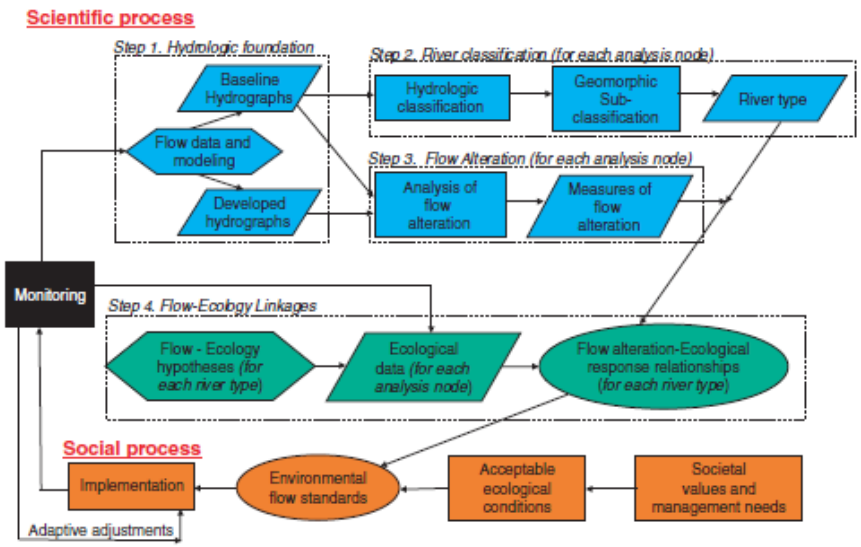
Validating environmental flow recommendations/standards

Timothy H. Bonner
Texas State University
Department of Biology
San Marcos, Texas

Funding: Texas Water Development Board

E-flow recommendations/standards

2. Monitoring



3. Adjusting

1. Setting a standard

ELOHA (Poff et al. 2009)

Irvine et al. (1987)

- Validated a type of e-flow recommendation
- Concluded recommendation was not related to fish biomass
- "…*hope* that the [instream] values will be protected" (Jowett and Biggs 2008)

- Texas (SB III) E-flow purpose:
  - Maintain sound ecological environments (SEE)
  - Ecological integrity (Karr and Dudley 1981)
  - ‘comparable species composition, diversity, and functional organization’

- E-flow validation purpose:
  - Are e-flows maintaining SEE?

Broad objectives (2012 – current)

- Develop methodologies to assess e-flow recommendations/standards

- Apply methodology

Constraints and challenges:

- Methodology must inform a standard or recommendation
  - Regardless if you like them or not
  - Not assessing if “flows are important”

Season	Flow Tier	Duration	Science Committee	Stakeholder Committee	TCEQ
Summer	S		X	X	X
Fall	B		X	X	X
Winter	2/S	X	X	X	X
Spring	1/S	X	X	X	X
	1/Y	X	X	X	
	1/2Y	X	X	X	
	1/5Y	X	X	X	

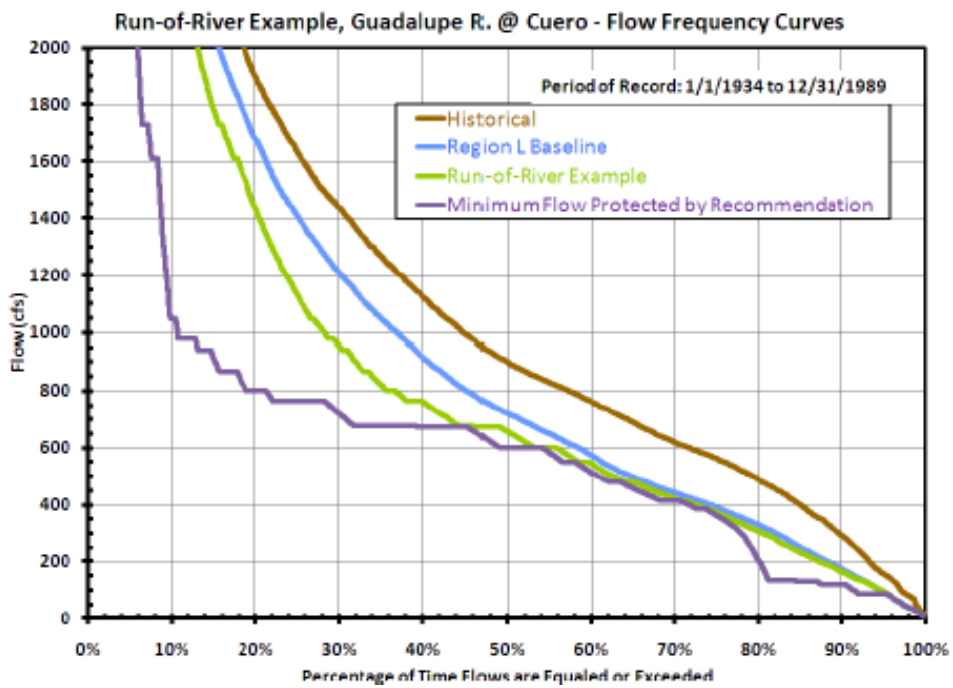
Constraints and challenges:

- Validation process can reveal that more water to remain in channel or more water can be harvested (Jowett and Biggs 2008)

- Understand how the e-flow recommendations/standards work
  - SB III: extracting water or not
  - Precipitation provides the conditions
  - Assessing how much water to remove (not leave in)

Constraints and challenges:

- Validating before recommendations/standards are fully executed
  - Test components (S, B, 1/S, etc.) of recommendations/standards



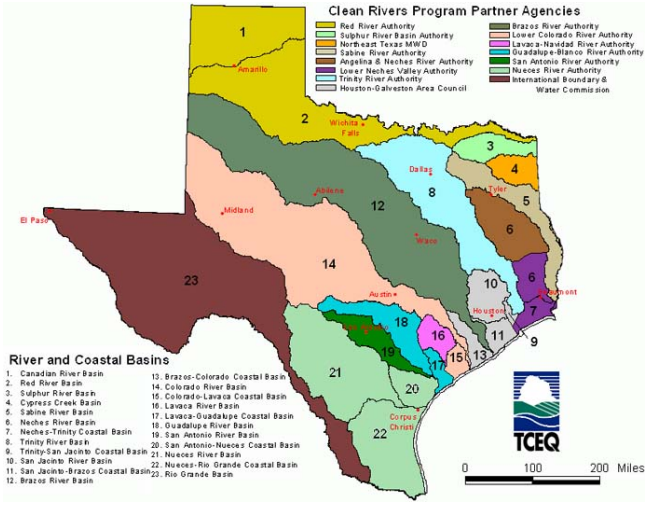
Constraints and challenges:

- Experimental design with a priori predictions and sufficient replication
  - Same recommendations/standards applied to multiple reaches. Use a few to assess value.
  - Ability (eventually) to understand confounding influences:
    - pre-existing conditions and antecedent conditions
  - Concept of ecological integrity by reach
    - Historical conditions, reference conditions

Validation Process

Guadalupe River

- Natural Flow Paradigm- ecological integrity of river ecosystems depends on their natural dynamic character (Poff et al. 1997)
  - E-flow recommendations are applications of NFP



Conceptual model (various studies):

- Upper reaches:
  - high water permanency (karst aquifers)
  - evolutionary refugia, high rates of endemism and spring associated fishes
- Flow reductions in:
  - Base flow: less spring associated fishes, more riverine fishes (exact mechanisms unknown)
  - pulses: more slackwater type fishes

Conceptual model (various studies):

- Lower reaches:
  - more dynamic flow, greater habitat heterogeneity, greater species diversity

- Flow reductions in:
  - Base and flow pulses associated with loss of fluvial specialists (exact mechanisms unknown)

  - more slackwater type fishes

Conceptual model (various studies):

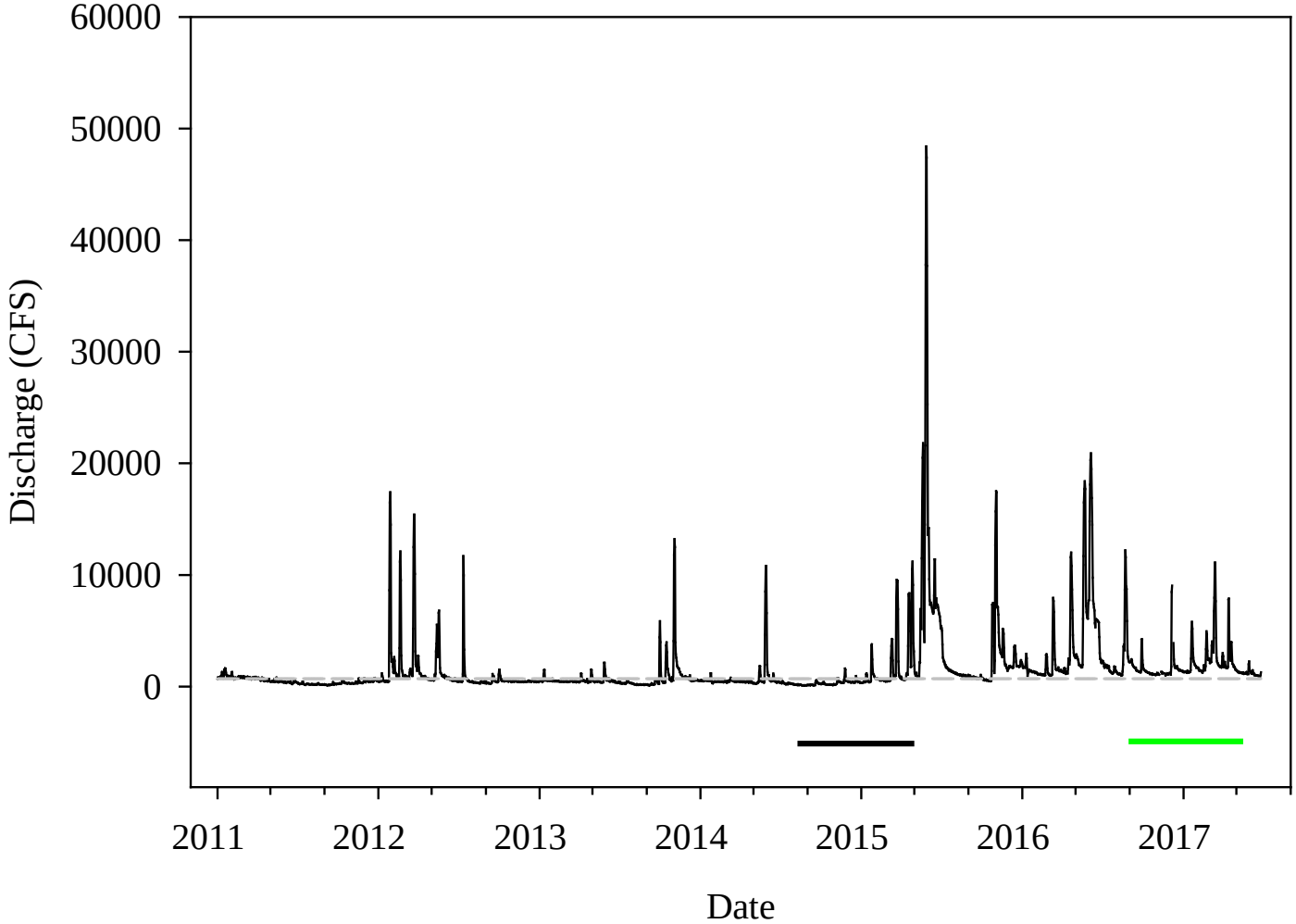
- Prolong subsistence and base flows can show trends in communities shifting from fluvial specialists to more slackwater fishes

- Flow pulses should show some detectable benefit to the fluvial specialists
  - Minckley and Meffe (1987): “differential selection”

Methods

- Watch USGS Stations
- Sample subsistence, base, and before and after flow tiers by season
- Quantify communities within riffle, run, pool, and backwater habitats (densities, relative abundances)

Preliminary results:



Flow Tiers (2014 - 2017)

	GSA	Brazos	Colorado	Total
Sites	7	6	5	18
Visits	59	68	26	153
Subsistence	1	3	0	4
Base	21	16	11	48
Flow Pulses	37	49	15	103
4 / season	-	6	-	6
3 / season	-	9	-	9
2 / season	5	12	8	27
1 / season	22	14	4	40
1 / year	5	2	3	10
1 / 2 year	1	1	0	2
1 / 5 year	4	5	0	9

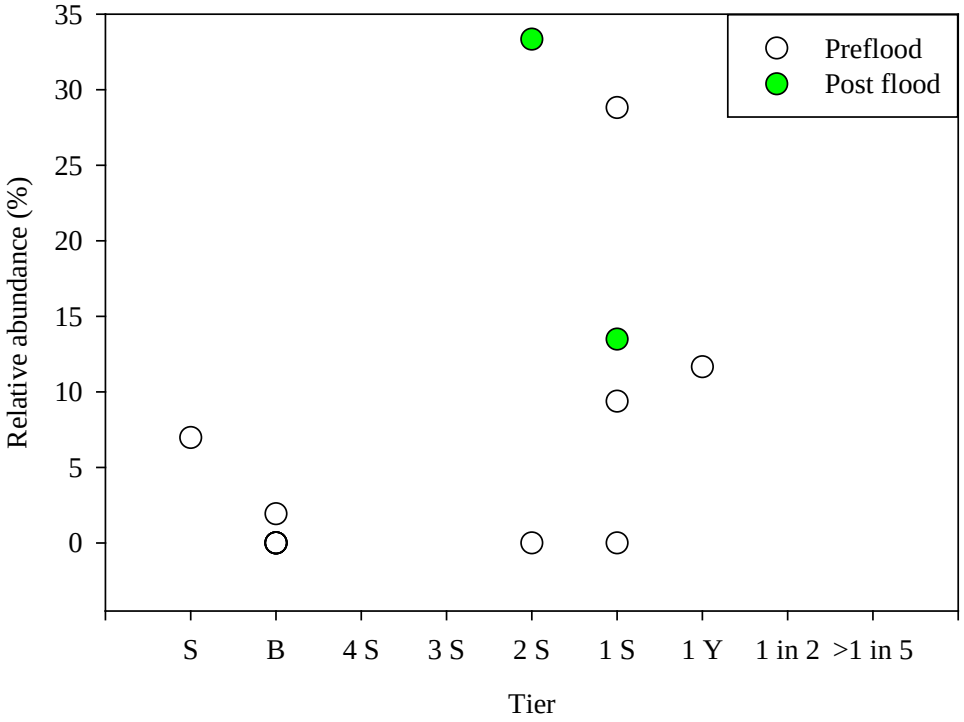
Overall model

- Dependent variables: macroinvertebrate and fish densities, relative abundances, grouped by guilds (swiftwater, moderate, slackwater; many more)

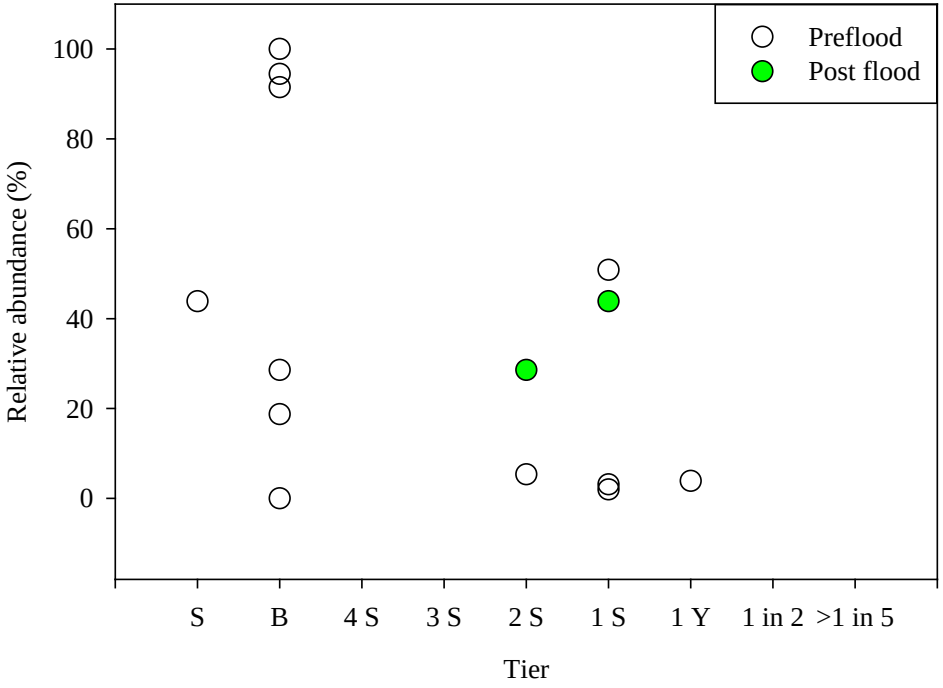
- Treatment: Flow tier, basin, season

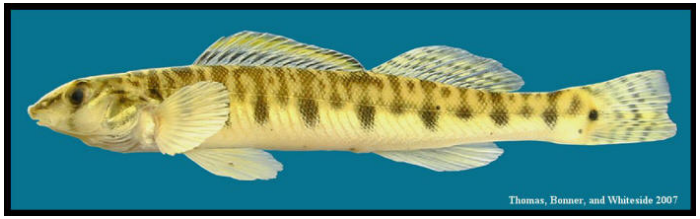
- Not significant:
  - Year 1: not enough replication
  - Year 2: able to explore more by site/reach

Lower reaches: riffle habitats

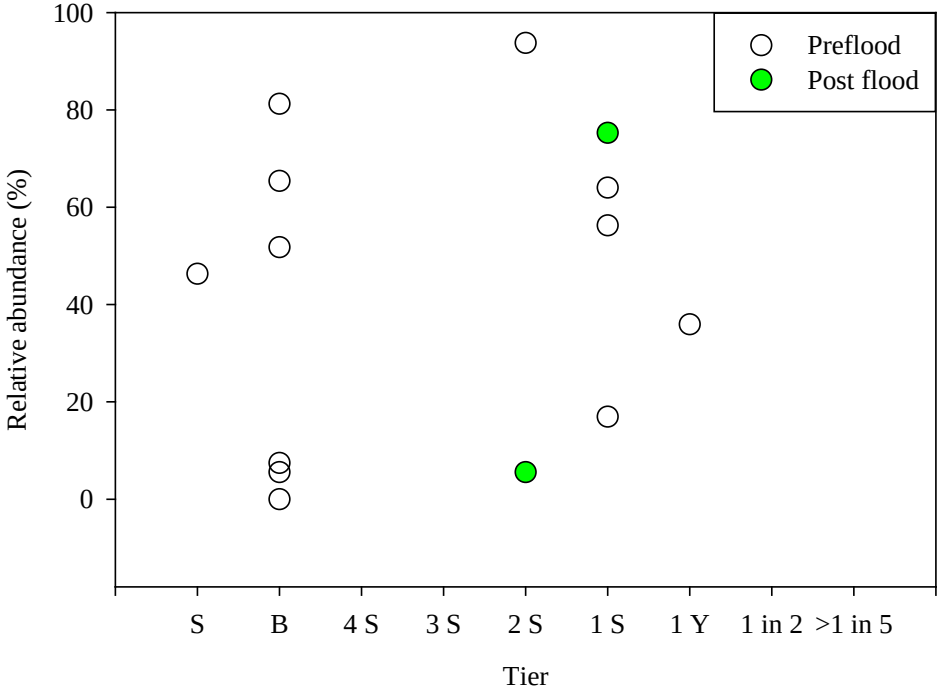


Lower reaches: riffle habitats





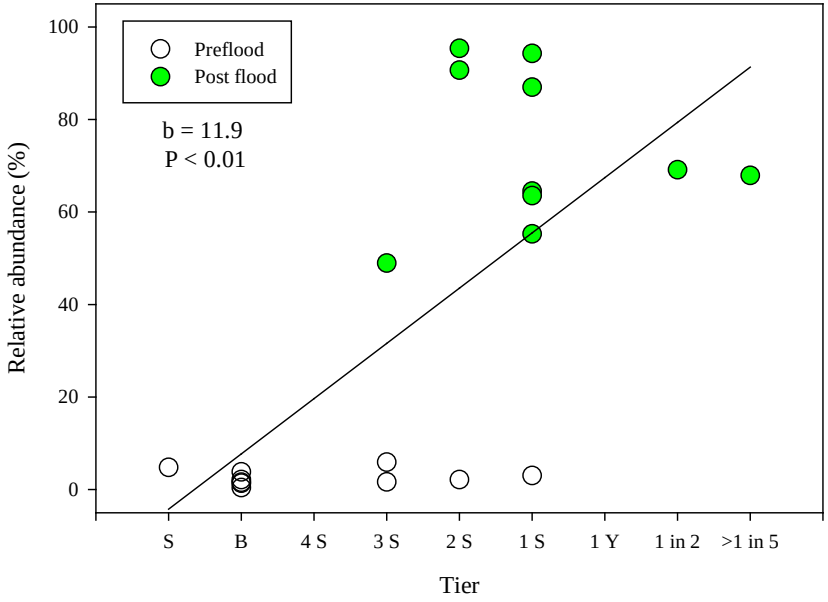
Lower reaches: riffle habitats

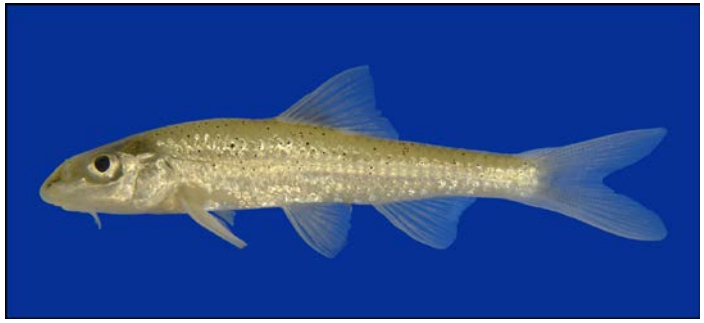


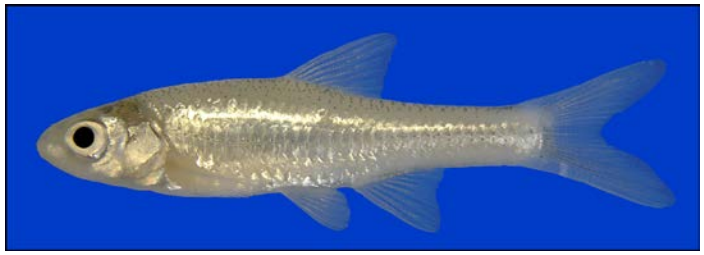
Findings so far (with all the necessary caveats…)

- Some predictions supported….

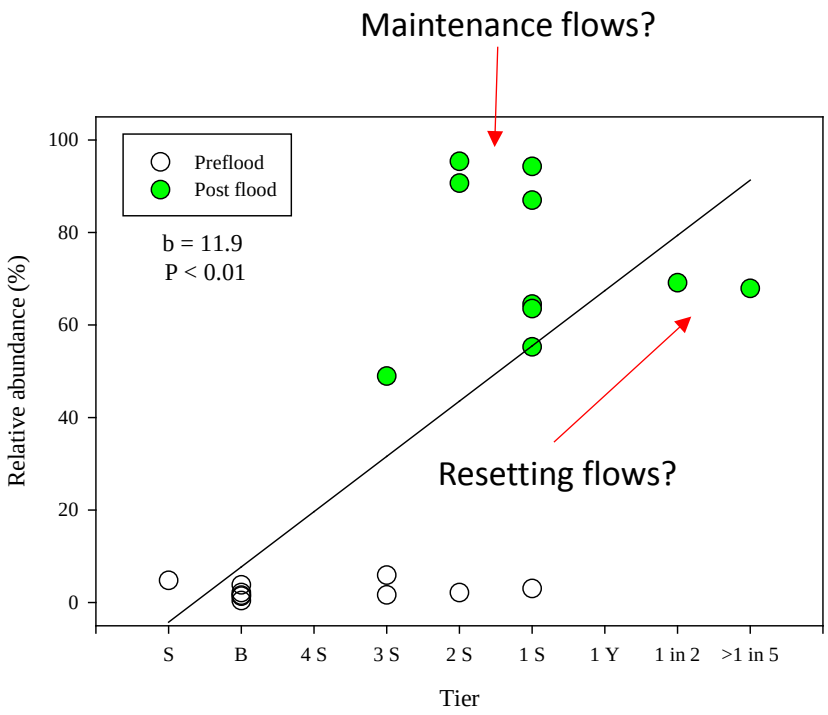
Lower Brazos River

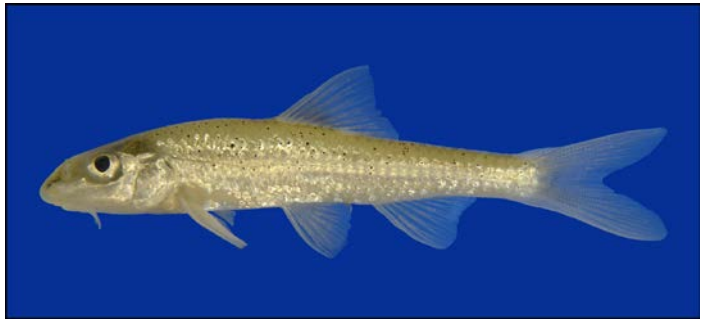


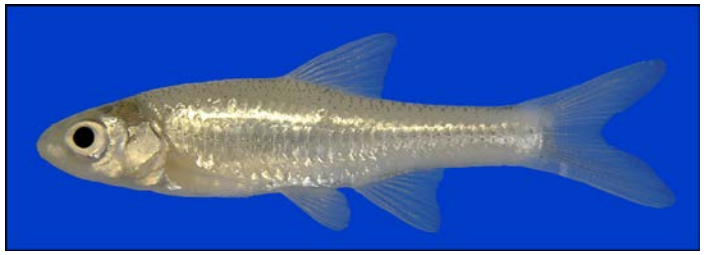




Lower Brazos River







Findings so far (with all the necessary caveats…)

- Some predictions supported (no replication)

- Many were not!

- Why? Range of reasons…
  - E-flow recommendations/standards inadequately captured the Natural Flow Paradigm?
    - 3 per season, 2 per season, 1 per season flow pulses (keeping the flow dynamic) are meaningless to defining "dynamic character"

  - Stream flow is not the master variable in regulating riverine communities?
    - Depends on stream order (upper vs. lower reaches), basin effects, season, adventitious streams, pre-existing and antecedent conditions?

Findings so far (with all the necessary caveats…)

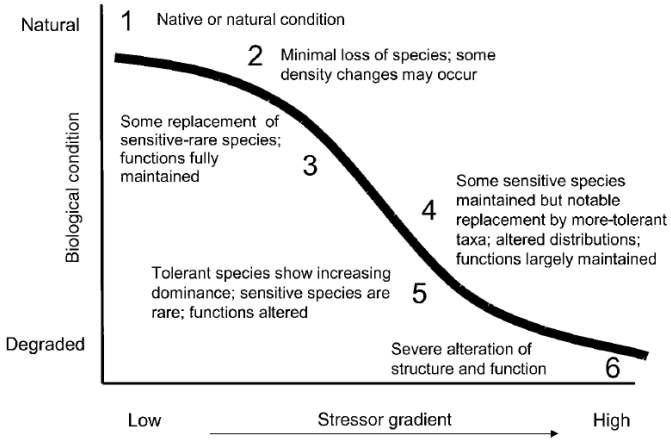
Insufficient quantification…need to see wider range of conditions?

- In Year 1, many of the flow pulse durations were not met

Future plans

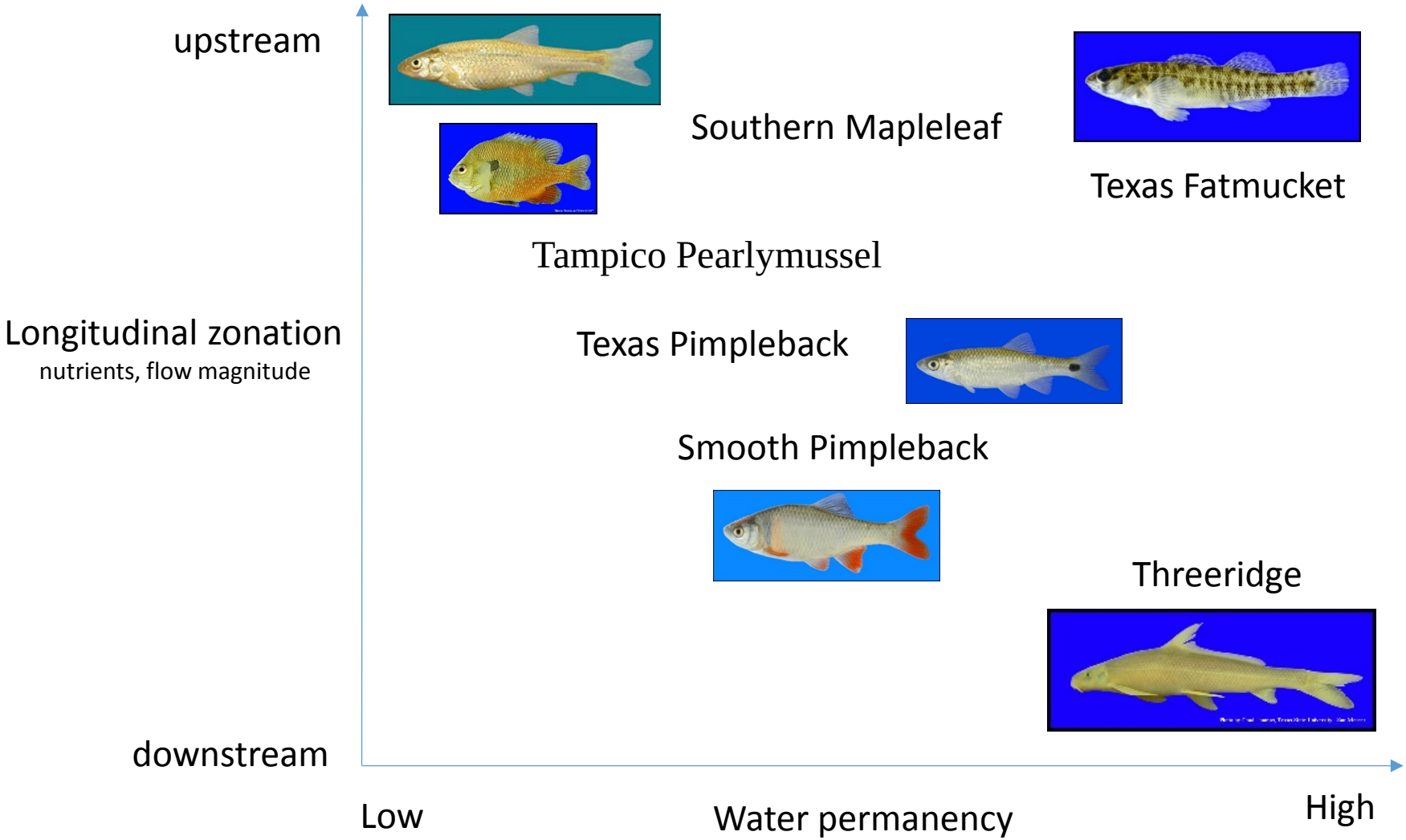
- Continue with methodology and quantification of biota in context to recommendations/standards

- Use concepts of Biological Condition Gradient (Davies and Jackson 2006) to establish Water Quantity Biomonitoring



- Are e-flows maintaining SEE with respect to mussel communities?
- What is the conceptual model for mussel occurrences and abundances within a basin?
- Homogeneous throughout?
- If not, what are the patterns and possible processes?

Correspondence between mussels and fishes abundance centroids, Colorado River



- How do components of flow recommendations select members of the regional species pool at the local scale?

- 150,000 cfs in Lower Colorado River displaced most mussels (response observed)
  - Prediction: with differential selection, more sculptured and obese mussels species persisted (Hornback et al 2010)
  - Maybe decreased density but with increases in relative abundances