



# Further exploring Flow-Fish Richness Relationships

Broad River Basin Council

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## What this info is

- **Guidances 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

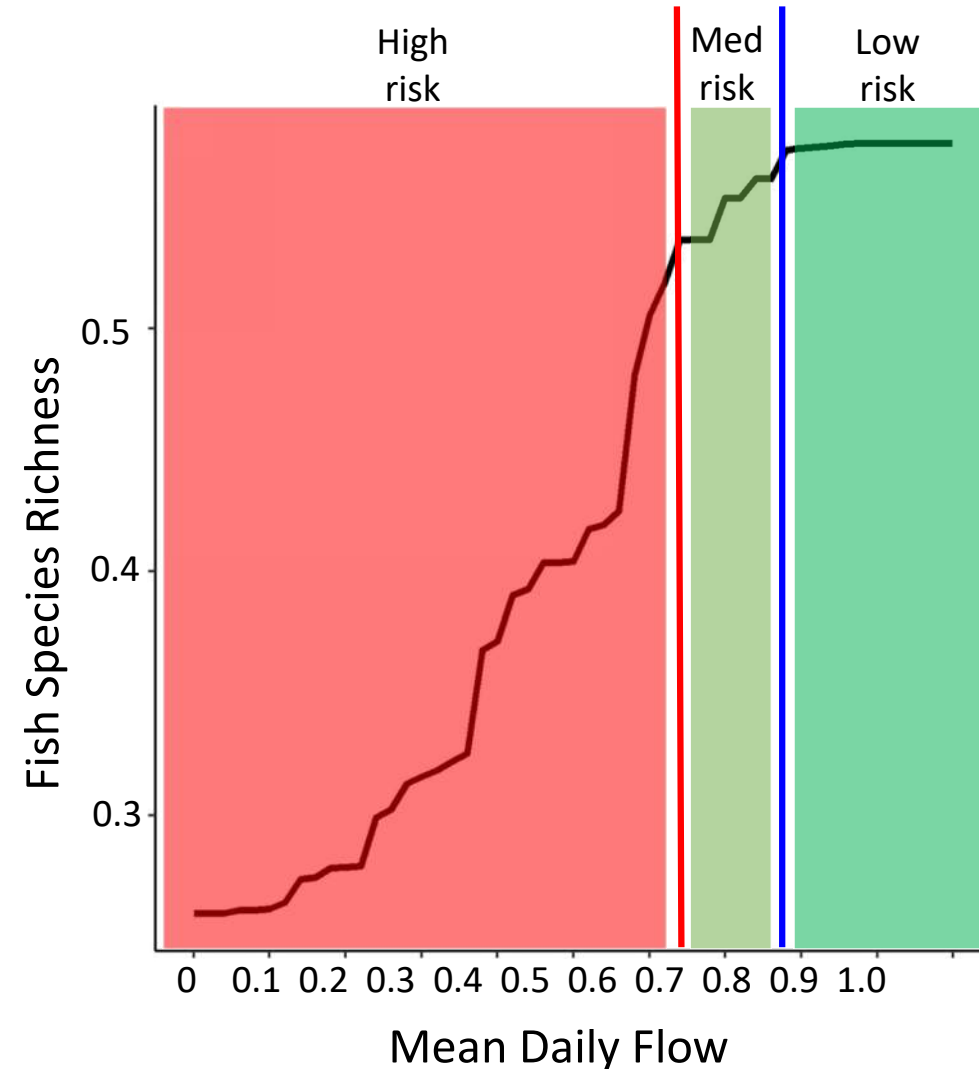
- **Arbitrary recommendations from 'expert advice'**
- **Perfect.**
- **More data = less uncertainty**
- **Changing climate & land cover = more uncertainty**
- **One-time withdrawal thresholds**
- **Applicable to large rivers and reservoirs**
- **Parsing out other factors that affect organisms**
- **Land use affects flow, etc.**

# 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



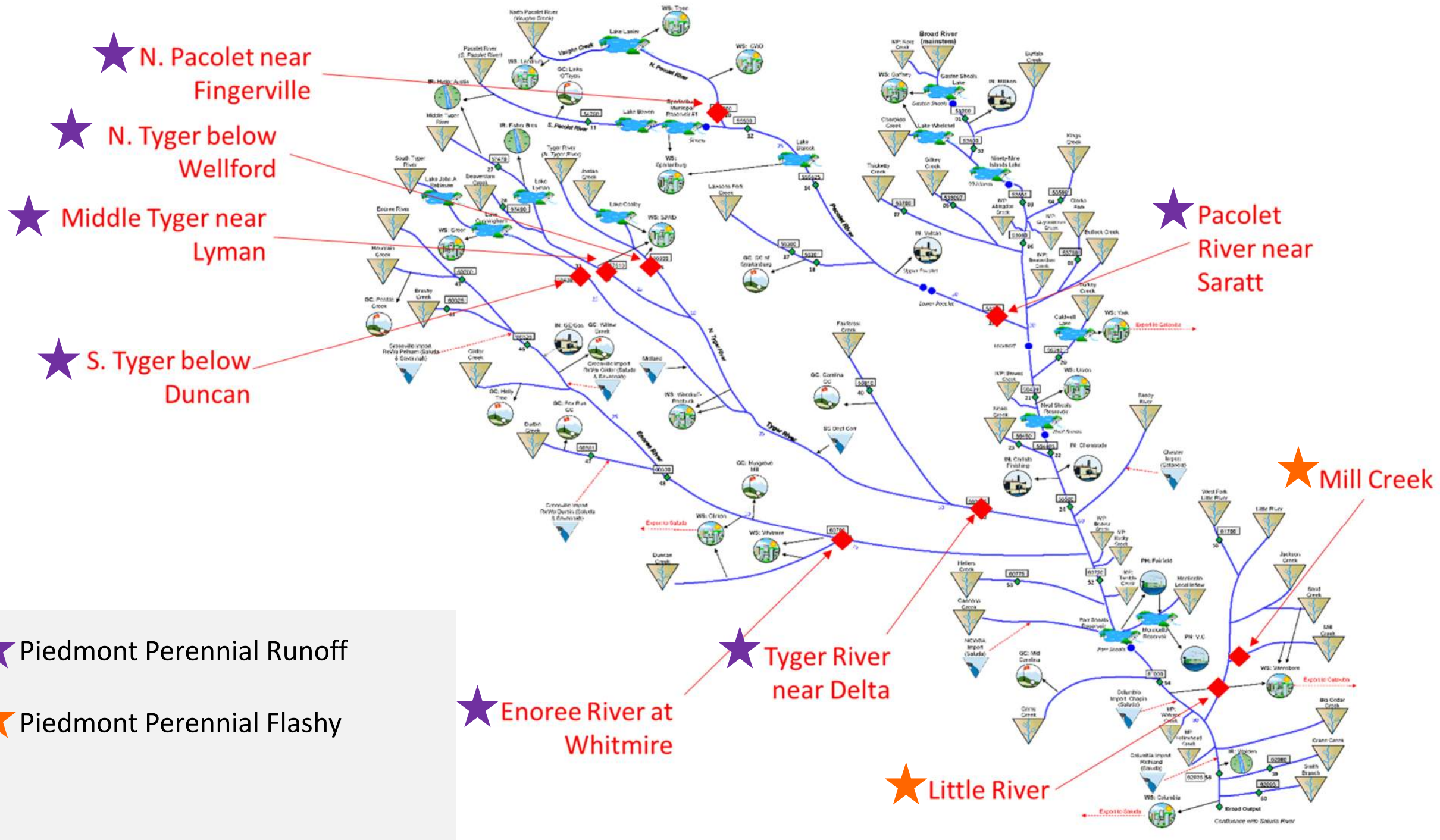
# Stream classes

- **Perennial runoff streams:** characterized by moderately stable flow and distinct seasonal extremes (Class 1, 615 stream segments)
- Stable baseflow streams: characterized by high precipitation, sustained high baseflows, and moderately high run-off (Class 3, 183 stream segments)
- **Perennial flashy:** characterized by moderately stable flow with high flow variability (coefficient of variation in daily flows) (Class 4, 138 stream segments)
- Intermittent streams, classified by intermittent periods of no flow punctuated by flooding events (Class 5, 45 stream segments)



# Flow-Ecology Relationships

- Four flow-ecology metrics were considered
  - **Mean daily flow – Average annual flow in a stream**
  - **Timing of low flow – Time of year when low flow occurs on average**
  - **High flow pulse count – How often high flows occur**
  - **High flow pulse duration – Average length of time for a high flow event**
- These were chosen based on:
  - relevance to water withdrawal and drought management;
  - strength of relationship
  - distribution (most stream classes and basin area represented)
  - calculable from SWAM output



★ N. Pacolet near Fingerville

★ N. Tiger below Wellford

★ Middle Tiger near Lyman

★ S. Tiger below Duncan

★ Pacolet River near Saratt

★ Tiger River near Delta

★ Enoree River at Whitmire

★ Little River

★ Mill Creek

★ Piedmont Perennial Runoff

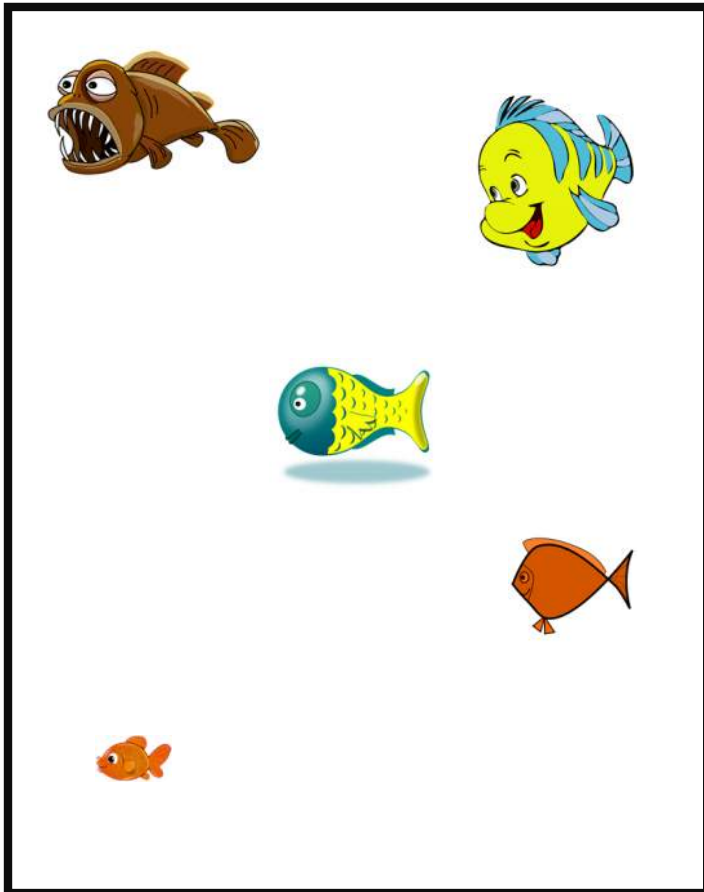
★ Piedmont Perennial Flashy

★ Piedmont Perennial Runoff

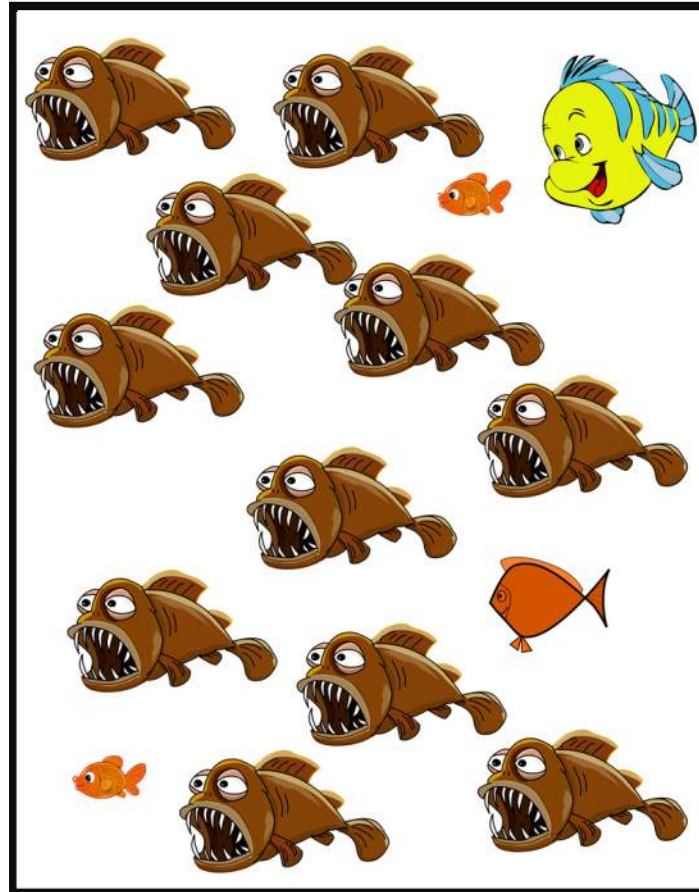
★ Piedmont Perennial Flashy

# Richness vs diversity (and evenness)

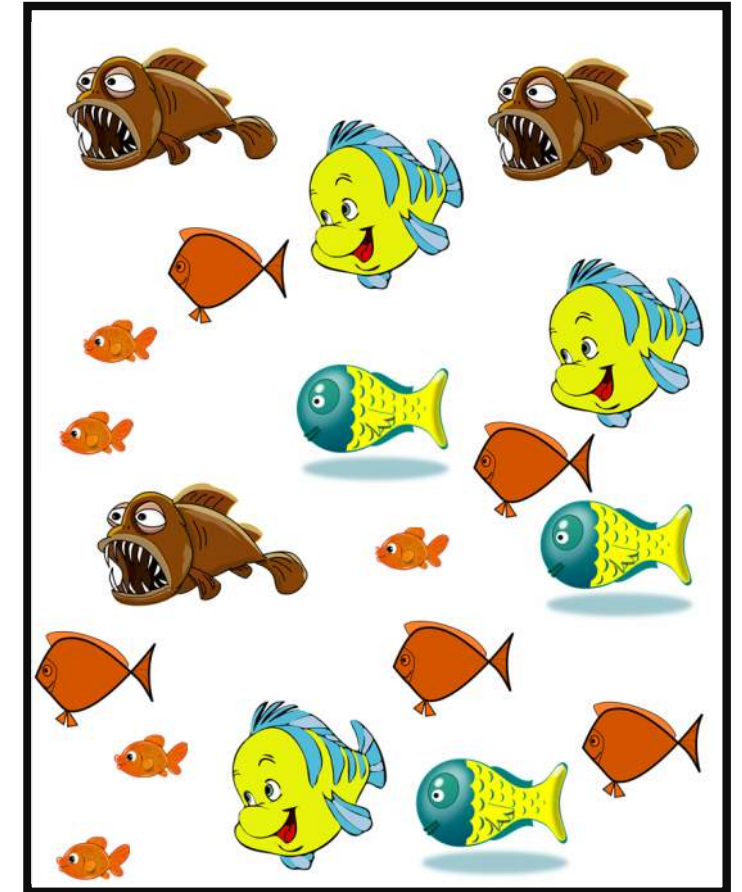
Abundance = 5  
Richness = 5  
Diversity = 1.61  
Evenness = 1.0



Abundance = 15  
Richness = 4  
Diversity = 0.857  
Evenness = 0.618



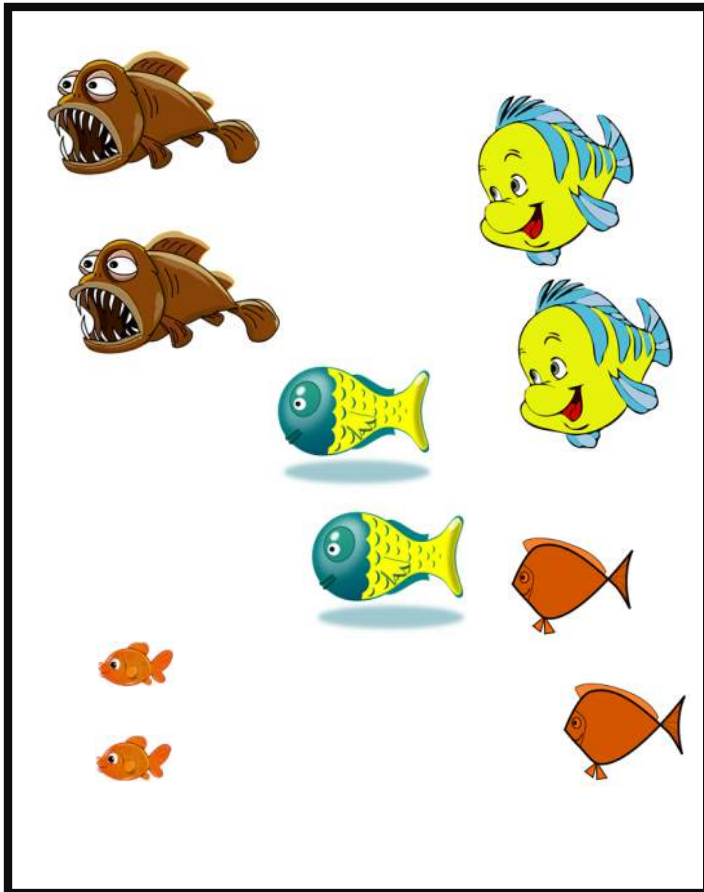
Abundance = 19  
Richness = 5  
Diversity = 1.58  
Evenness = 0.98



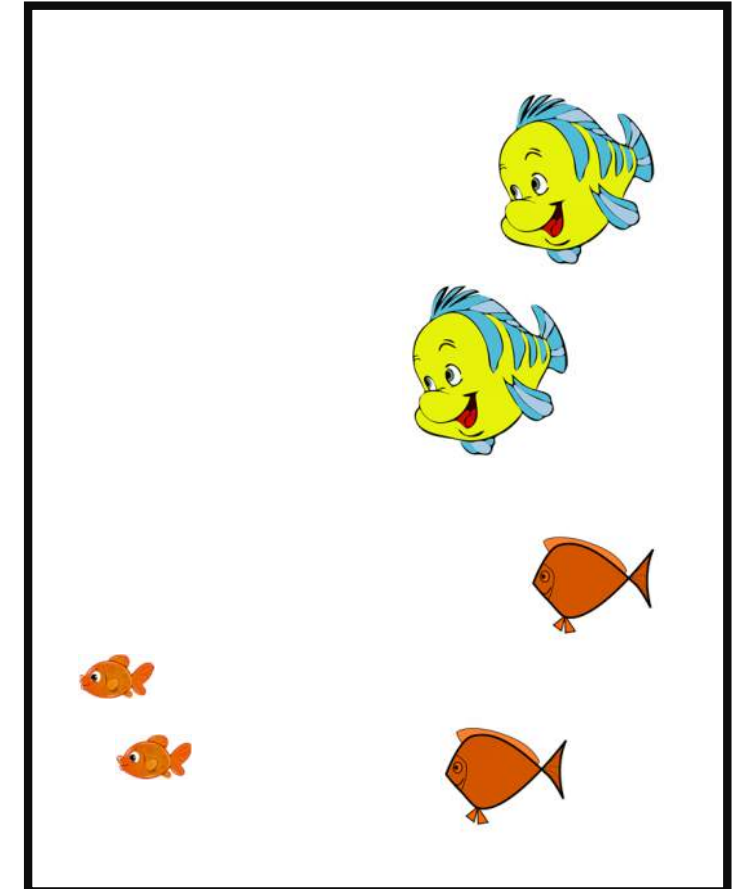


# What does loss of richness mean?

Abundance = 10  
Richness = 5  
Diversity = 1.61  
Evenness = 1.0



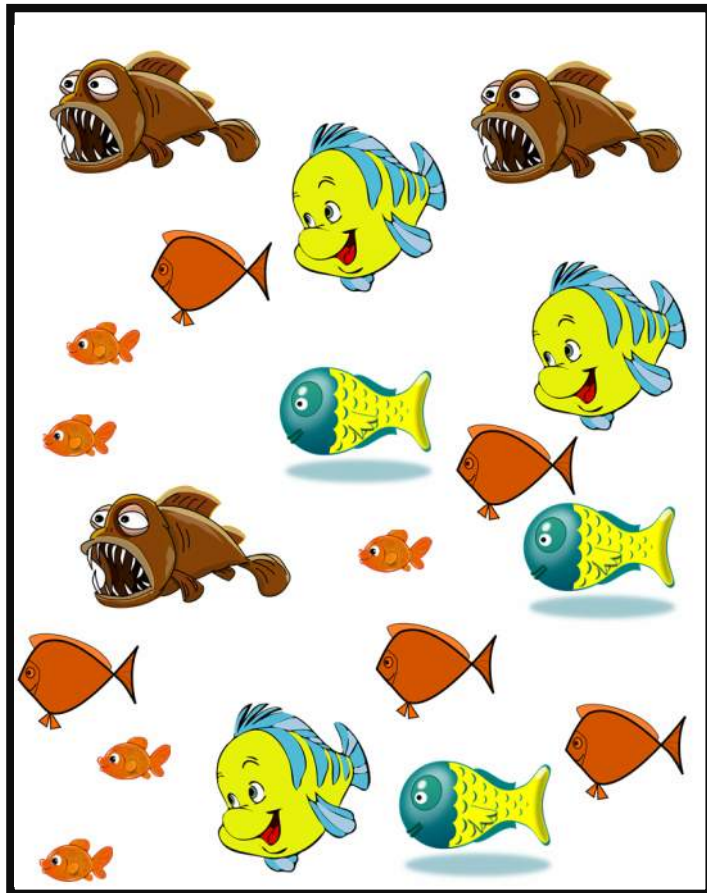
Abundance = 6  
Richness = 3  
Diversity = 1.1  
Evenness = 1.0



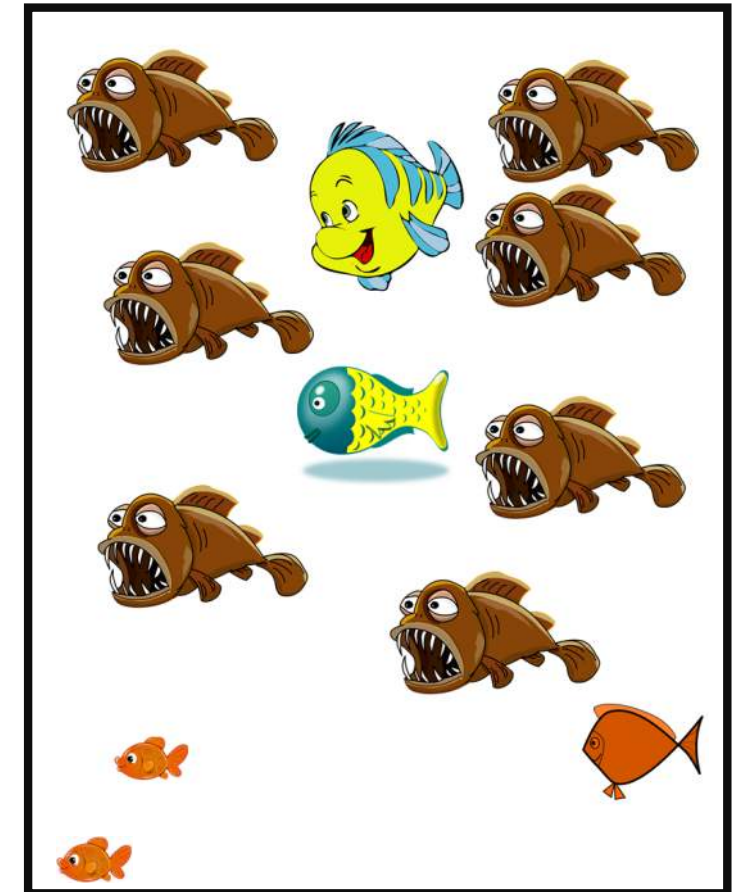
- Species are 100% extirpated from a designated geographic area
- Loss of both richness and diversity

# What does loss of diversity mean?

Abundance = 19  
Richness = 5  
Diversity = 1.58  
Evenness = 0.98



Abundance = 12  
Richness = 5  
Diversity = 1.23  
Evenness = 0.77



- Richness is maintained
- Diversity is lost

# Fish species richness

		Stream Gauge							
		N Pacolet near Fingerville		Middle Tyger River near Lyman		Enoree River at Whitmire		Mill Creek	
Fish Richness	Scenario	% change	SE	% change	SE	% change	SE	% change	SE
	UIF	12.7	7	7.9	7	-2.7	7	5.3	9
	MD 2070	-9.3	7	-11.5	7	1.6	7	0.5	9
	HD 2070	-15.9	7	-23.8	7	1.9	7	-5.3	9
	Full	-23.6	7	-30.6	7	-2.9	7	-6.8	9

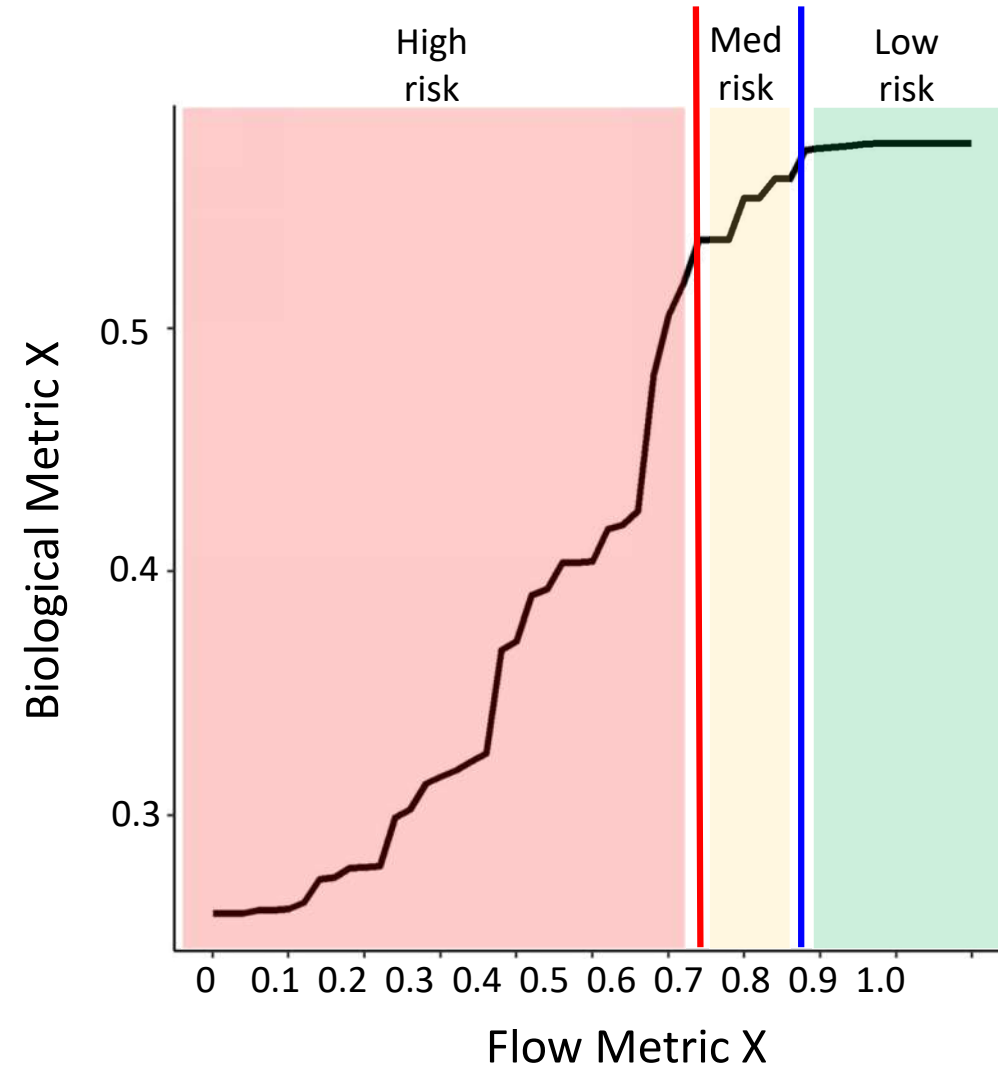
Sensitive to changes in flow

Could be as high as -37.6 or as low as -23.6

Could be as high as -18.5 or as low as -4.5

# Mean daily flow (MA1): biological response limits

- Lines defined by working group
- Consider this to be a performance measure where rapid changes are likely to occur
- Do not interpret y-axis

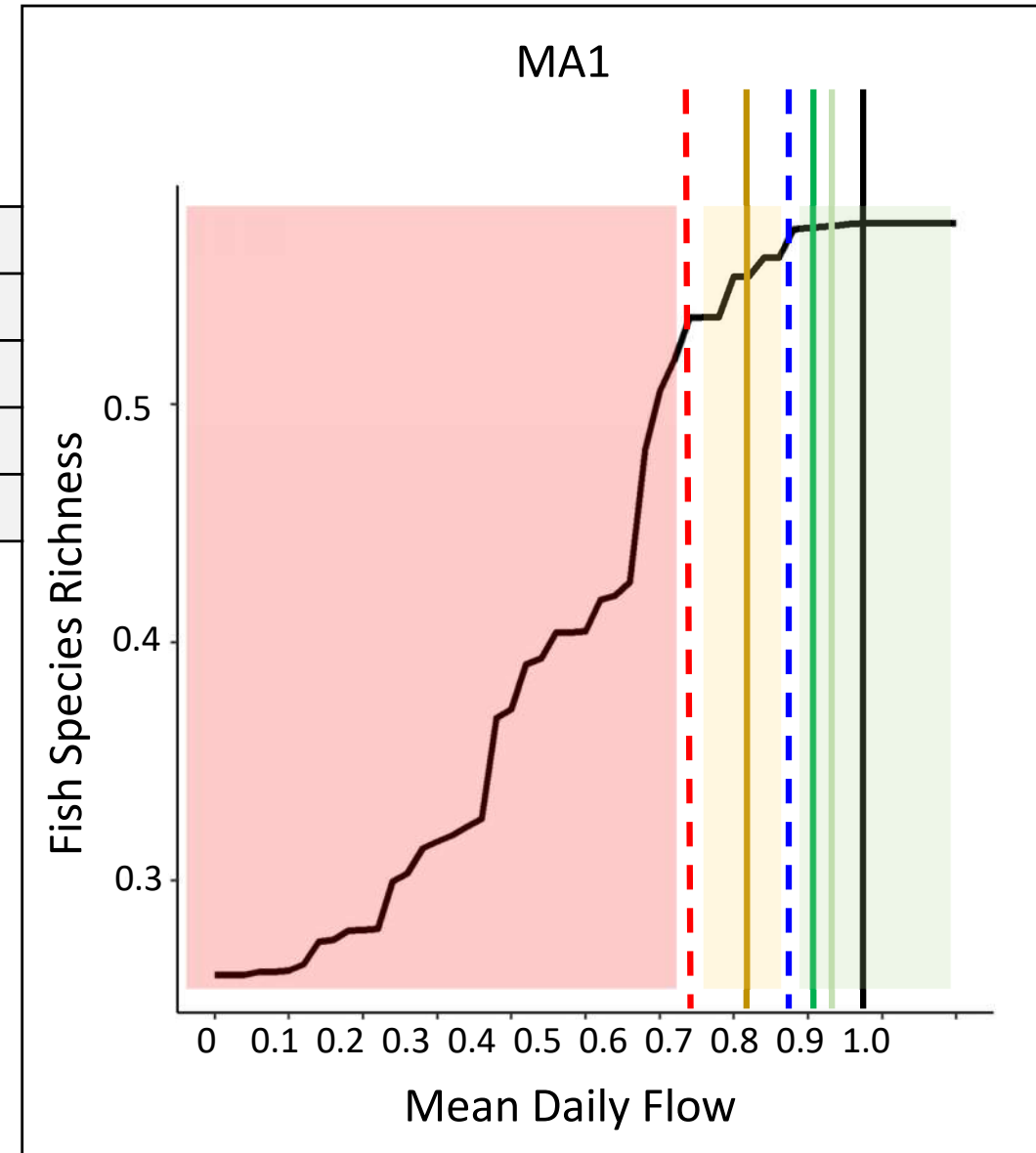
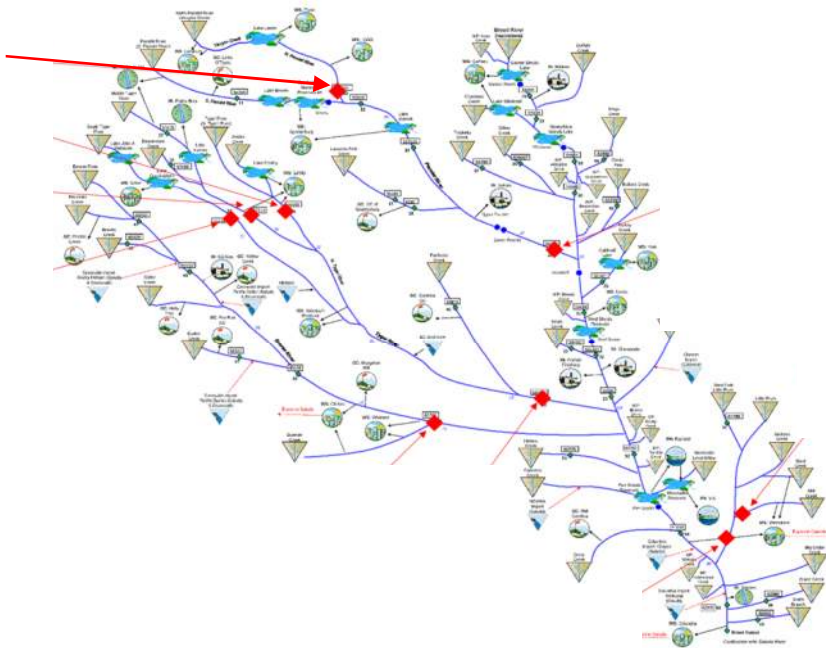




# N. Pacolet near Fingerville

Scenario	Current	Predicted	% change	Bio Metric	Change in Bio	SE
UIF	319.65	368.91	15.4%	Richness	12.7%	7
HD 2070	319.65	257.78	-19.4%	Richness	-15.9%	7
Full	319.65	227.65	-28.8%	Richness	-23.6%	7
MD 2070	319.65	283.39	-11.3%	Richness	-9.3%	7

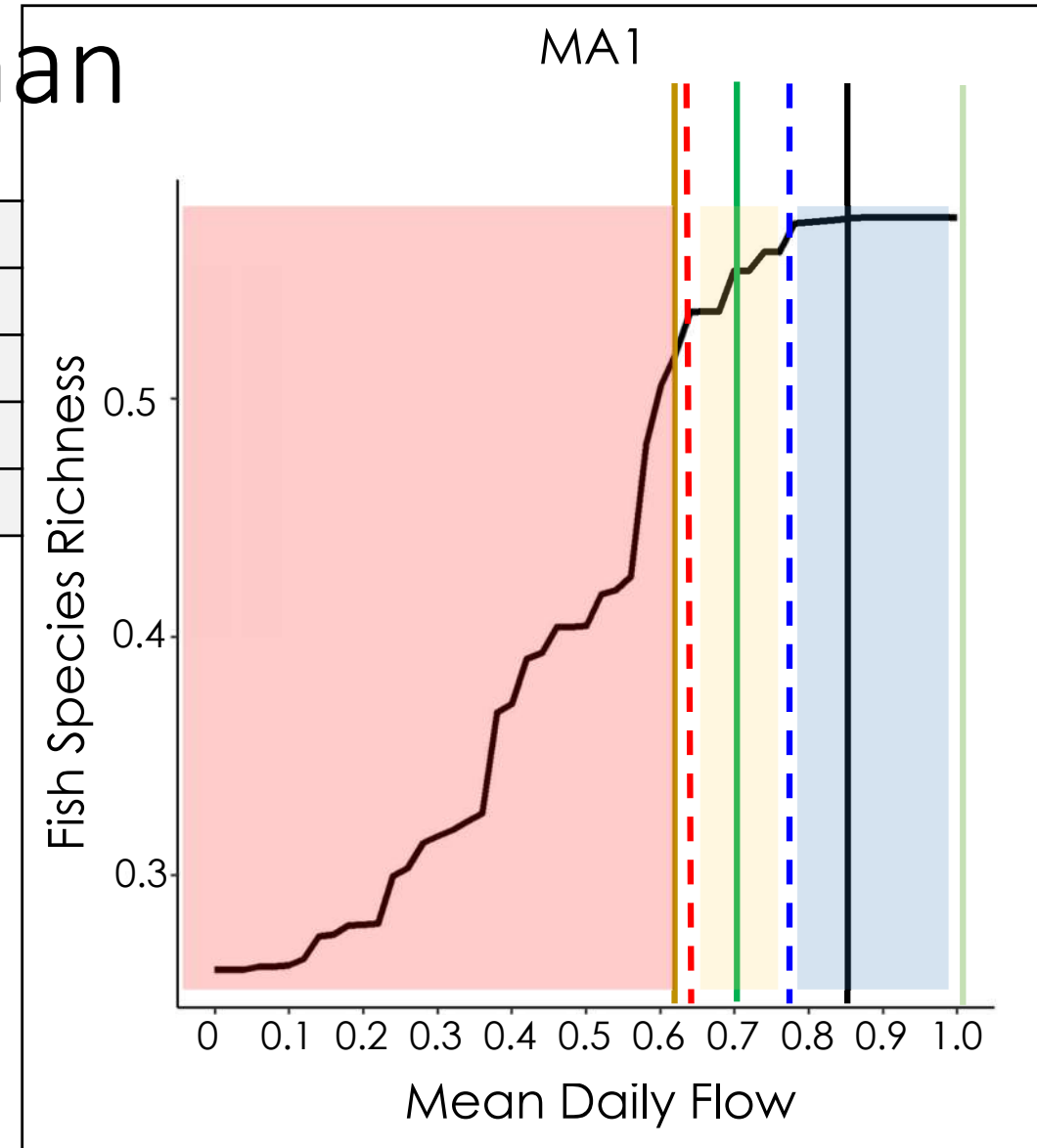
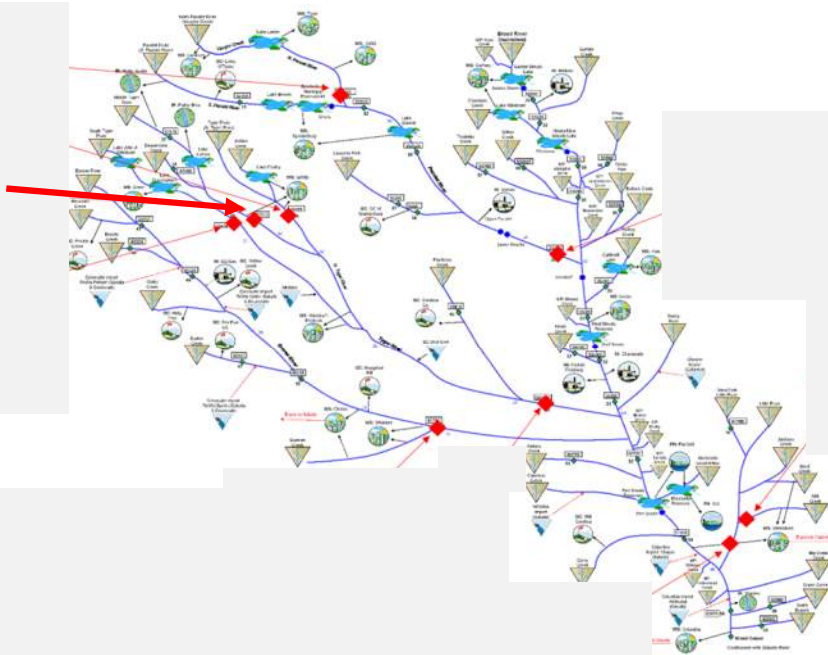
BRD12



# Middle Tyger River near Lyman

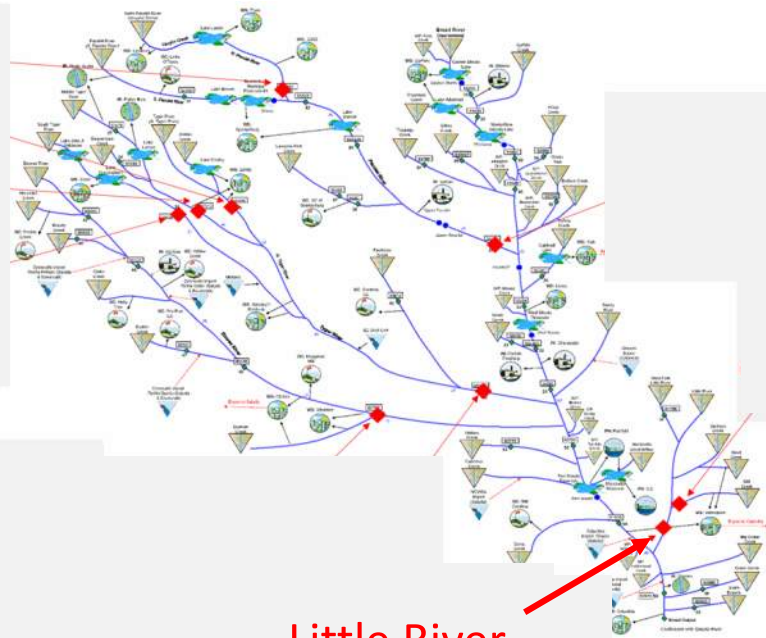
Scenario	Current	Predicted	% change	Bio Metric	Change in Bio	SE
UIF	98.35	107.83	9.6%	Richness	7.9%	7
HD 2070	98.35	69.85	-29.0%	Richness	-23.8%	7
Full	98.35	61.68	-37.3%	Richness	-30.6%	7
MD 2070	98.35	84.57	-14.0%	Richness	-11.5%	7

BRD30

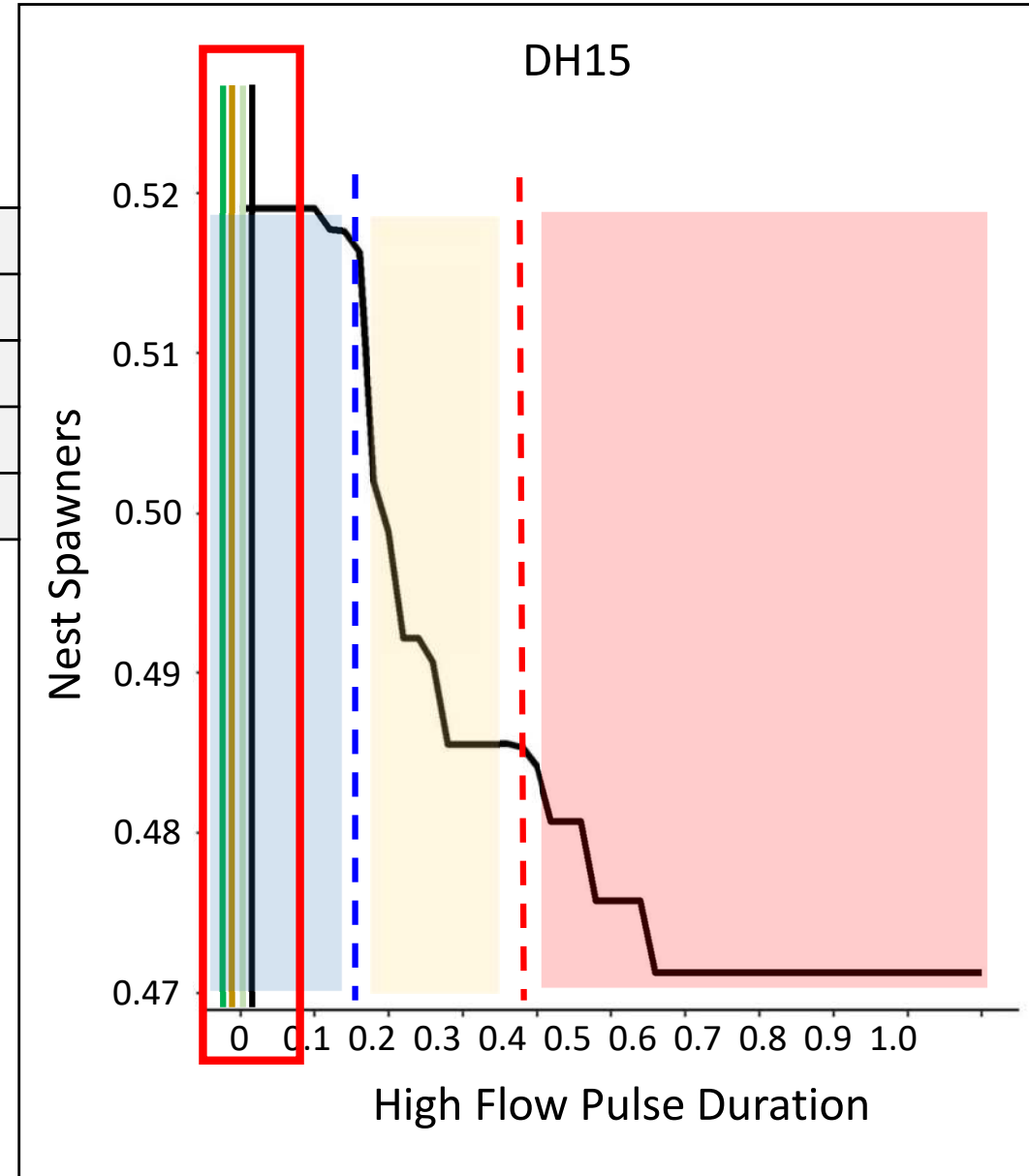


# Little River

Scenario	Current	Predicted	% change	Bio Metric	Change in Bio	SE
UIF	4.6	4.6	0.0%	Nest Spawn	0.0%	15
HD 2070	4.6	4.4	-0.04%	Nest Spawn	4.5%	15
Full	4.6	4.4	-0.04%	Nest Spawn	4.5%	15
MD 2070	4.6	4.6	0.0%	Nest Spawn	0.0%	15



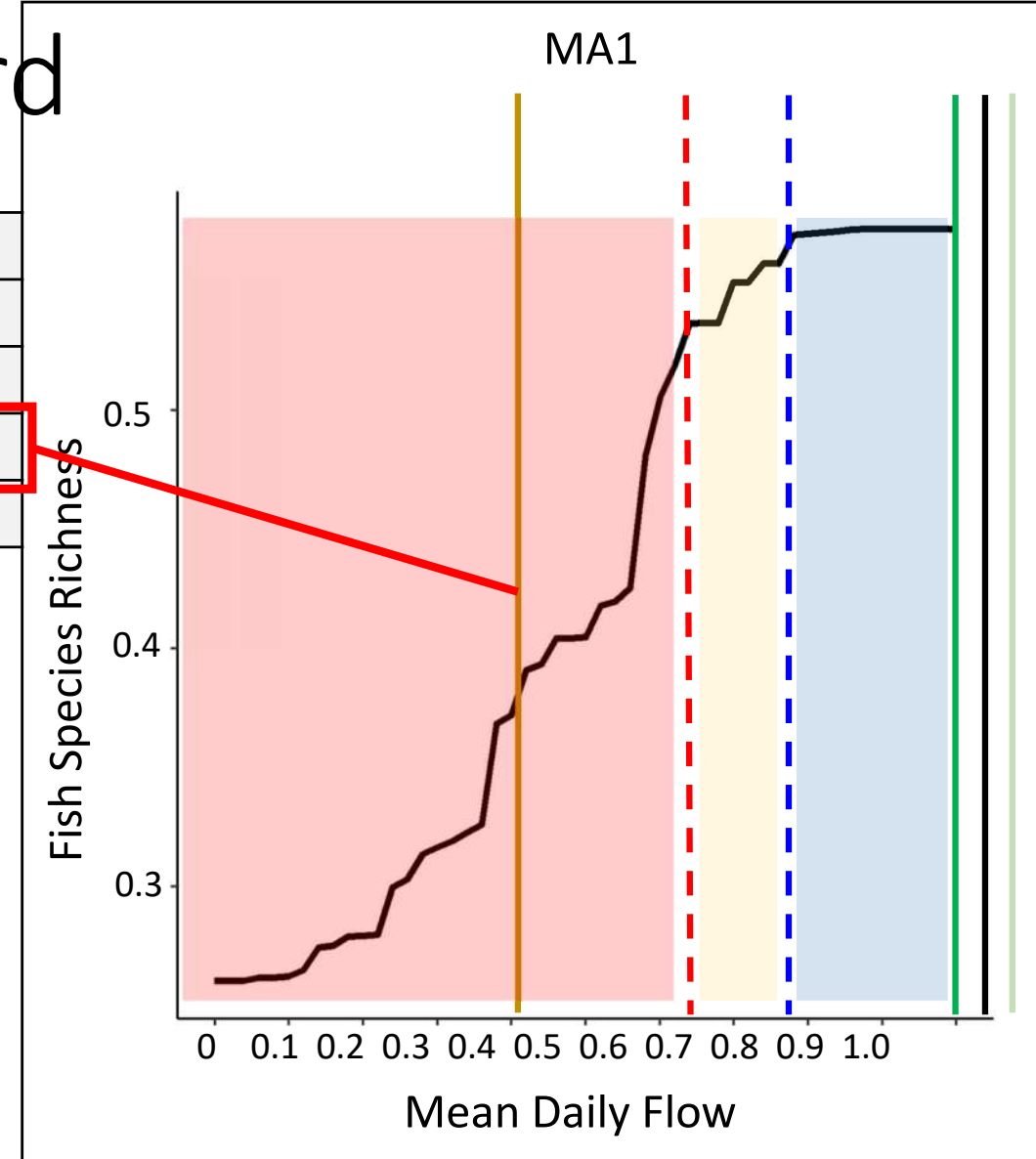
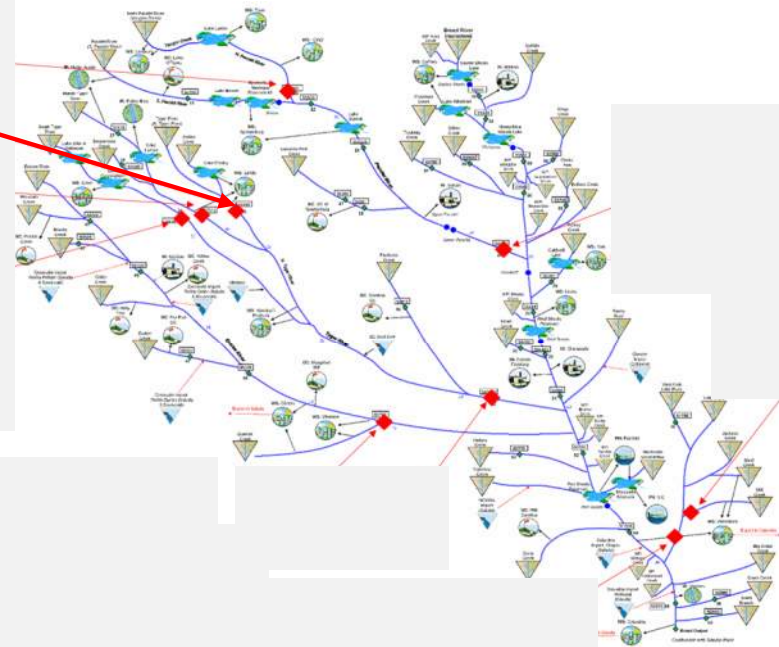
Little River



# N. Tyger River below Wellford

Scenario	Current	Predicted	% change	Bio Metric	Change in Bio	SE
UIF	47.12	51.45	9.2%	Richness	7.6%	7
HD 2070	47.12	47.24	0.3%	Richness	0.2%	7
Full	47.12	18.29	-61.2%	Richness	-50.3%	7
MD 2070	47.12	49.84	5.8%	Richness	4.7%	7

BRD25

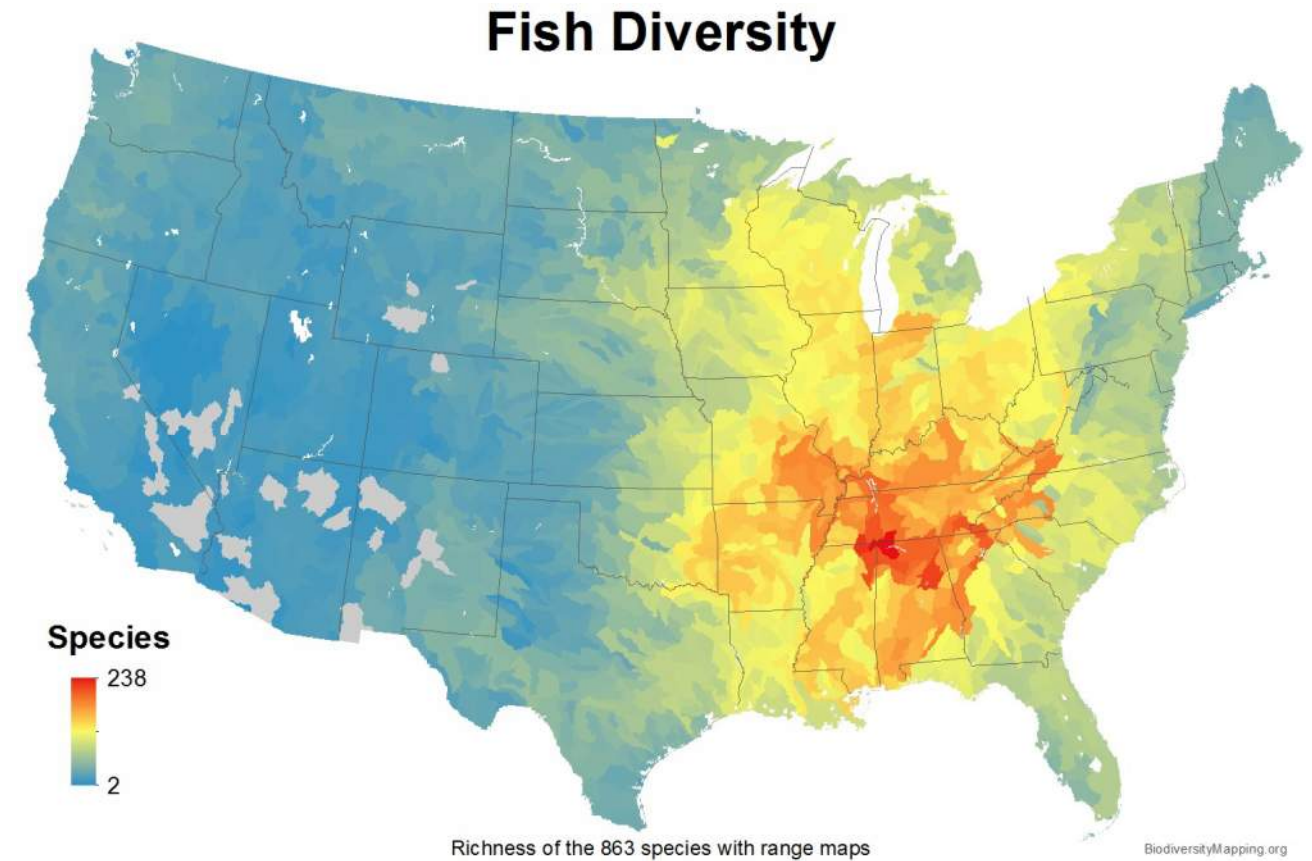




# Fish diversity comparison

## Broad River Basin

- 35 species collected at 20 sites in upper Broad River basin
- Average 14 species per site



# Conservation now to avoid regulation in the future

## ESA definition of “Take” and “Incidental Take”

- **Take** as defined under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."
- **Incidental take** is an unintentional, but not unexpected, taking.

