Urban Bioassessments Indicate Increased Benthic Tolerance

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Department of Public Works and Environmental Services
Working for You!

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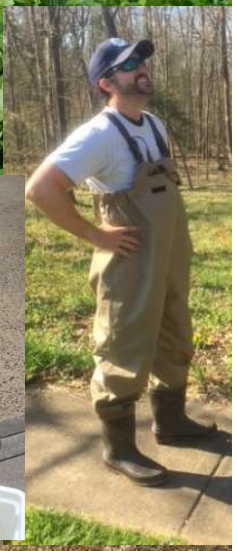
Thanks to Fairfax County Ecologists

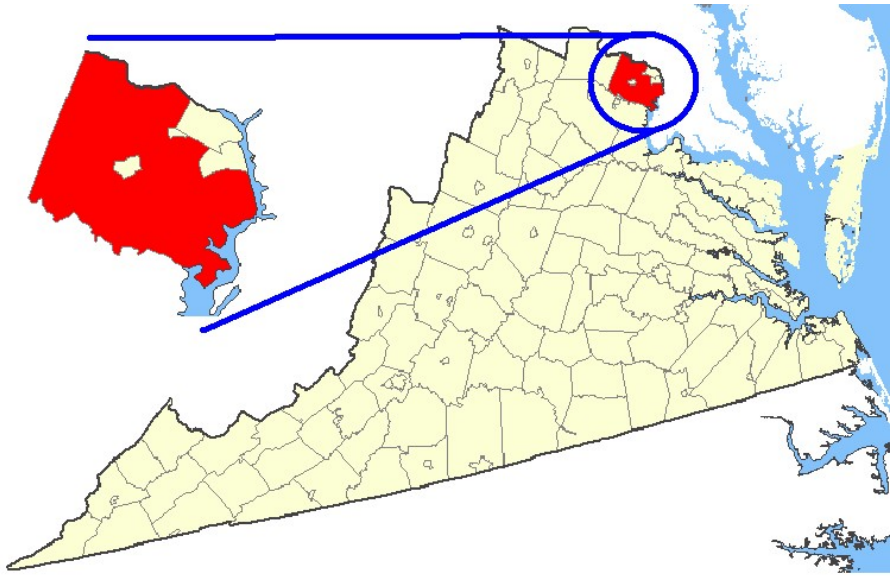
- Meanwhile in Fairfax County, Virginia…
  - LeAnne Astin
  - Shannon Curtis
  - Samantha Duthe
  - Chad Grupe
  - Anna Haley
  - Chris Mueller
  - Joe Sanchirico
  - Jonathan Witt
  - Danielle Wynne

Thursday, 1:20pm, Salon A



Fairfax County, VA

- 400 square miles, ~800 miles perennial stream
- 1.1 million residents
- Rich benthic monitoring data set, including a large number of sites with extreme levels of watershed imperviousness



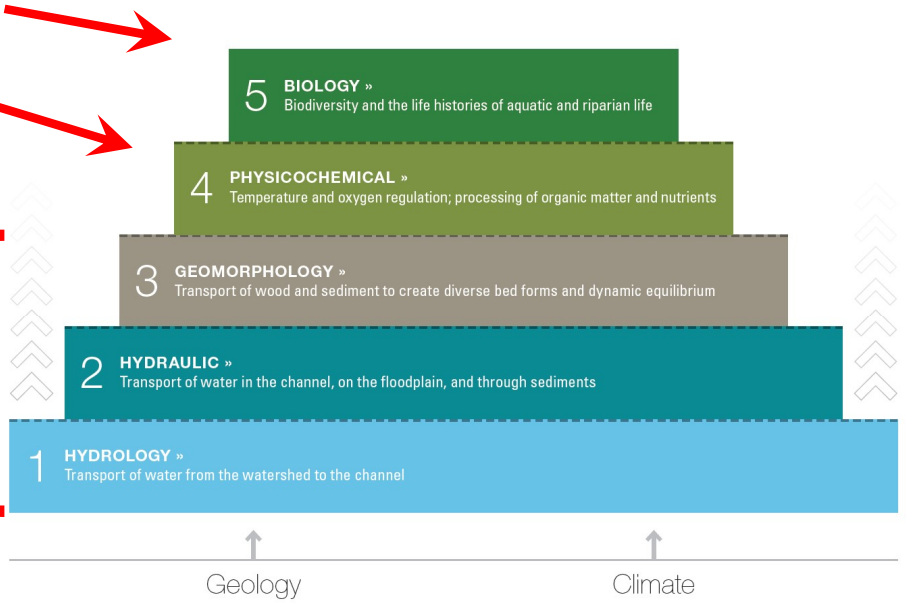
https://upload.wikimedia.org/wikipedia/commons/7/7b/Map_showing_Fairfax_County%2C_Virginia.png

Why monitor?

- Short- & long-term trends in water quality
- MS4 permit-required
- Need to meet Chesapeake Bay TMDL reduction targets: N, P, TSS
- Need to meet local TMDL reduction targets & biological endpoints.
- Fairfax Co. spends $26+ M/year on watershed improvement projects

Local TMDLs – direct measures (benthics, fish, water chemistry, etc.)

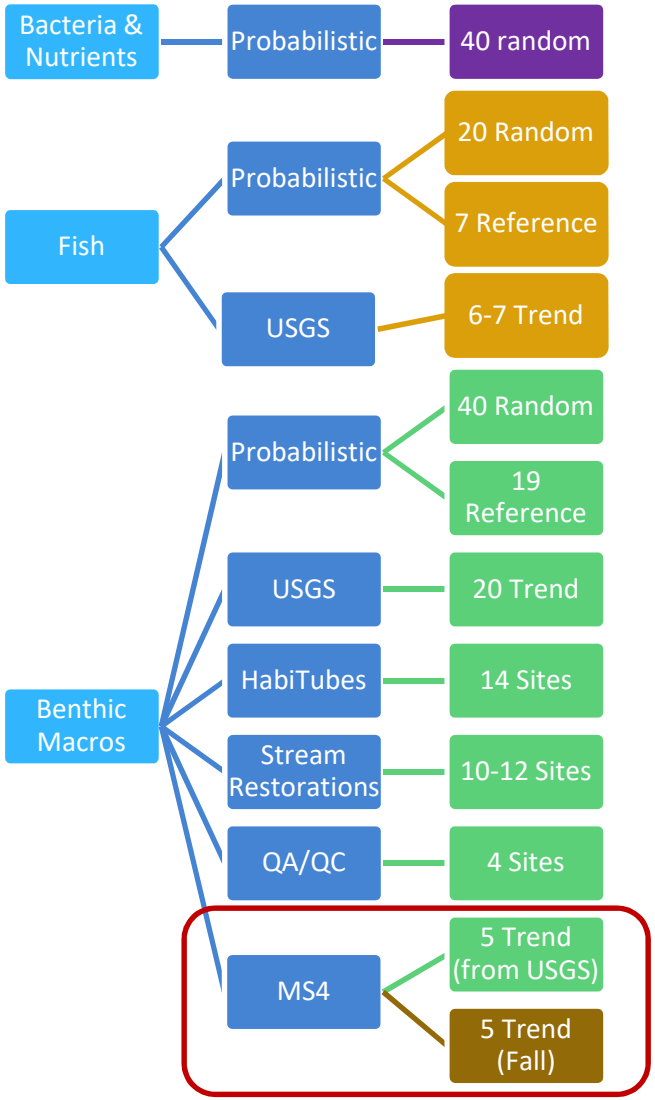
Bay TMDL Credits – required indirect reductions (modelled) for LF of stabilization



Residents and elected officials (we) want this…

But we often get this… (Restoration from early 2000s)

Comprehensive Biological Monitoring



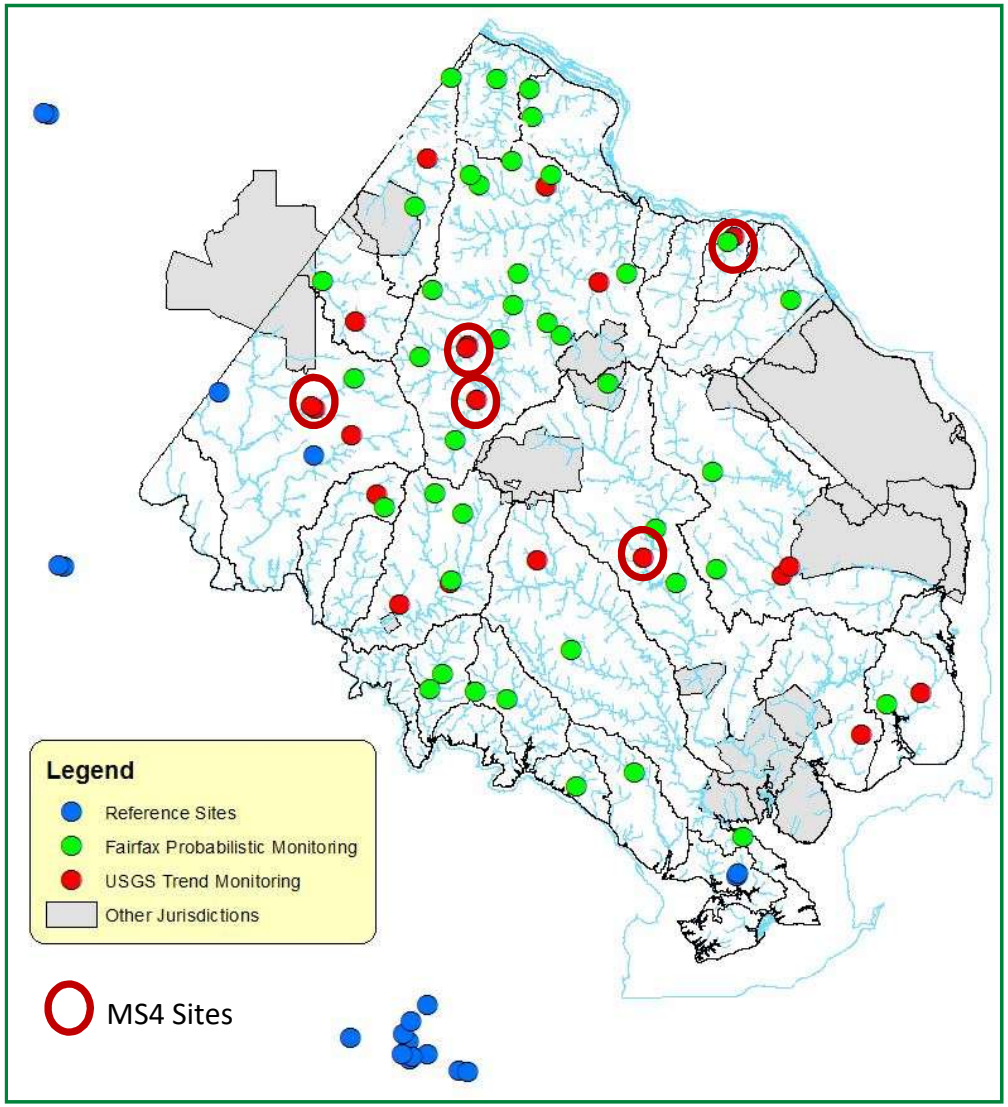
Continuous (5X per year)

Late Summer (Aug-Sept)

Spring (Mar-Apr)

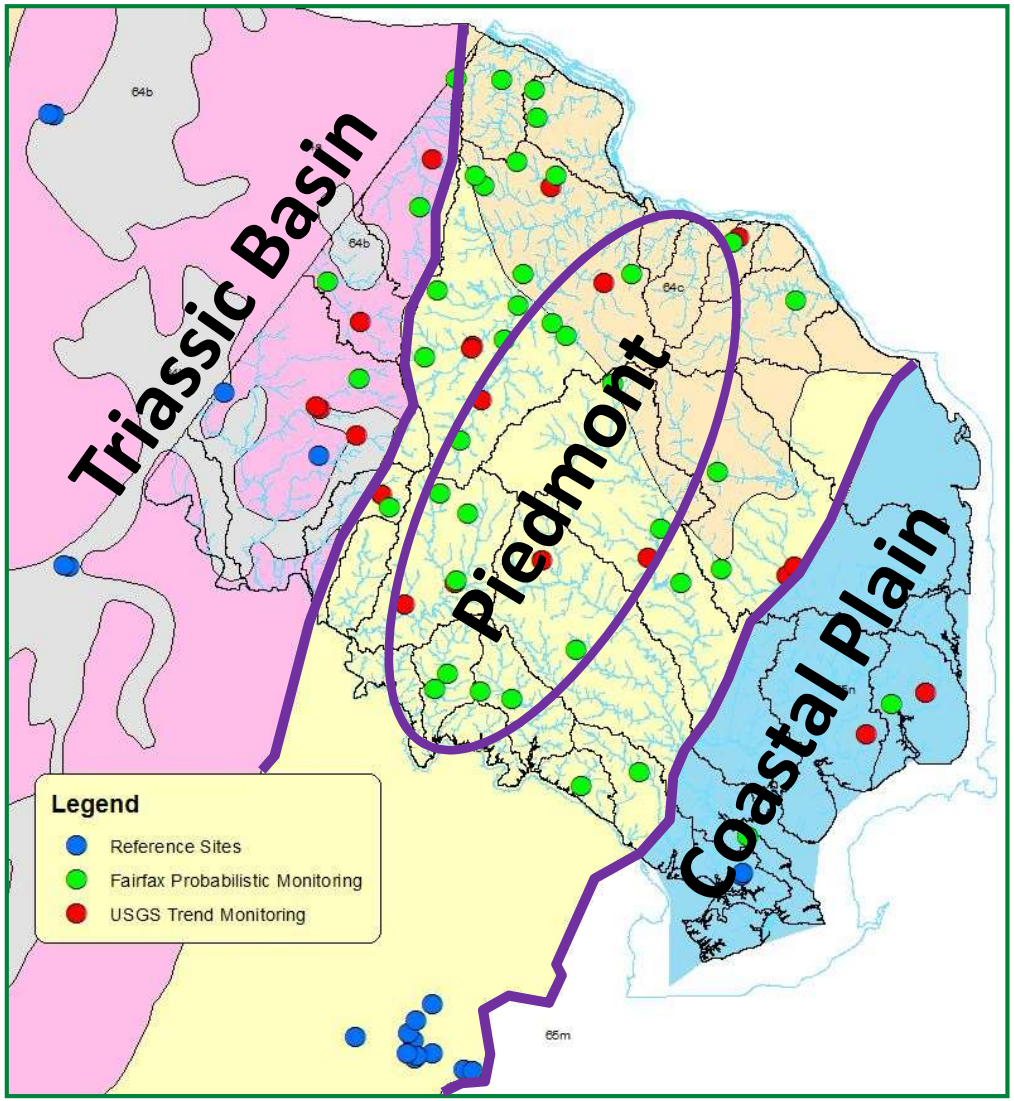
Fall (Oct)

Typical Year of Fairfax Co. Benthic Monitoring



- Probabilistic [40]
- USGS (trend) [20]
- Reference (trend) [18]
- Restorations and special projects [~20]
- QA/QC [4]
- 100+ sites annually

Level IV Ecoregions – Benthic Monitoring Example



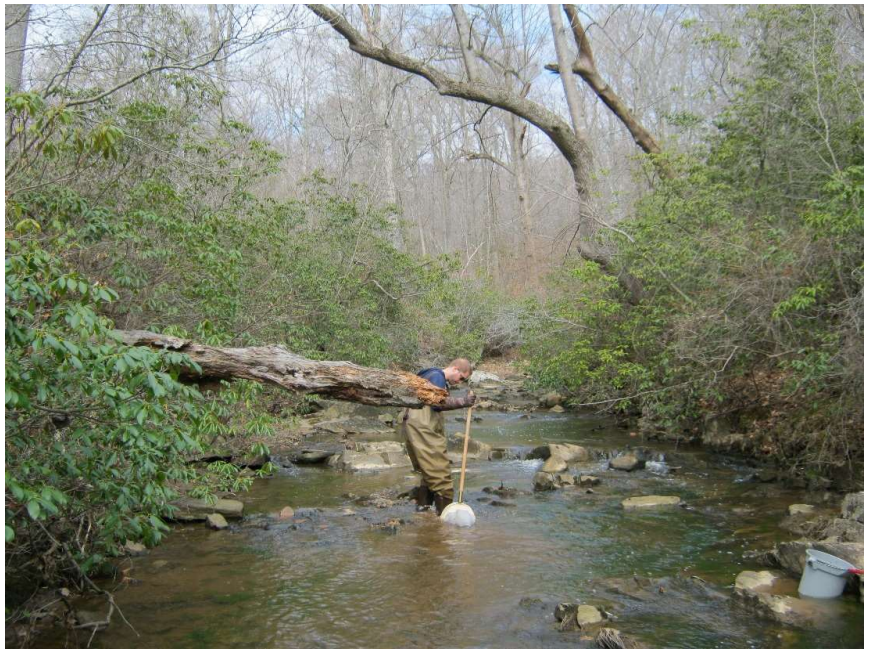
- Northern Piedmont (64)
  - 64a Triassic Lowlands
  - 64b Diabase and Conglomerate Uplands
  - 64c Piedmont Uplands
- Piedmont (45)
  - 45e Northern Inner Piedmont
- Southeastern Plains (65)
  - 65e Chesapeake Rolling Coastal Plain

Study Goals

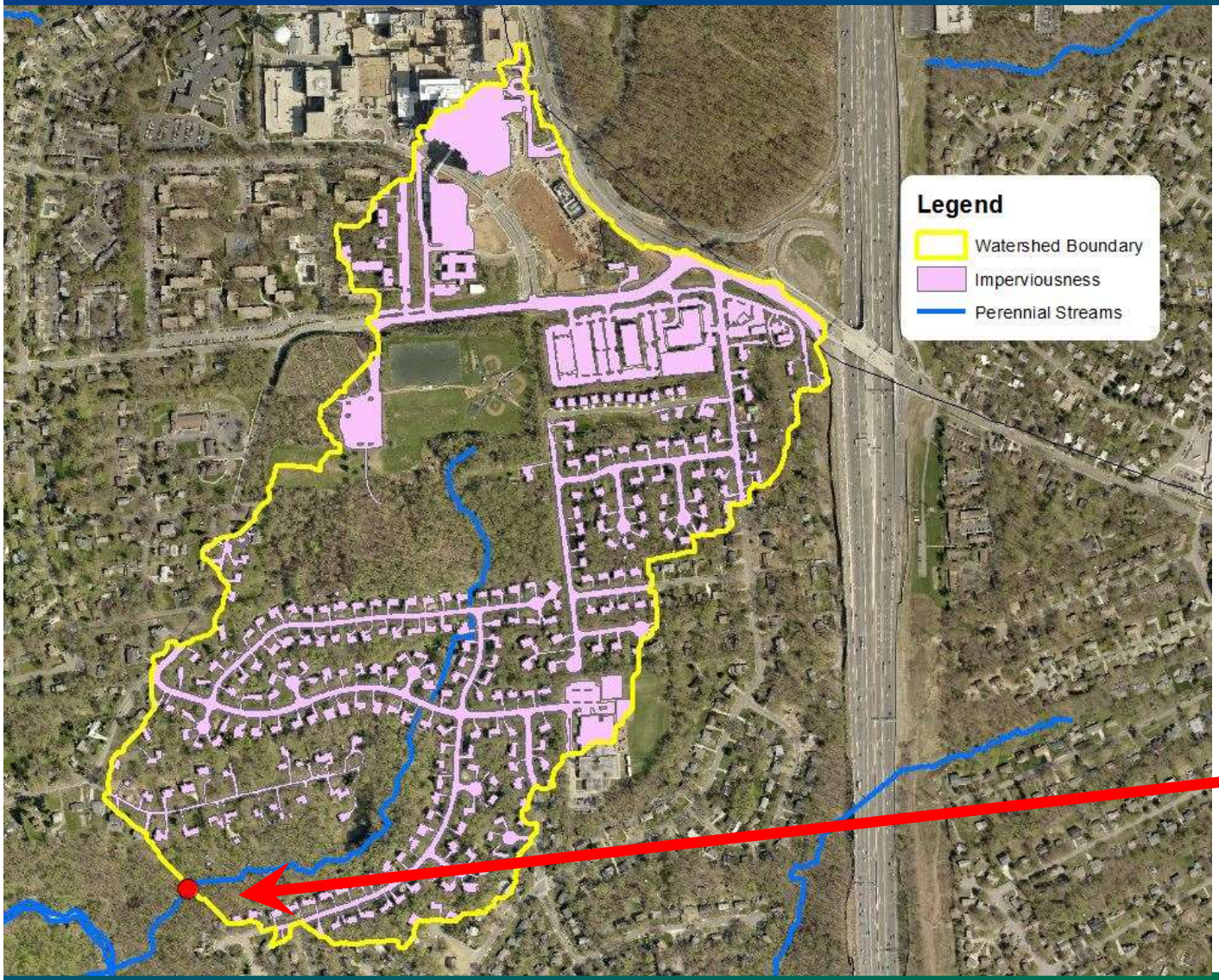
- Many existing B-IBIs use TVs developed by others or for other stressors (HBI = organic pollution) or sampling frames (local, state, regional)
- Biomonitoring programs should re-visit TVs periodically
- New approach to calculate benthic taxa tolerance values (TVs)
- Many benthic invertebrates are resilient to urban stress and the TVs should be increased (more tolerant)

Fairfax Co. Data for this Study

- 616 benthic samples (2004-2016) from the Piedmont (VA)
- Drainage areas (DEMs)
- 2009 Planimetric layer (fly-over) for impervious areas with stormwater network



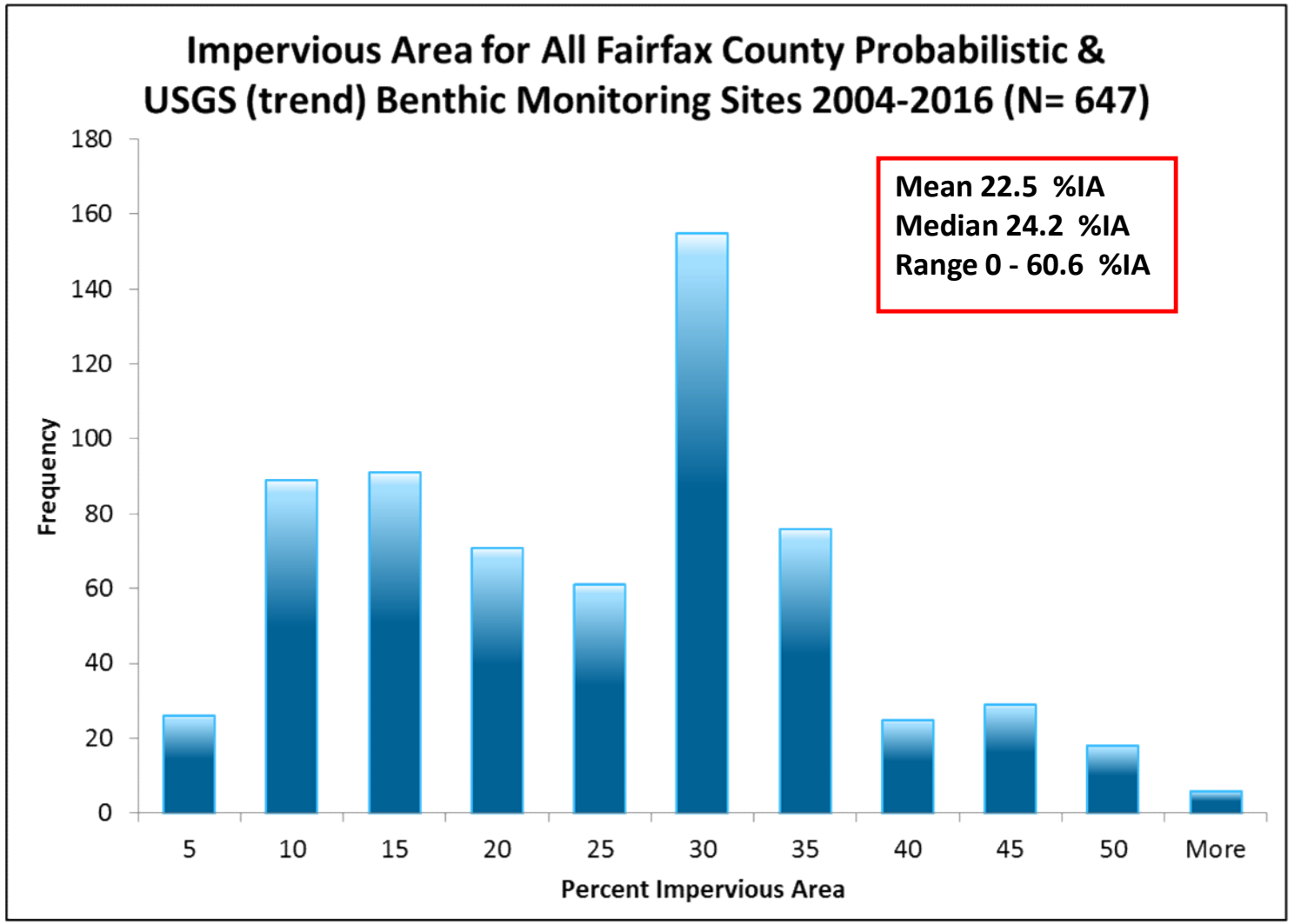
Impervious Surface Area - Sampling Urban Streams



- 27.2% Impervious Surface Area

Downstream Extent of Benthic Sampling Reach

Impervious Surface Area - Sampling Urban Streams

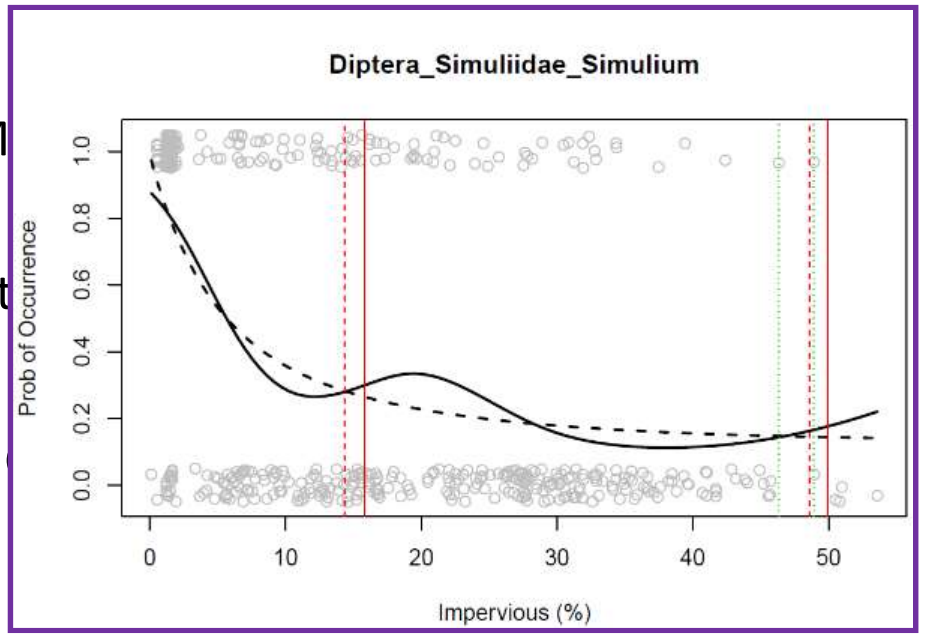


Sensitivity Analyses

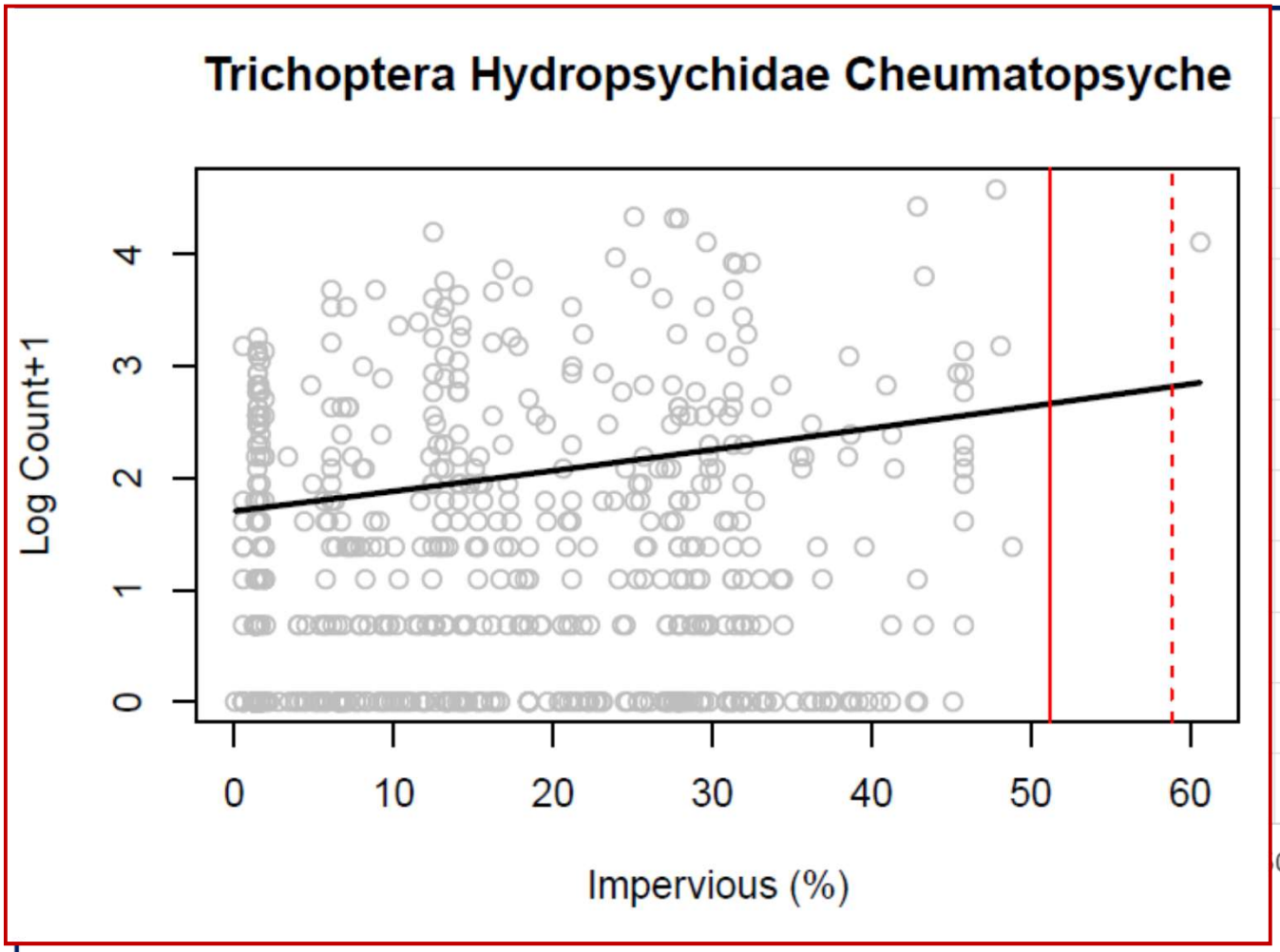
- Cumulative Frequency Distributions (CFDs) [as in Utz et al. 2009]
  - Process for linking sensitivity of benthic taxa to a particular stressor
  - Requires much data (20-25 occurrences of a taxa)

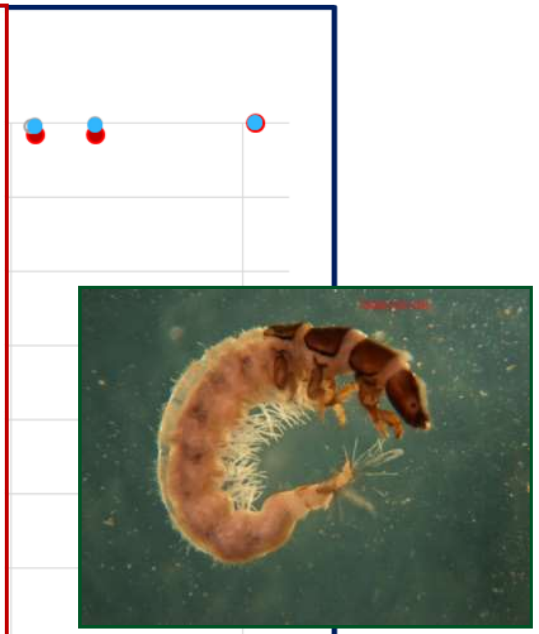
- Regression modelling
  - Generalized Additive Models (GAM
  - Quadratic and linear regressions
  - Method dictated by data constraint

- Taxa sensitivity to derive Toleran
  - P:A (Occurrence)
  - Abundance



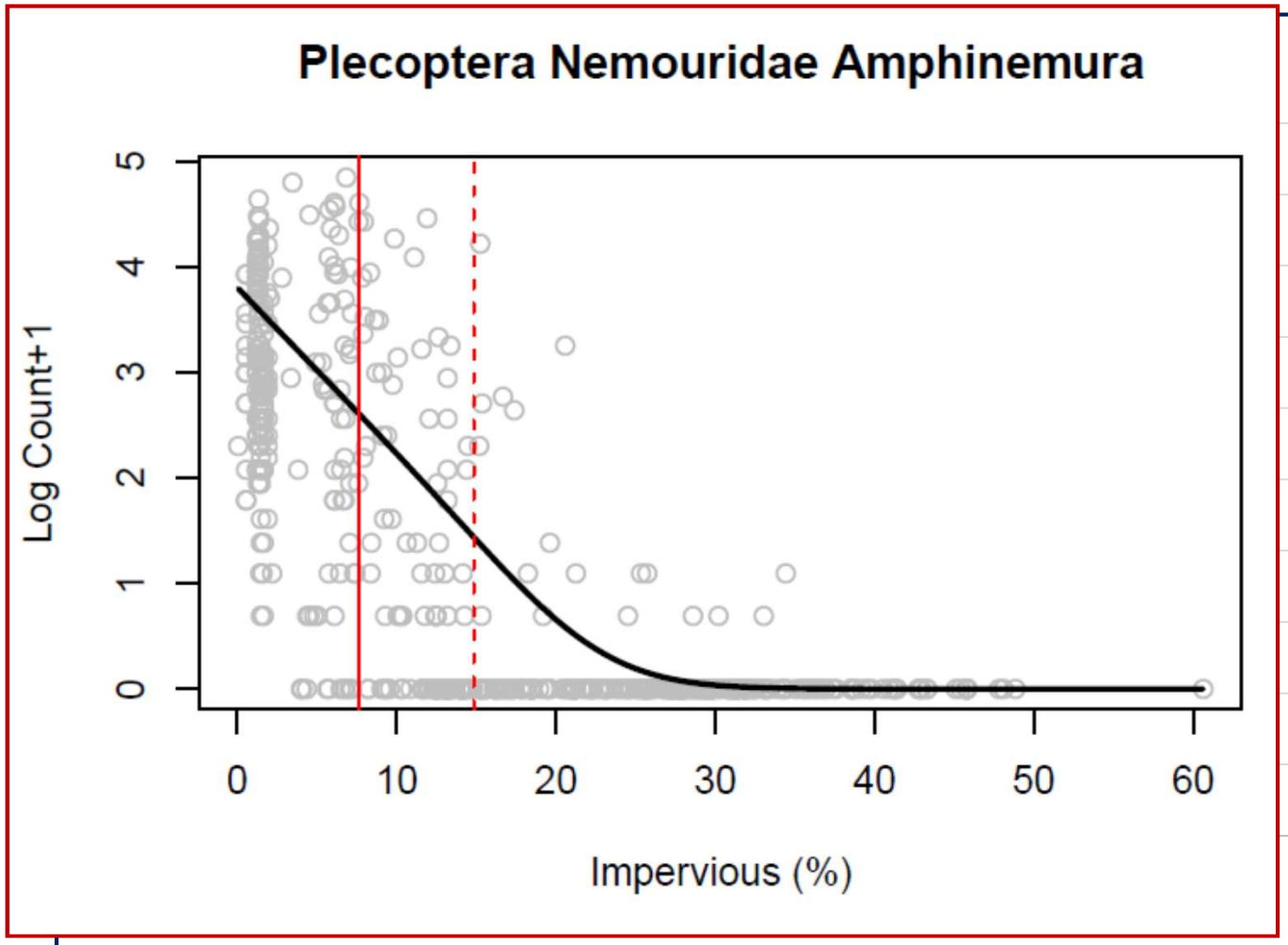
Positive Response to Stressor (% Imp. Area)





Cheumatopsyche Abundance Expected (all taxa) Cheumatopsyche P:A

Negative Response to Stressor (% Imp. Area)

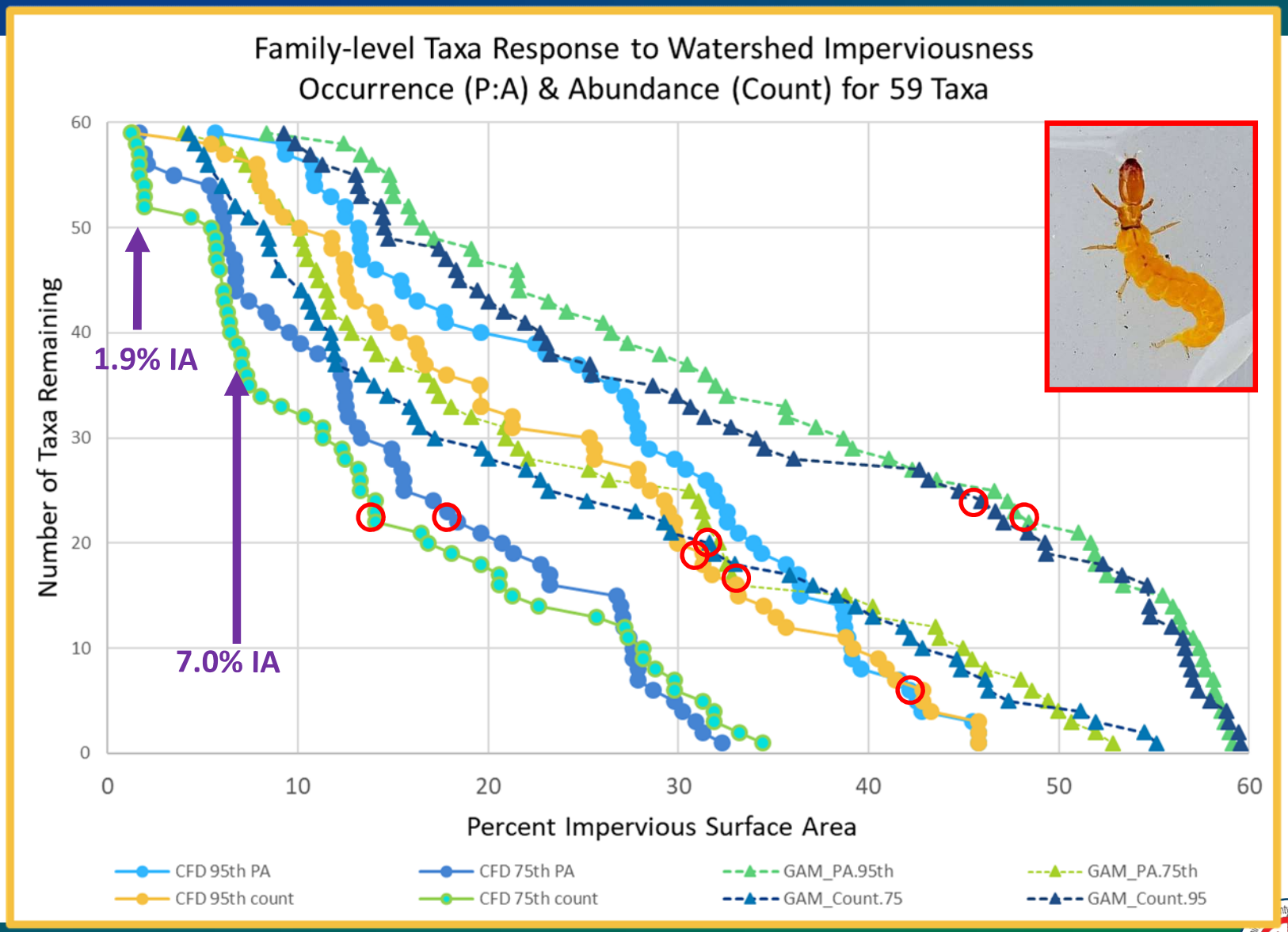


Amphinemura P:A Amphinemura Abundance Expected (all taxa)

Developing New Tolerance Values (TVs)

- Use the average of the 8 stressor responses
  - 4 CFDs
    - P:A & Relative Abundance
    - 75th and 95th Percentile
  - 4 GAMs
    - P:A & Relative Abundance
    - 75th and 95th Percentile
- Spread the data 0-10
  - Stressor-weighted (%IA)
  - Rank order

Family-Level Richness vs Stressor (% Imp Area), 59 taxa



Family-level Tolerance Values (6 of 59 taxa)

Order	Family	N Sites	N	**Fairfax Co Urban TV (new 2017)**	VADEQ (VSCI 1994-98)	MBSS 2004	Chessie BIBI	HBI 1988
Trichoptera	Philopotamidae	270	1695	**5.9**	3	2.6	3	3
Coleoptera	Hydrophilidae	40	50	**7.1**	5	nv	5	nv
Diptera	Tipulidae	383	1226	**8.7**	3	4.8	4	3
	C. Oligochaeta	558	15549	**8.1**	nv	10	9	nv
Trichoptera	Hydropsychidae	471	5537	**9.3**	6	5.7	5	4
Odonata	Calopterygidae	148	344	**9.9**	5	nv	5	5

Genus–level Tolerance Values (3 of the 76 taxa)

Hydropsyche

TV 7.5→9.7

Net-spinning Caddis

Chimarra

TV 4.4→7.6

Cheumatopsyche

TV 6.5→9.2

Conclusions

- Using GAMs & CFDs to create a synthetic stressor is effective for evaluating taxa sensitivity (new approach)
- Increased monitoring of urban environments will likely show higher benthic macroinvertebrate tolerance to urban stressors
- Develop metrics with stressors that can inform your program
- Be cautious when using aggregated metrics like % EPT in MMIs

Next Steps

- Test other likely stressors
  - RBP habitat, specific conductance, nutrients, land use or other factors?
- Create synthetic stressor based on suite
  - Mixed models, PCA, CCA or NMDS axes
- Apply new TVs to evaluate/re-redevelop BIBI, BCG, or USS
- Explore differences among Ecoregions (Triassic, Coastal Plain)

Additional Information

For additional information, please contact

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Genus-level Tolerance Values (12 of 76 taxa)

Taxonomic Unit (mostly Genus)	TV ImpArea (New 2017)	TV MBSS 2004
Trichoptera Philopotamidae Chimarra	**7.6** ⇧	**4.4**
Odonata Coenagrionidae Enallagma	**8.3**	**9**
Diptera Chironomidae ChironomidaeG	**8.5** ↑	**6.6**
Diptera Tipulidae Tipula	**8.6** ↑	**6.7**
C. Oligochaeta	**8.8**	**10**
Diptera Ceratopogonidae Dasyhelea	**8.9** ⇧	**3.6**
Trichoptera Hydropsychidae Cheumatopsyche	**9.2** ⇧	**6.5**
Odonata Calopterygidae Calopteryx	**9.6**	**8.3**
Trichoptera Hydropsychidae Hydropsyche	**9.7** ⇧	**7.5**
Diptera Empididae Hemerodromia	**9.8** ↑	**7.9**
Diptera Tipulidae Antocha	**9.8** ↑	**8**
Odonata Coenagrionidae Argia	**10.0**	**9.3**

⇧ Increased by at least 2 ↑ Increased by 1.8-1.9

Family Ranks of P:A & Abundance (59 taxa)

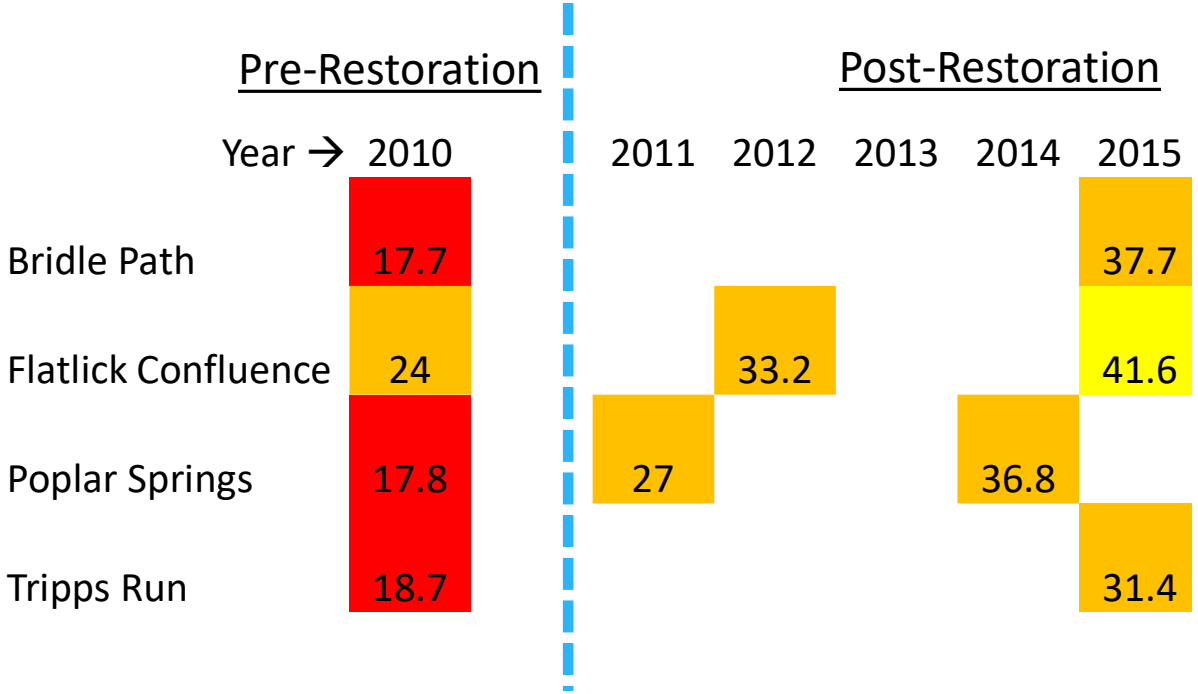
Order	Family	N Sites	N	TV %ImpArea (new 2017)	VADEQ (VSCI 1994-98)	MBSS 2004	Chessie BIBI	HBI 1988
Trichoptera	Philopotamidae	270	1695	5.9 ↑	3	2.6	3	3
Amphipoda	Gammaridae	26	146	6.6	6	nv	5	4
Coleoptera	Hydrophilidae	40	50	7.1 ↑	5	nv	5	nv
Diptera	Empididae	142	334	7.7	6	7.5	6	6
Diptera	Chironomidae	616	69677	7.4	6 or 9	6.6	6	6
Coleoptera	Haliplidae	20	26	8.2	7	nv	6	nv
Diptera	Tipulidae	383	1226	8.7 ↑	3	4.8	4	3
	C. Oligochaeta	558	15549	8.1	nv	10	9	nv
Trichoptera	Hydropsychidae	471	5537	9.3 ↑	6	5.7	5	4
Odonata	Coenagrionidae	127	455	9.4	9	9	8	9
Odonata	Calopterygidae	148	344	9.9 ↑	5	nv	5	5

↑ Increased by at least 2

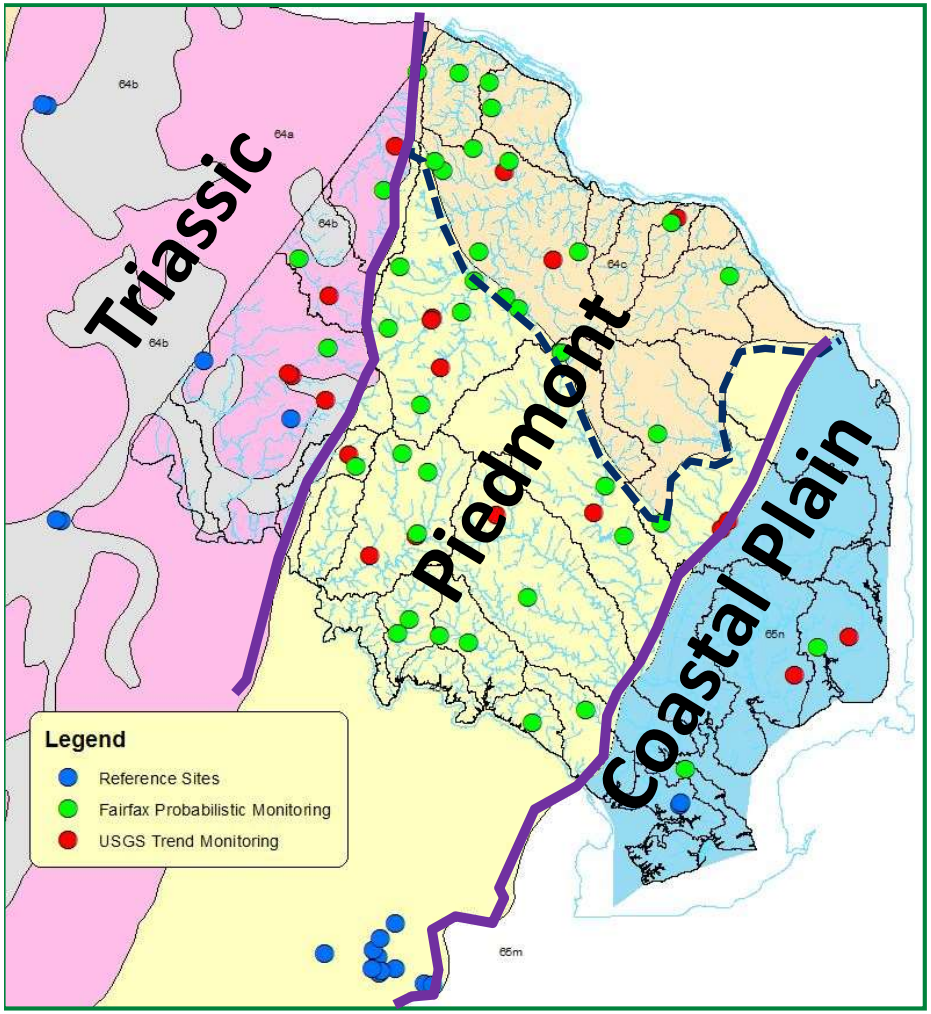
Stream Restoration Monitoring - Benthics

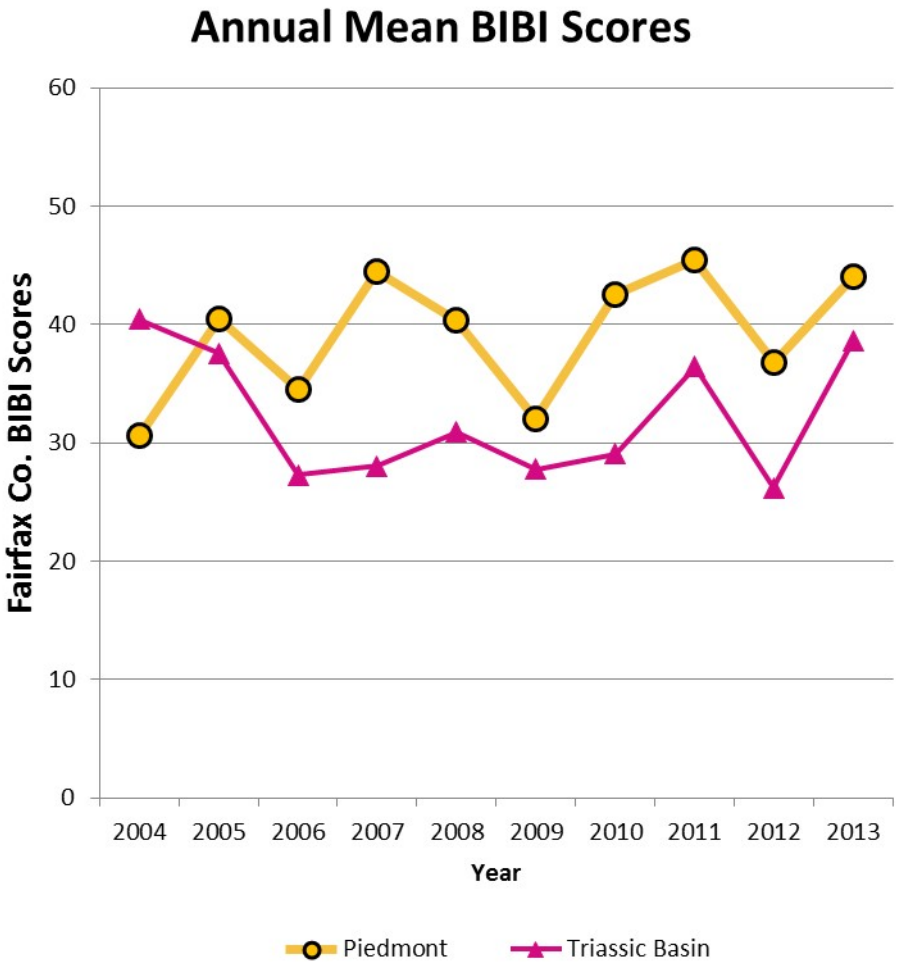
- Success! Or not?
- Cautionary tale of limited data

FFX_Genus_ IBI
Excellent (80-100)
Very Good (60-79)
Fair (40-59)
Poor (20-39)
Very Poor (0-19)

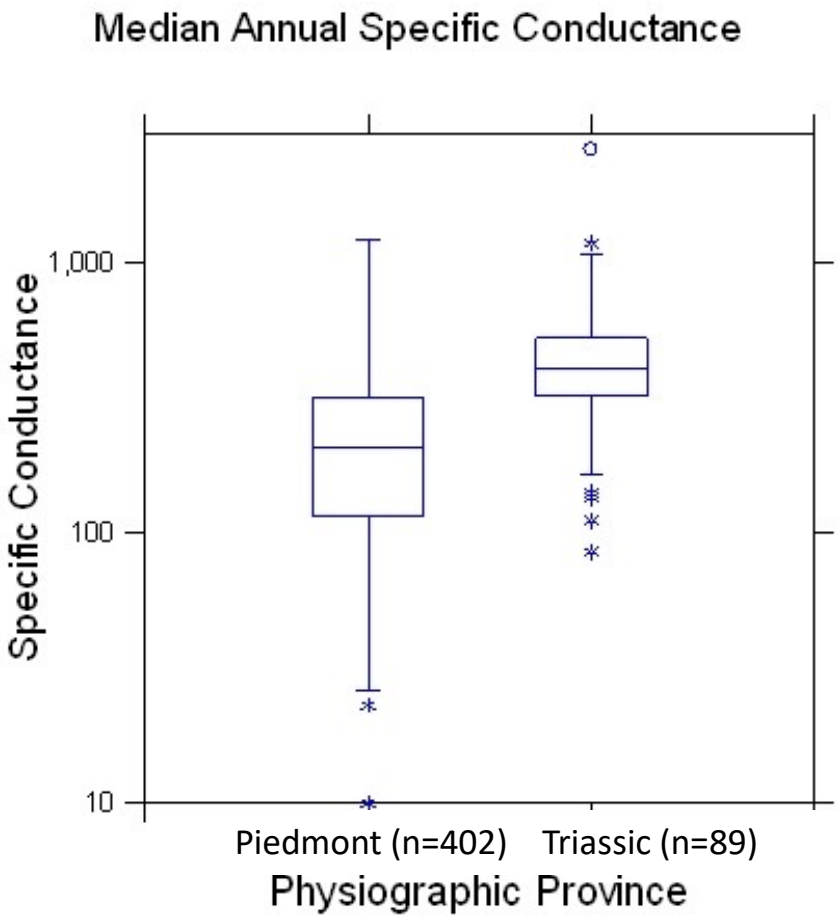


Ecoregion variation





Specific Conductance – Ecoregion Signal



Triassic Basin (64a & b) mean specific conductance is **225.5** µS/cm³@25°C **higher** than Piedmont (64c & 45e).

(159 to 292, 95%CI, $p < 0.0005$)

Ecoregion variation