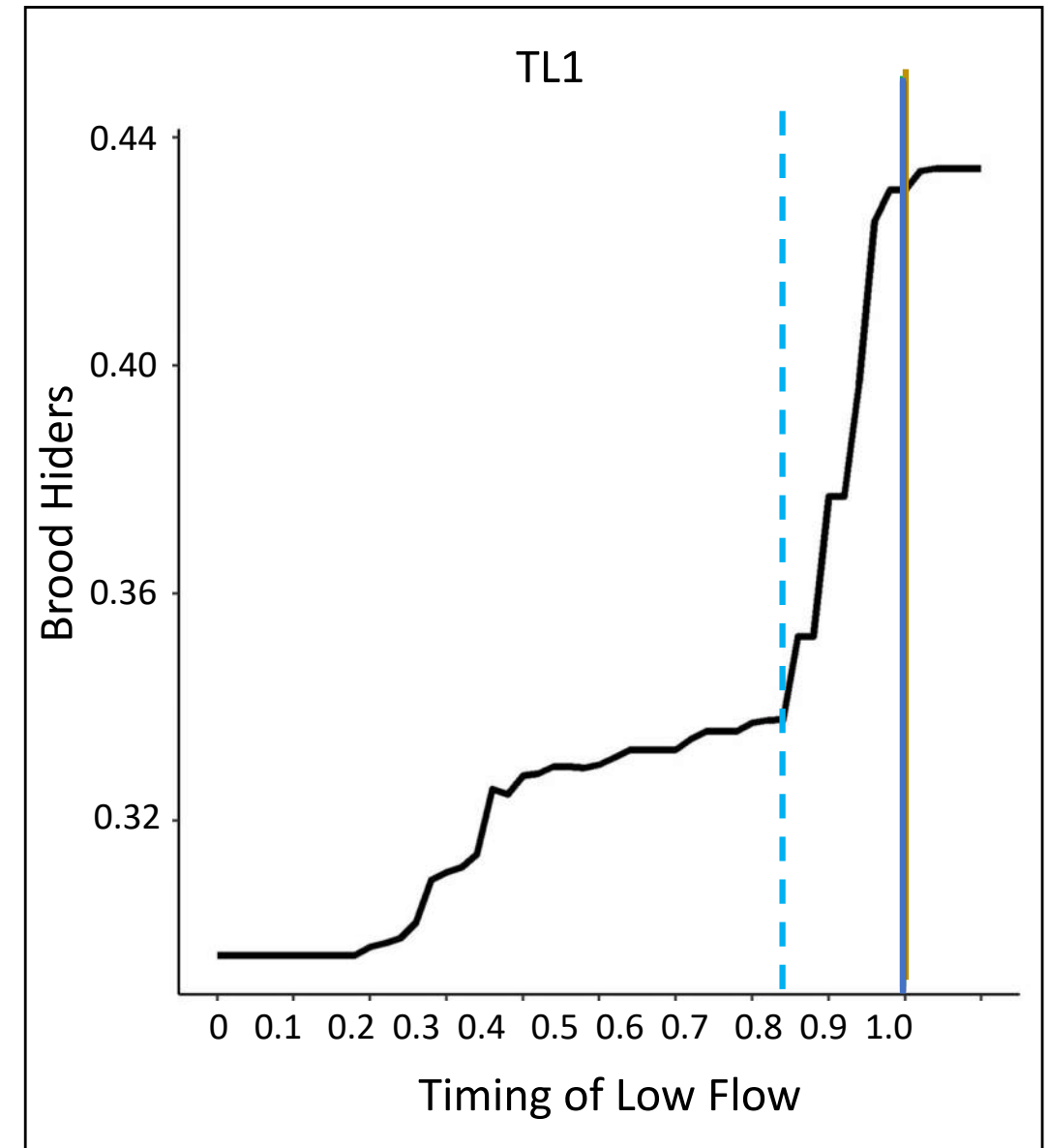
RCSN Rabon Creek: MA1-Richness

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	99.83	104.24	-4%	Richness	Low
MD 2070	99.83	99.64	0%	Richness	Low
HD 2070	99.83	98.48	-1%	Richness	Low
P&R	99.83	35.562	-64%	Richness	High
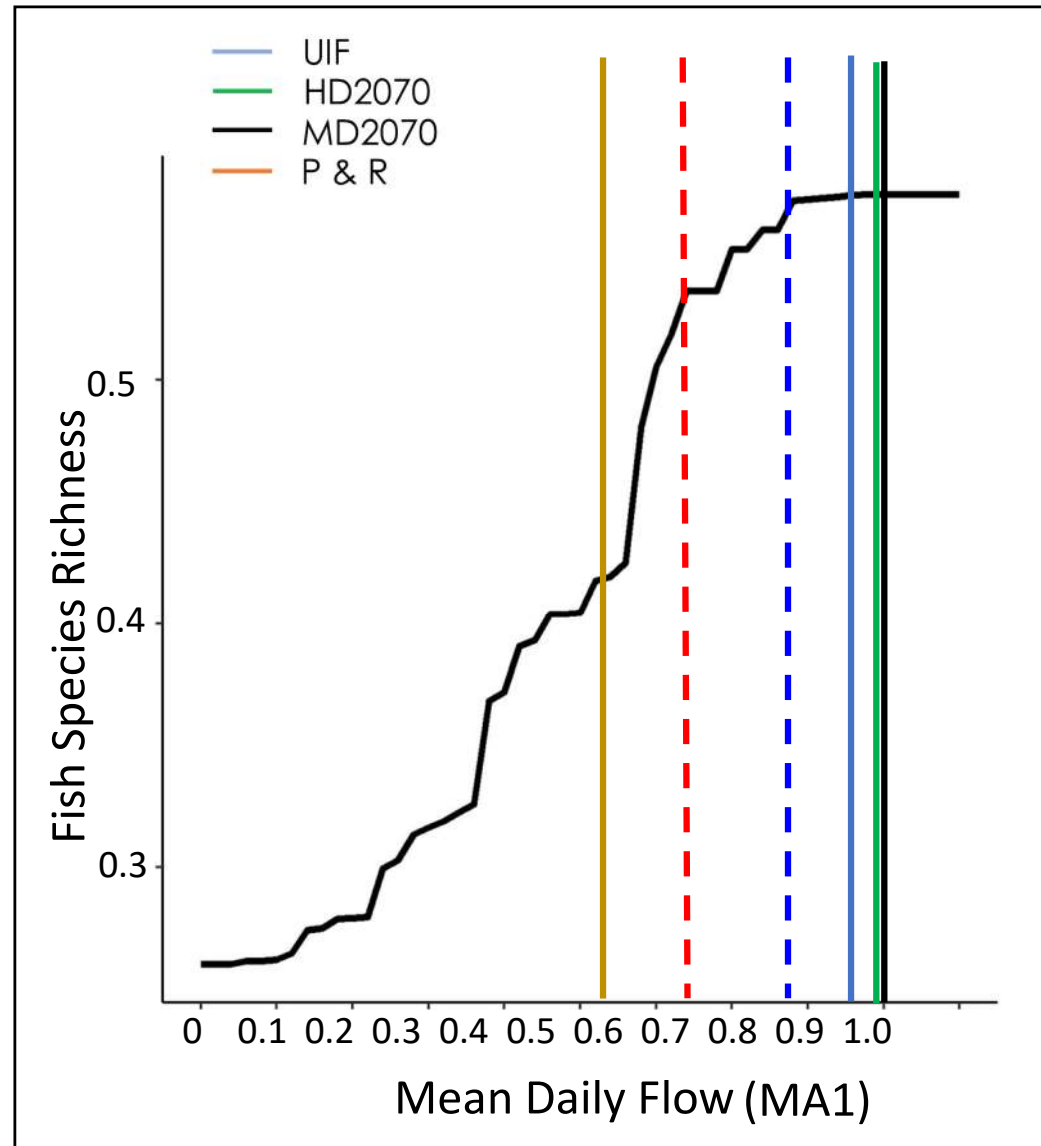
RCSN Rabon Creek: MA1-Richness
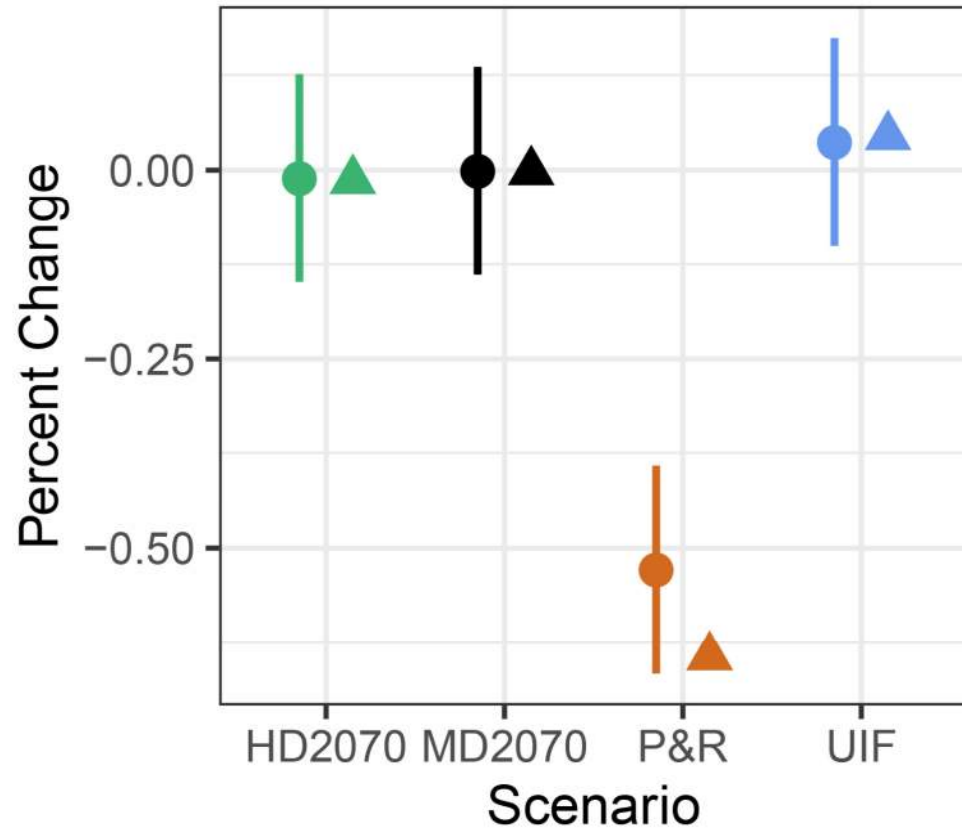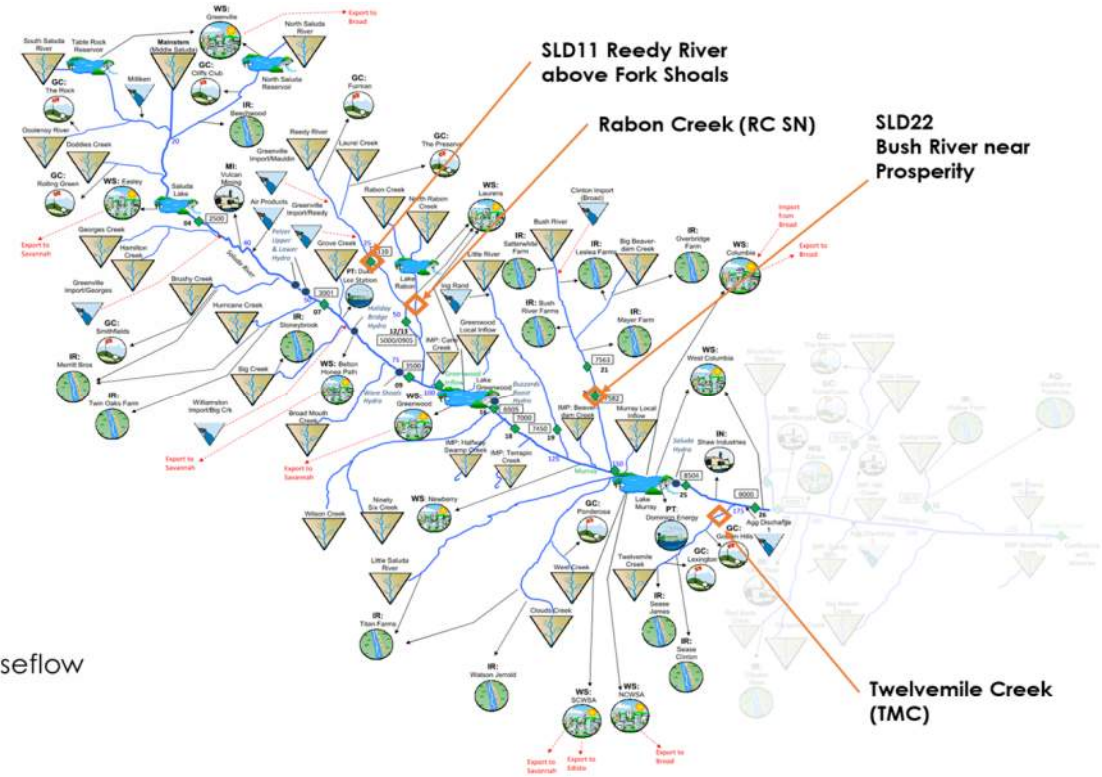
Scenario	Current	Predicted	% Flow	Bio Metric	% Bio	SE	95%
UIF	99.83	104.24	-4%	Richness	-4%	7	13.9
MD 2070	99.83	99.64	0%	Richness	0%	7	13.9
HD 2070	99.83	98.48	-1%	Richness	-1%	7	13.9
P&R	99.83	35.562	-64%	Richness	-53%	7	13.9

RCSN Rabon Creek: TL1-Brood hiding fishes

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	256	256	0%	Brood	Low
MD 2070	256	256	0%	Brood	Low
HD 2070	256	257	<-1%	Brood	Low
P&R	256	255	0%	Brood	Low
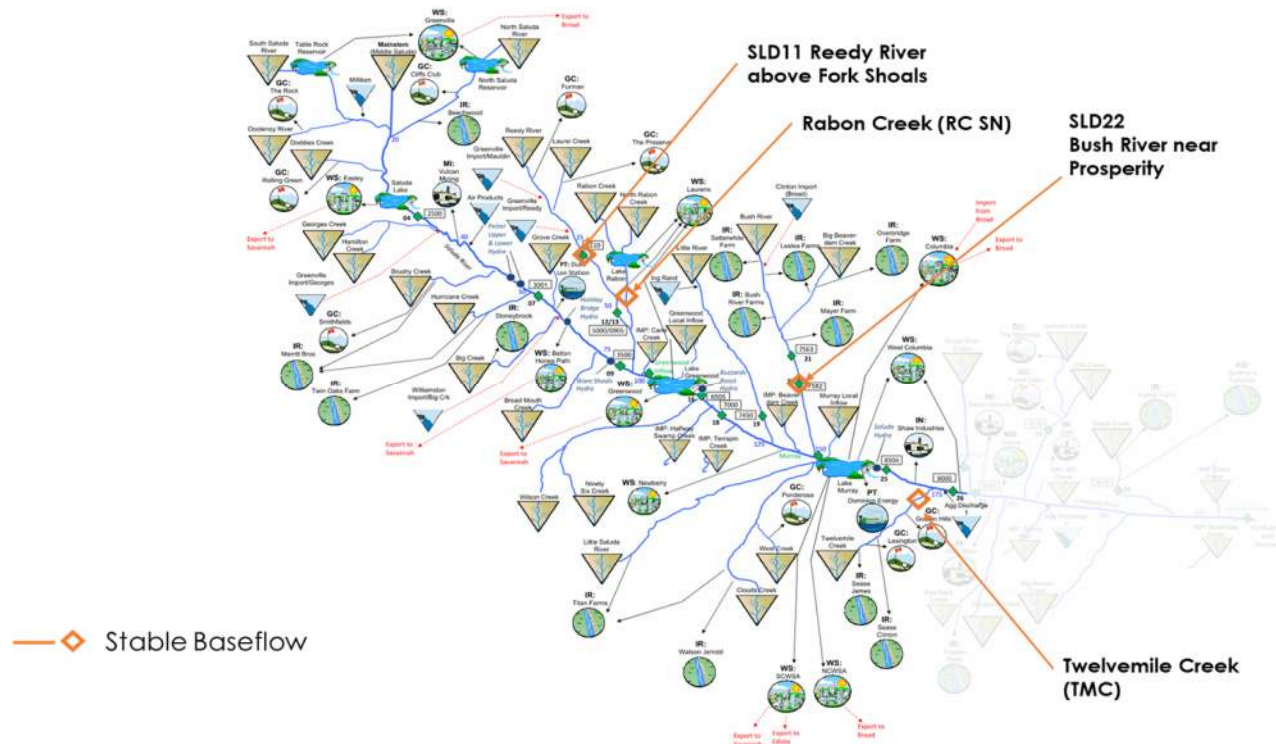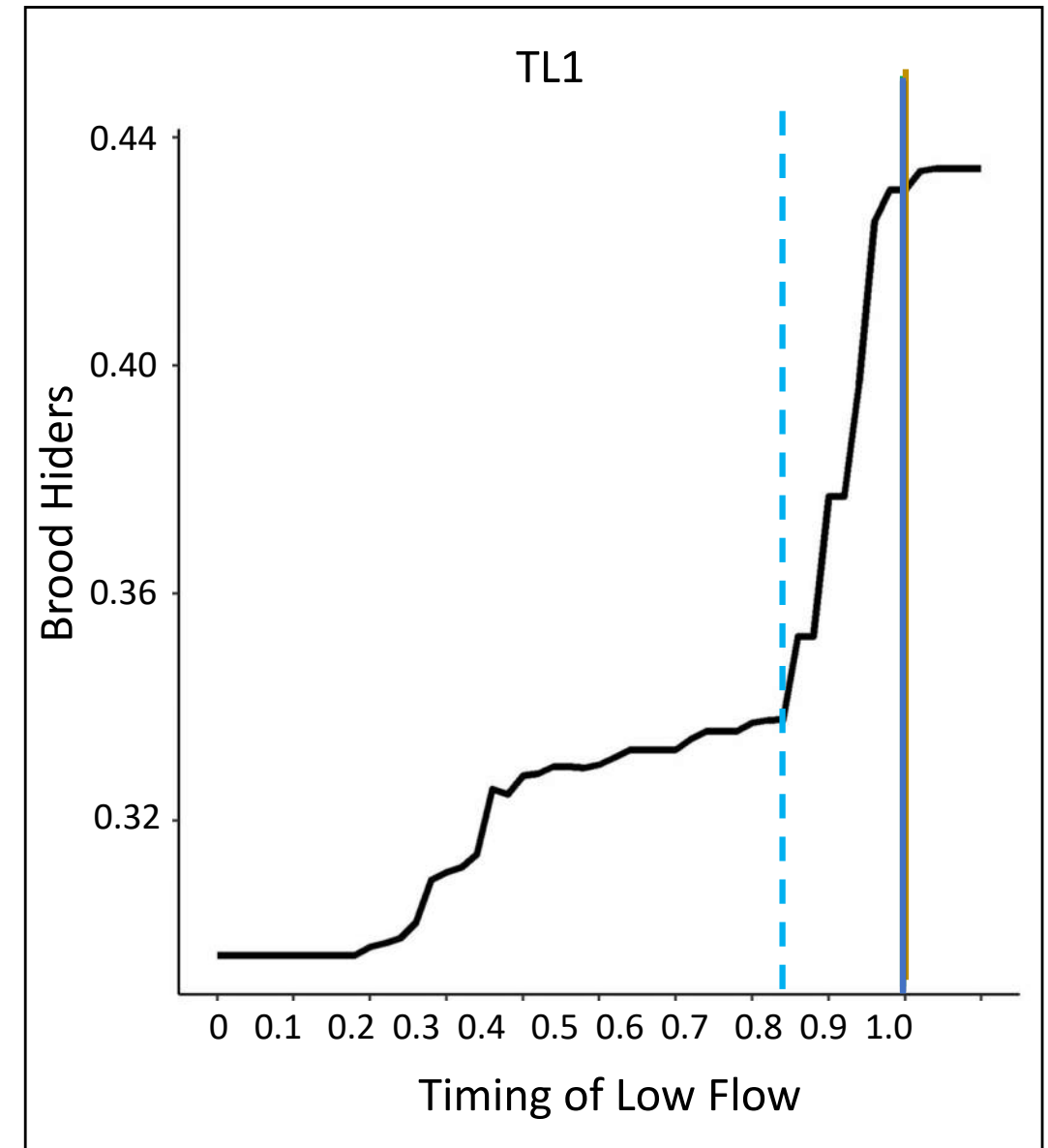
SWAP-listed fishes in Saluda River basin

V-LIP REDHORSE

Santee Chub

Carolina Darter

Greenfin Shiner

Seagreen Darter

Fieryblack Shiner

Highback Chub

Carolina Fantail Darter

Eastern Brook Trout

All photos from ncfishes.com

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

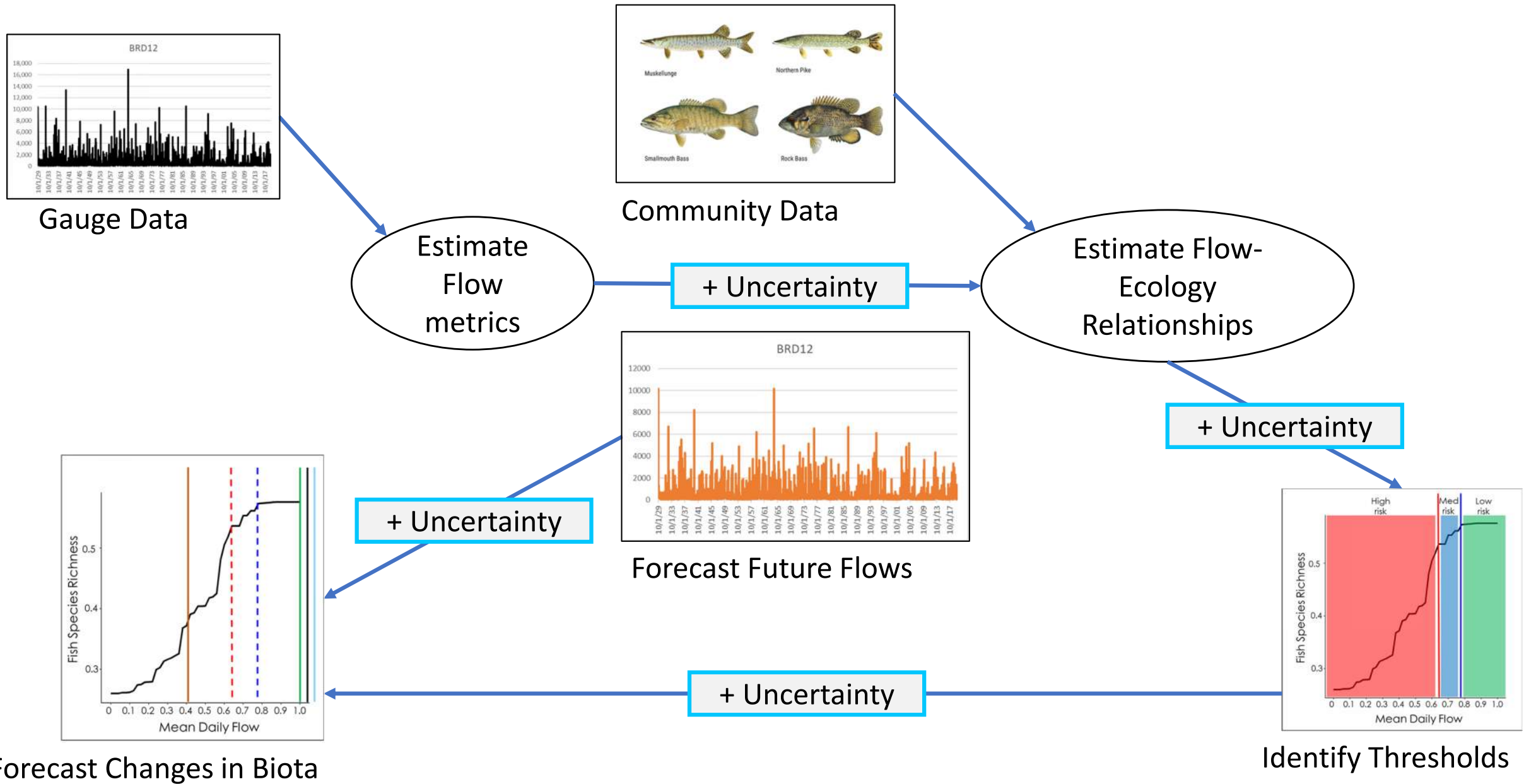Forecast Changes in Biota

+ Uncertainty

Identify Thresholds

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**
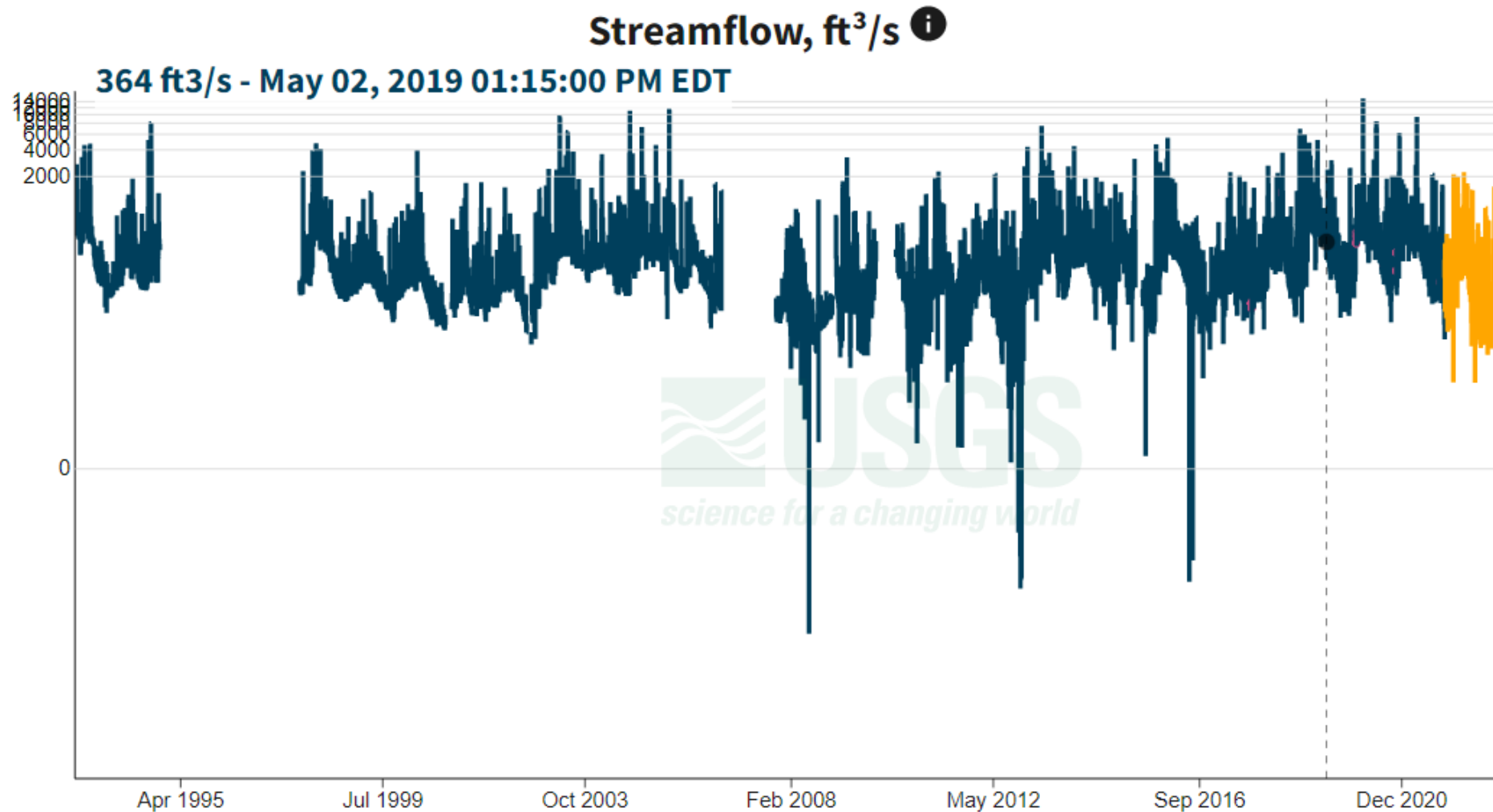
What this info *is not*

- **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 summer

- P&R scenario showed greatest impact for MA1 and Richness.
  - Other SWAM scenarios show little to no impact on flow

- Little to no change in TL1 for all scenarios

- Report to follow

Questions

SLD111 Reedy River: MA1-Richness

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	223.56	180.13	-19.4%	Richness	Med
MD 2070	223.56	231.17	-0.03%	Richness	Low
HD 2070	223.56	232.74	-0.04%	Richness	Low
P&R	223.56	230.62	-0.03%	Richness	Low
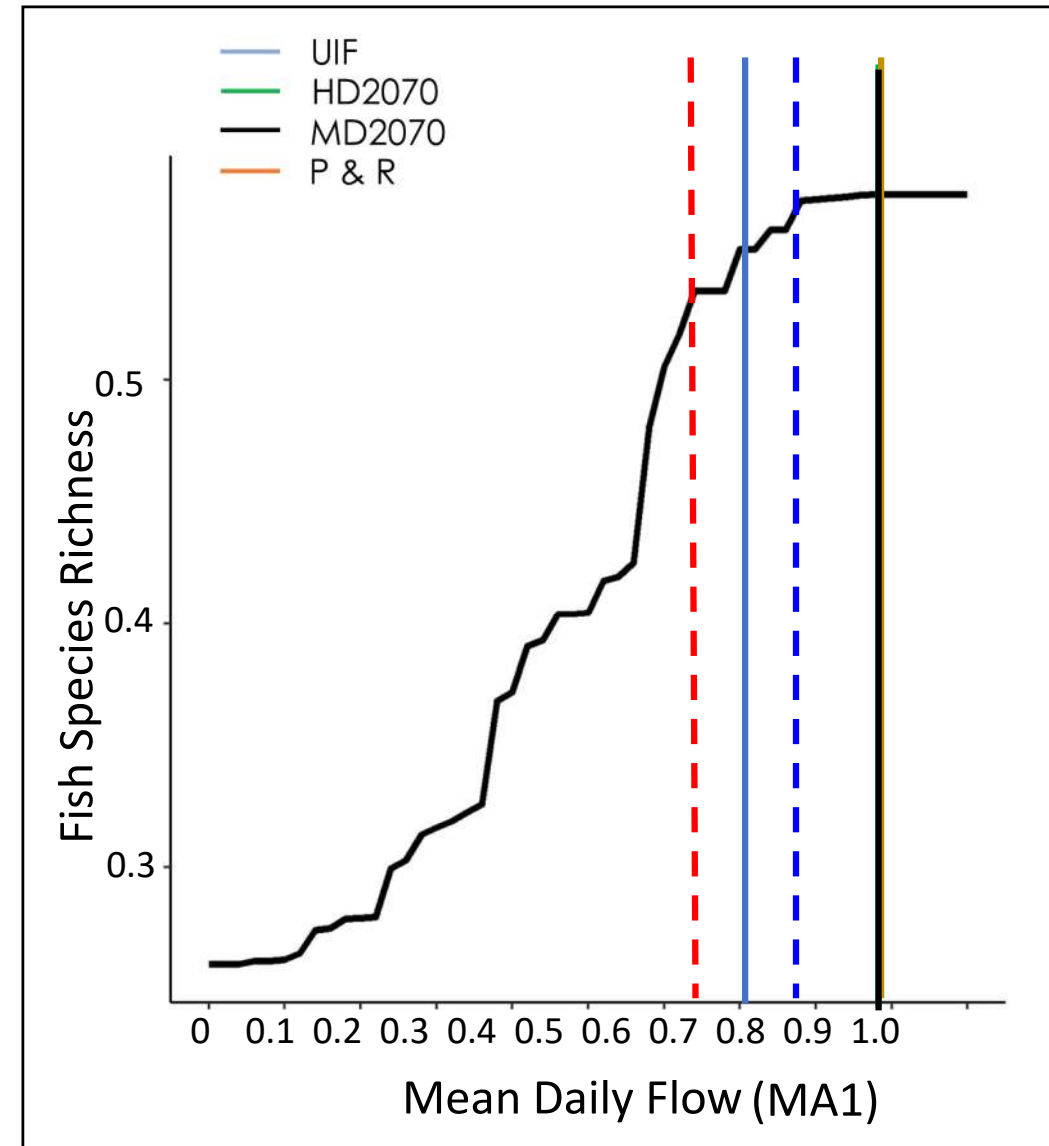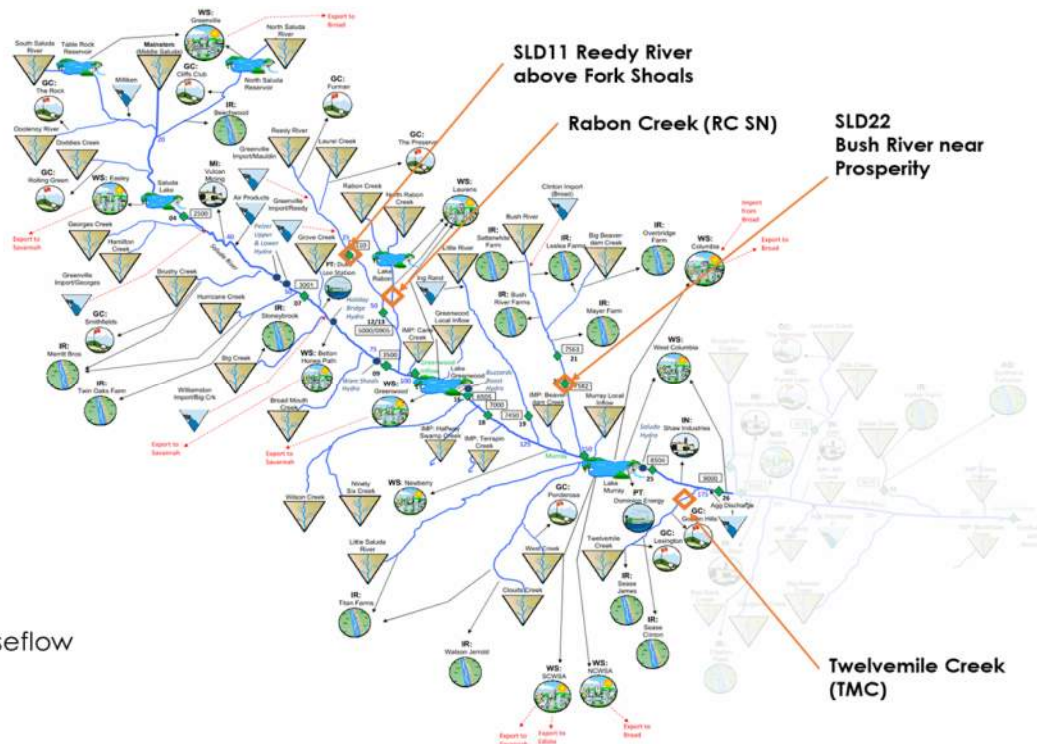
SLD111 Reedy River: MA1-Richness
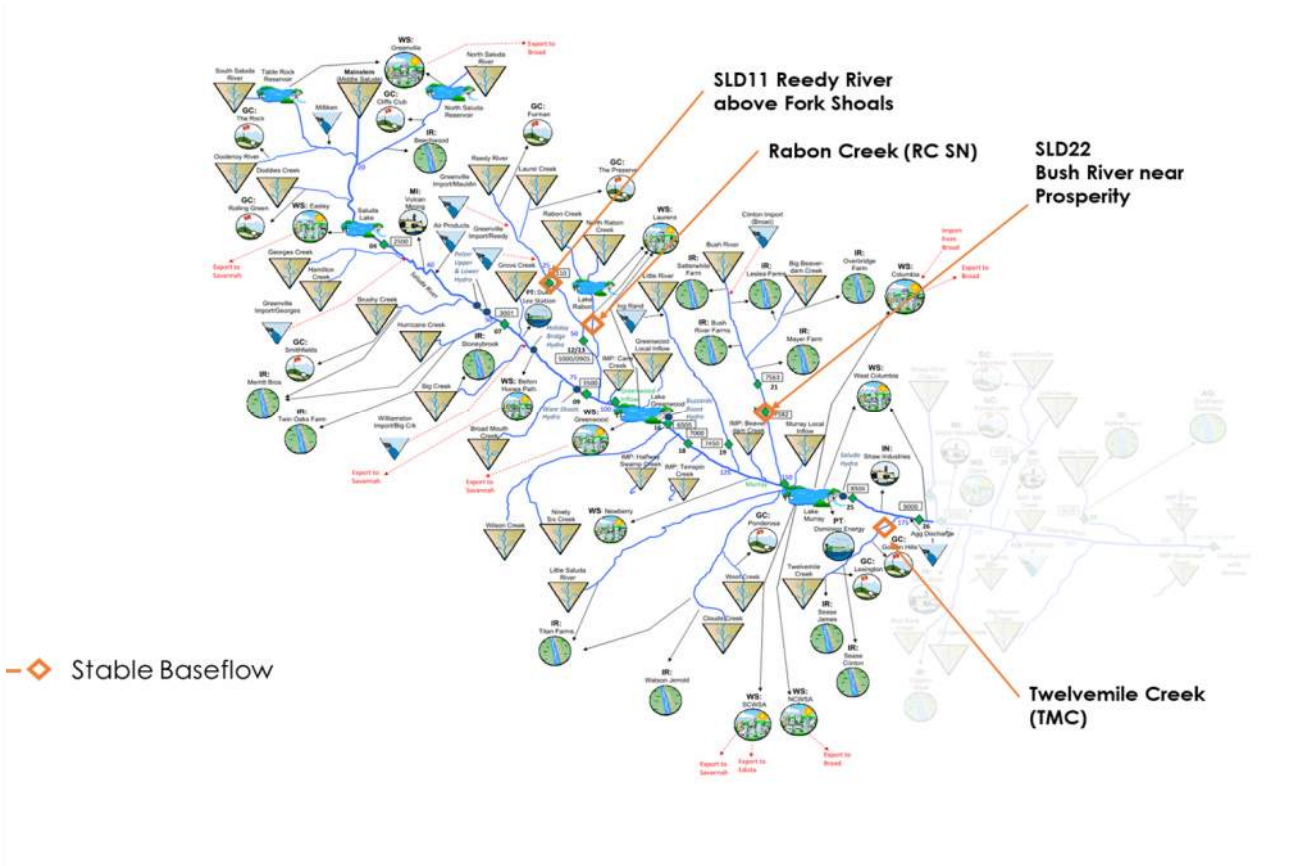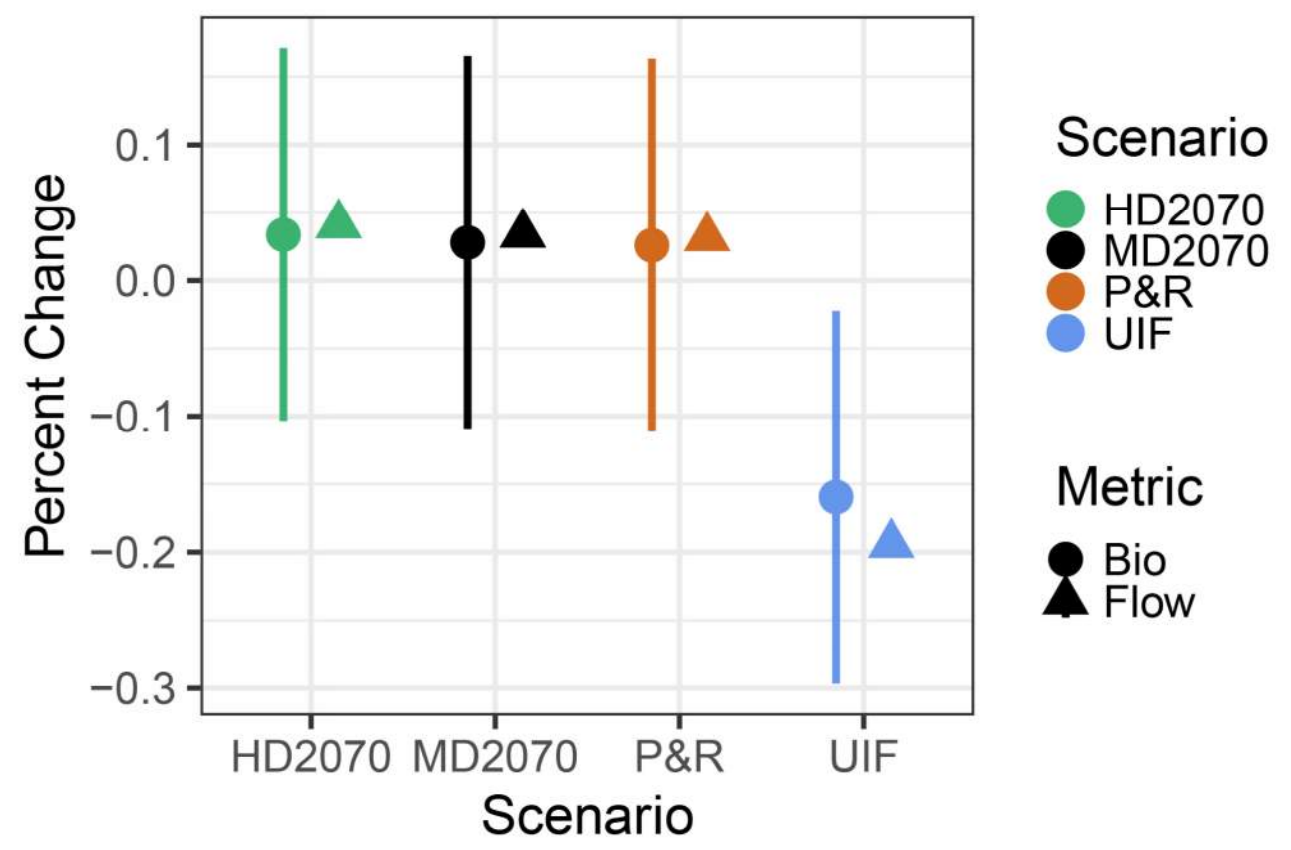
Scenario	Current	Predicted	% Flow	Bio Metric	% Bio	SE	95%
UIF	223.56	180.13	-19.4%	Richness	-16%	7	13.9
MD 2070	223.56	231.17	-0.03%	Richness	-3%	7	13.9
HD 2070	223.56	232.74	-0.04%	Richness	-3%	7	13.9
P&R	223.56	230.62	-0.03%	Richness	-3%	7	13.9

SLD111 Reedy River: TL1-Brood hiding fishes

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	260	260	0%	Brood	Low
MD 2070	260	259	<-1%	Brood	Low
HD 2070	260	258	<-1%	Brood	Low
P&R	260	259	<-1%	Brood	Low
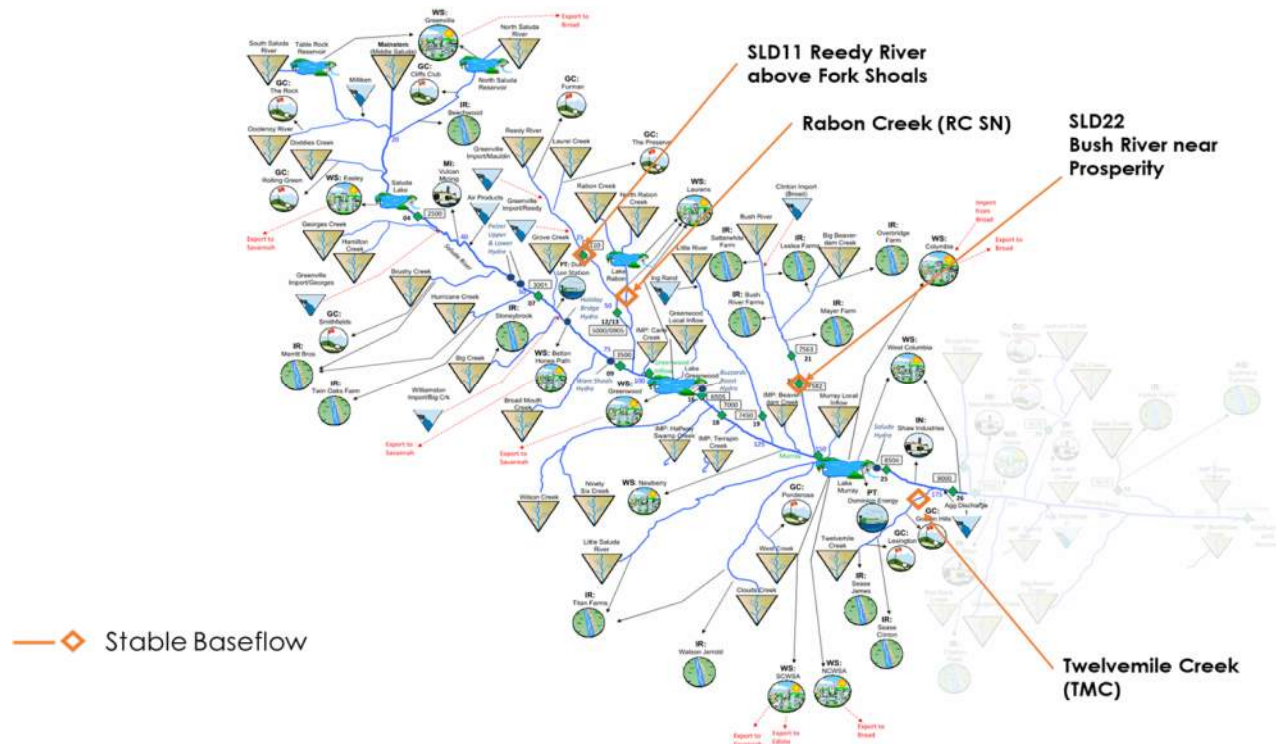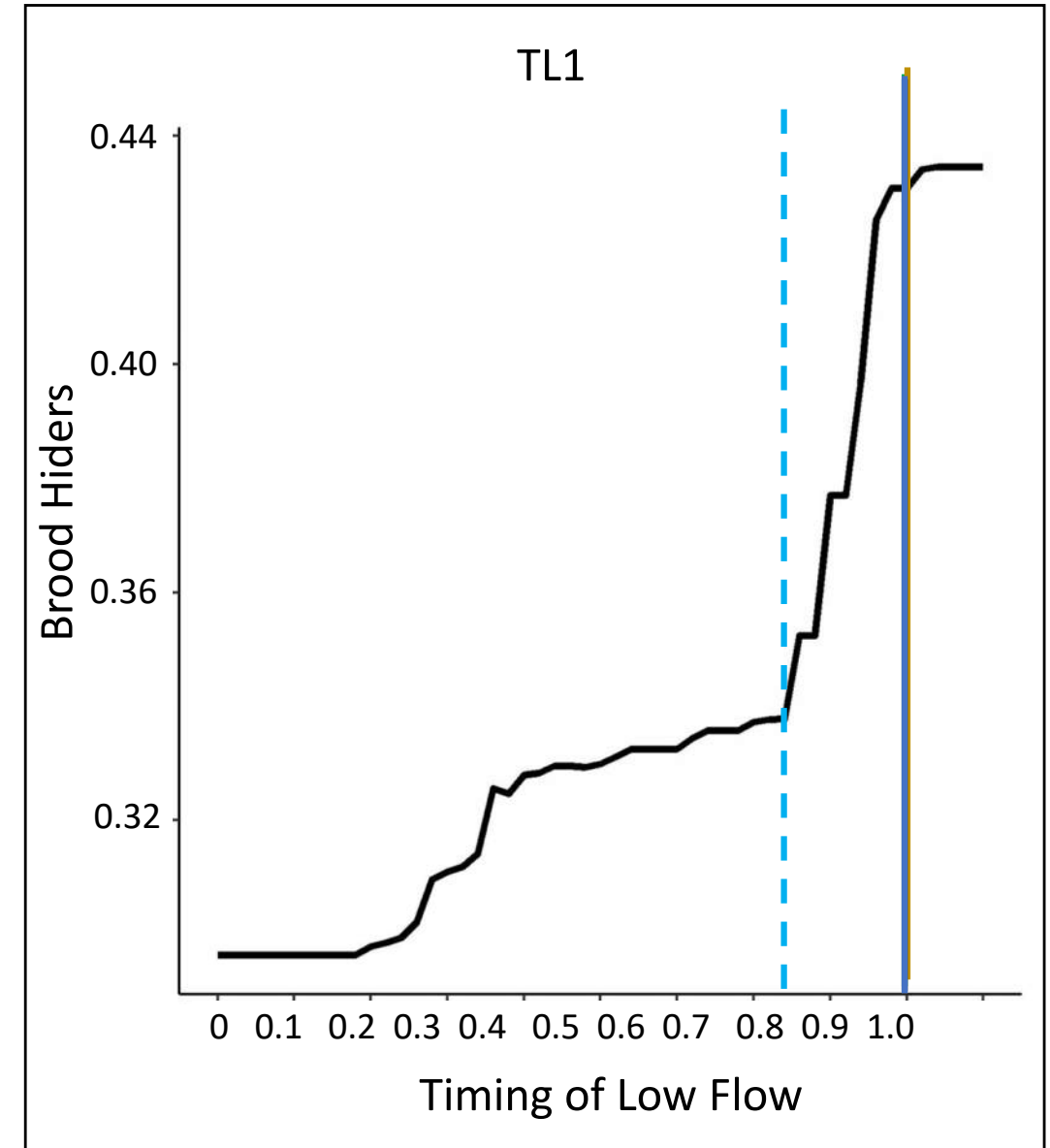
Twelvemile Creek: MA1-Richness
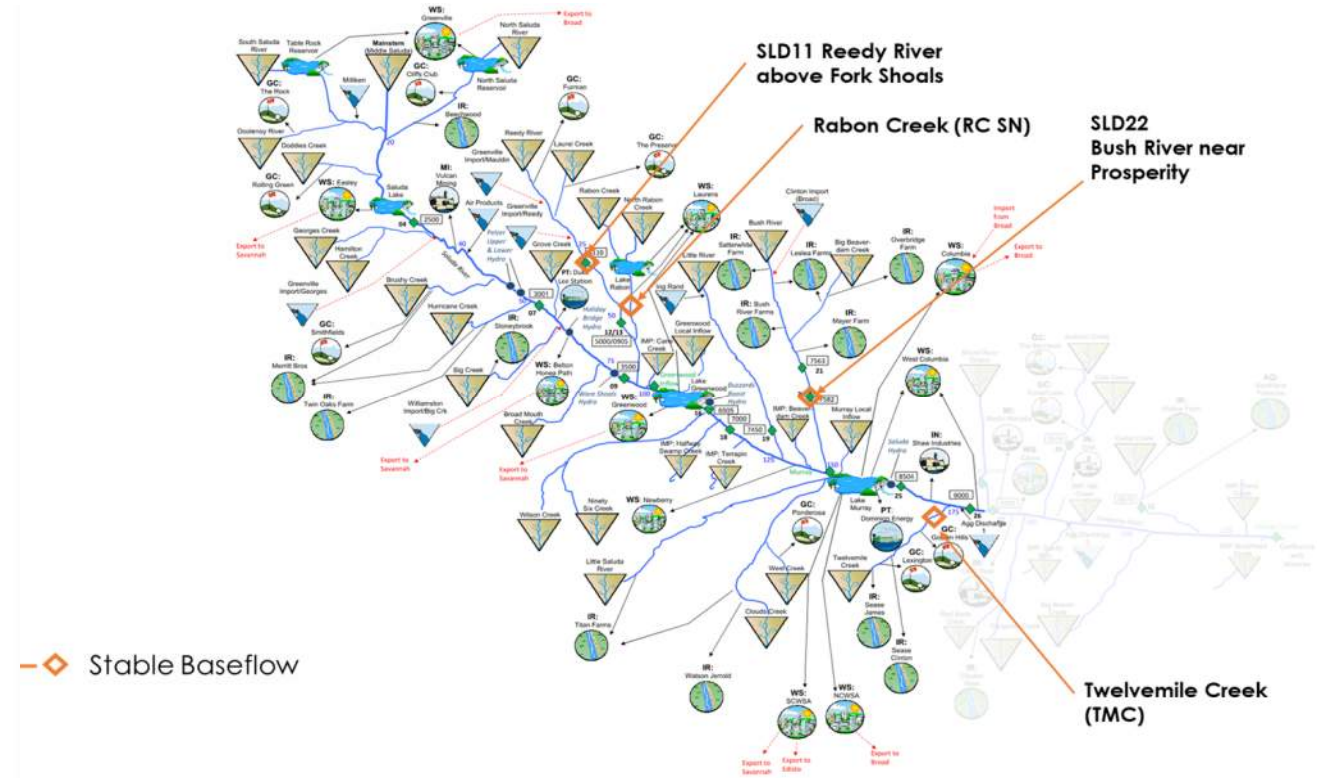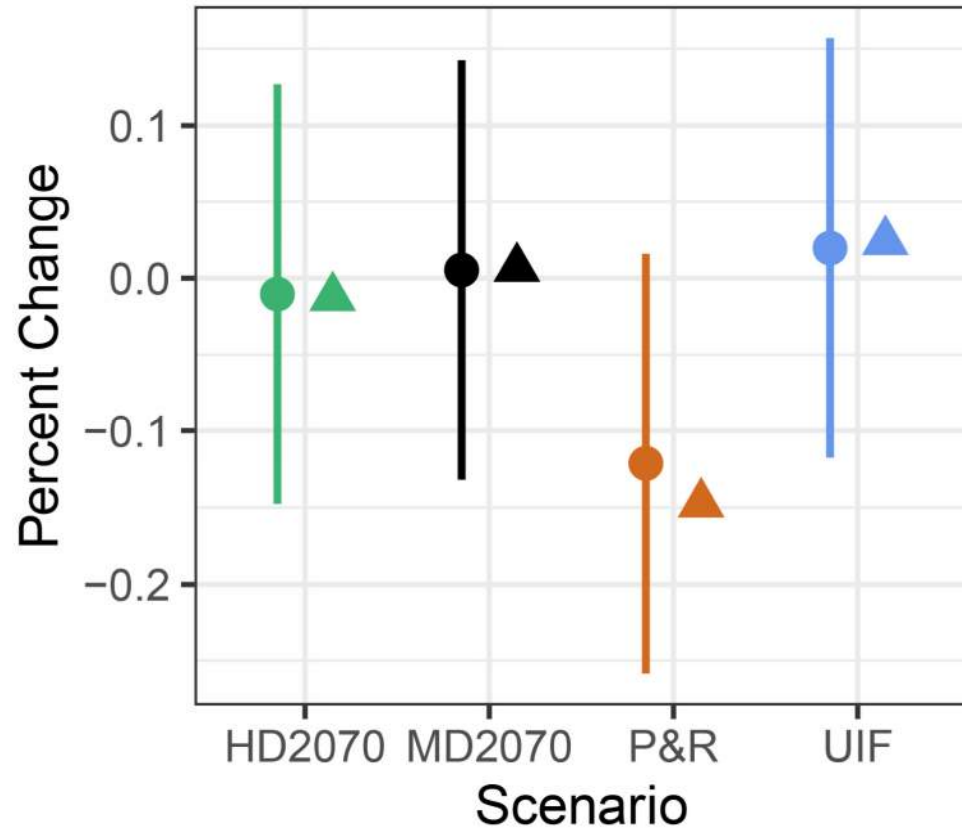
Scenario	Current	Predicted	% Flow	Bio Metric	% Bio	SE	95%
UIF	27.78	28.44	2.4%	Richness	2%	7	13.9
MD 2070	27.78	27.96	<1%	Richness	<1%	7	13.9
HD 2070	27.78	27.43	-1%	Richness	-1%	7	13.9
P&R	27.78	23.68	-15%	Richness	-12%	7	13.9

Twelvemile Creek: MA1-Richness

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	27.78	28.44	2.4%	Richness	Low
MD 2070	27.78	27.96	<1%	Richness	Low
HD 2070	27.78	27.43	-1%	Richness	Low
P&R	27.78	23.68	-15%	Richness	Med
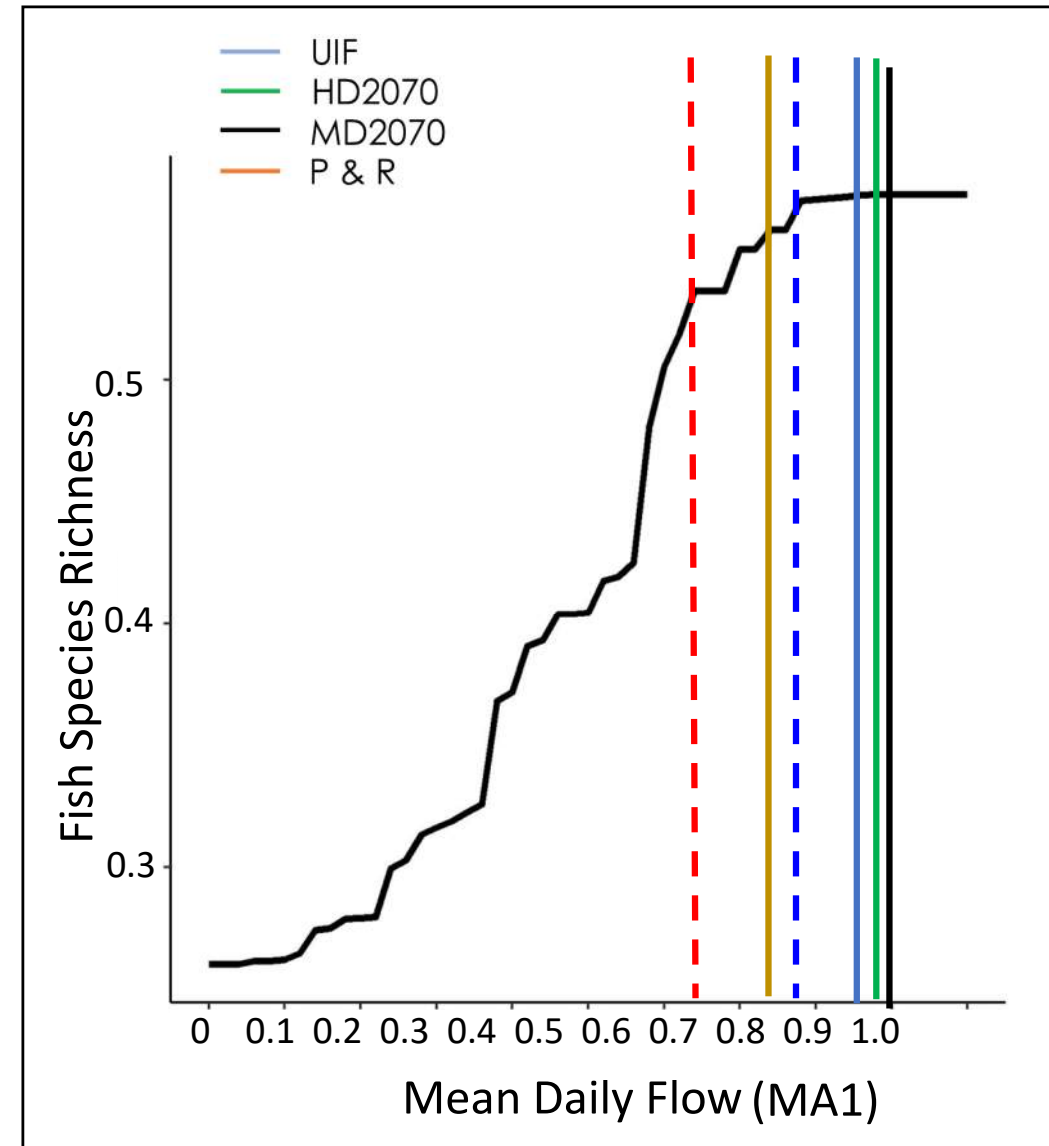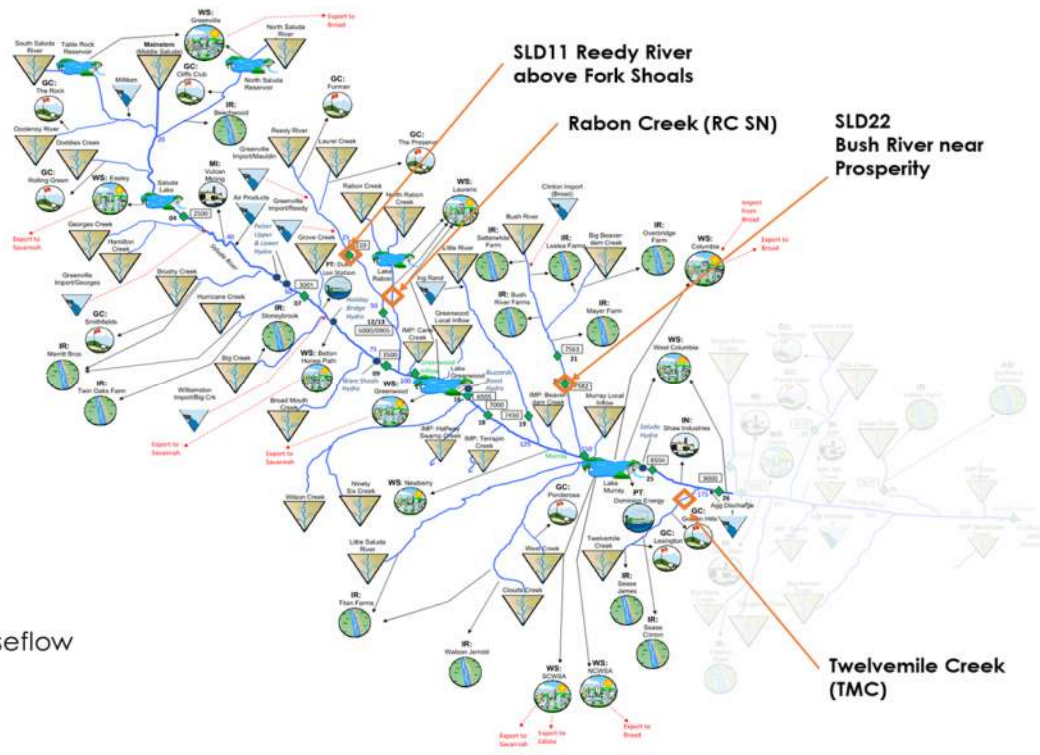
Twelvemile Creek: TL1-Brood hiding fishes

Scenario	Current	Predicted	% change	Bio Metric	Risk
UIF	257	259	<1%	Brood	Low
MD 2070	257	260	1%	Brood	Low
HD 2070	257	255	<-1%	Brood	Low
P&R	257	256	<-10%	Brood	Low

SLD11 Reedy River above Fork Shoals

Rabon Creek (RC SN)

SLD22 Bush River near Prosperity

Twelvemile Creek (TMC)

Stable Baseflow

TL1

Brood Hiders

Timing of Low Flow