Detecting and Assessing Ecological Responses in Urban Waters

Shannon Curtis, Fairfax County Stormwater Planning

Department of Public Works and Environmental Services
Working for You!

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Presentation Overview

- ✓ Introduction to Fairfax County, VA
- ✓ Stream bioassessments
- ✓ Fairfax County USGS stream gage network – ecological analyses
  - ✓ Selected results from the benthic macroinvertebrate assessments
- ✓ The “urban stream” biotic trajectory …and management implications
- ✓ What’s next?

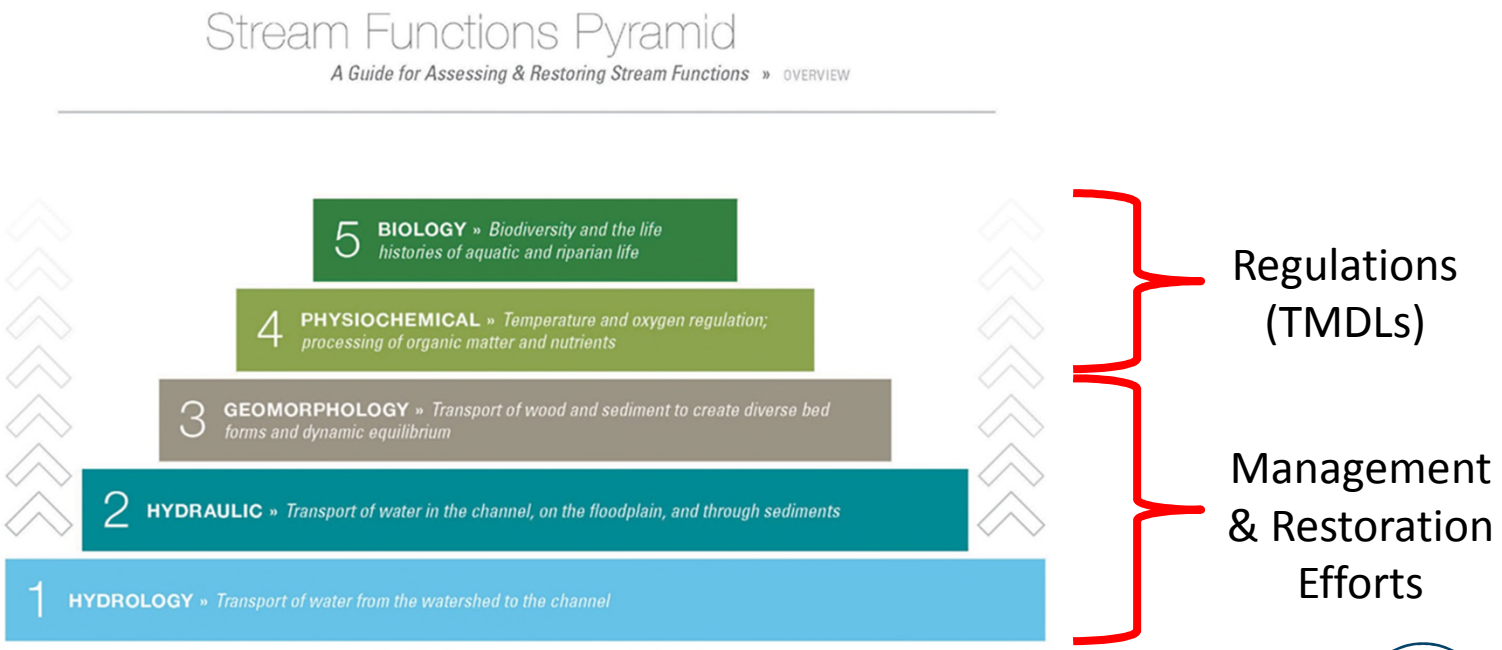
Welcome to Fairfax County, Virginia!

- Suburb of Washington DC
  - Population = 1.14 million
  - Regulated Phase I MS4 Community
- ChesapeakeBay/Potomac River Watershed
- 30 watersheds draining 400 miles^2
  - 88% land use Residential
  - Average impervious ~ **25%**
  - >1,600 miles of stream channels
  - **3 Physiographic Provinces/Ecoregions**
- >75% streams rated in *Fair*, *Poor* or *Very Poor* health
- FY20 County budget approx. $**8.4**billion
  - SWM Program funded through Service District (3.25¢/$100 assessed real estate value)
  - $82.9 million for STW Management program **($26M for WQ projects**)
  - 8 staff Ecologists (in monitoring group)

Stream Bioassessments for Watershed Management

Why biological monitoring?

- Cumulative impacts vs. ephemeral changes in WQ
- Provides ecological context for system
- Community structure/composition tell us about particular stressor(s)
- End game (usually) for restorations and regulations (CWA)



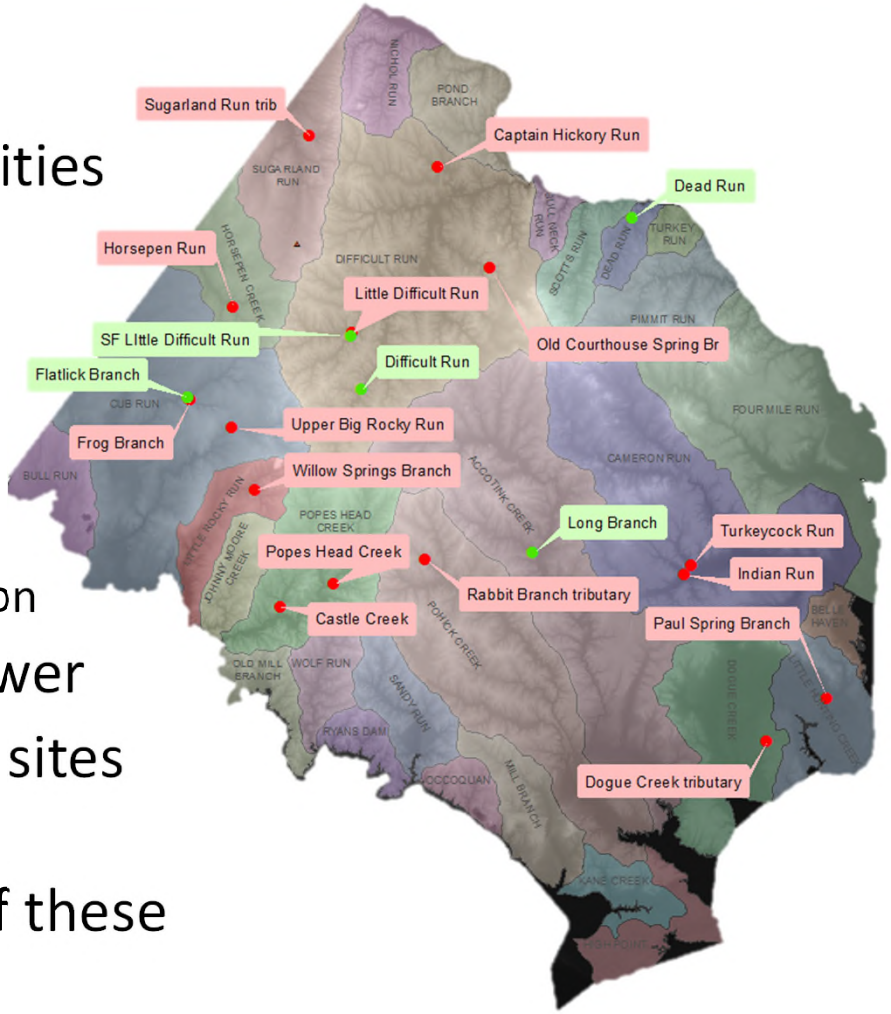
Biological Monitoring Programs in Fairfax County

Sample >100 sites for benthic macroinvertebrates ("benthics") annually:

- 40 Probabilistic (stratified random) design
  - Statistically valid "countywide condition", trends
- 20 Reference Sites
  - Benchmarking, trends
- 20 Stream Restoration sites
  - Ecological lift?
- 20 USGS Gage sites
  - Small watershed responses to BMPs
- Genus-level taxonomic ID at all sites
- All work performed "in-house", by staff

USGS Gage Network Study with Fairfax County

- Bioassessment Objectives:
  1. **Characterize** benthic communities
  2. Detect any **trends** over time
  3. Relate trends to changes in
     - Land use
     - Hydrology
     - Water quality
     - Restorations & BMP implementation
- 20 network sites: 14 original + 6 newer
- Benthics sampled annually at all 20 sites
- Stream restorations and BMP implementation ongoing in many of these watersheds



Objective 1: **Characterize** benthic communities

Methods:

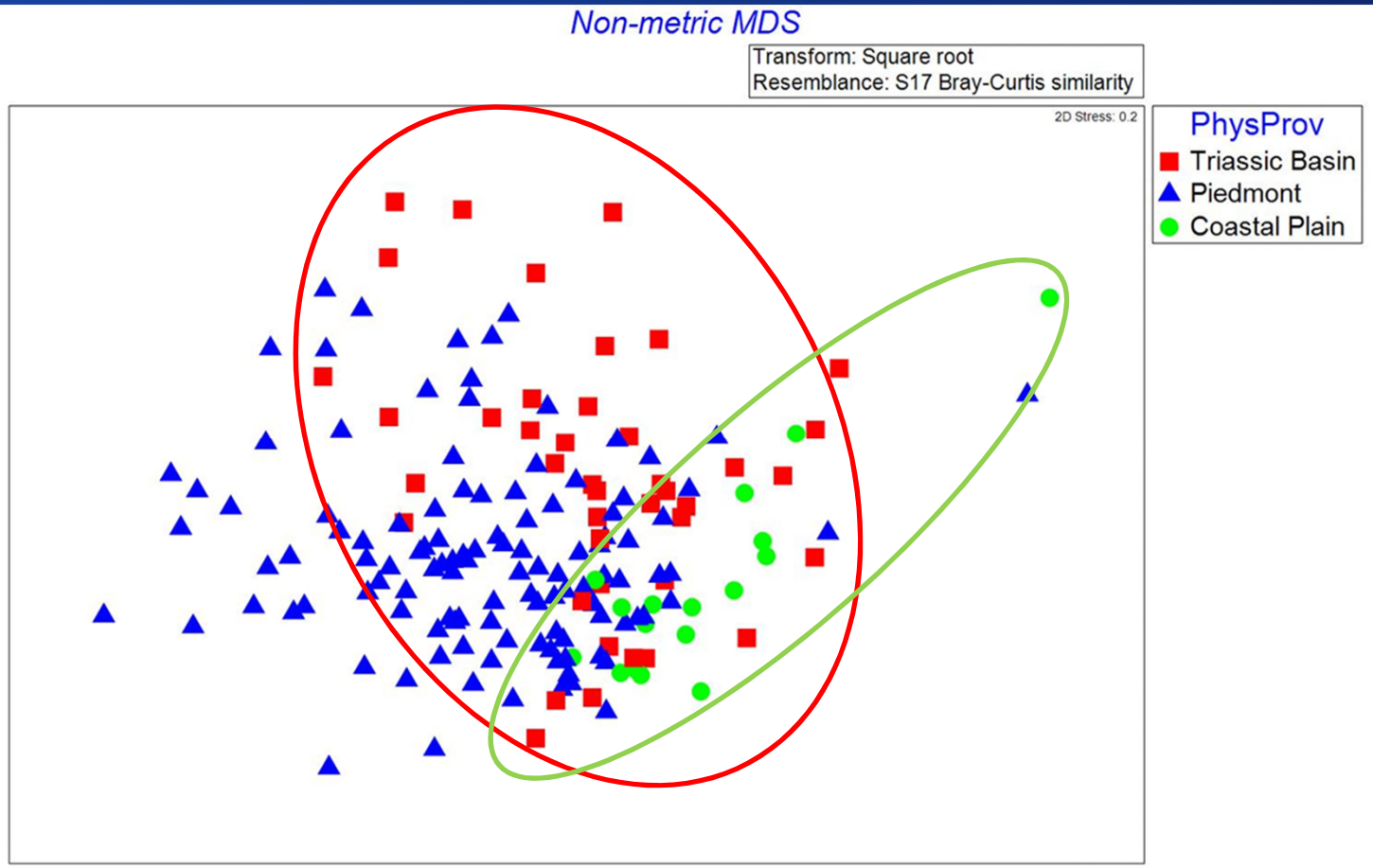
Used non-metric, multi-dimensional multi-metric scaling (NMDS) plots to evaluate benthic **community composition** at all 20 sites.

NMDS is a an ordination technique used for visualizing the level of similarity of data by translating these similarities into unitless spatial scales

Each point represents the community for a given site sample.

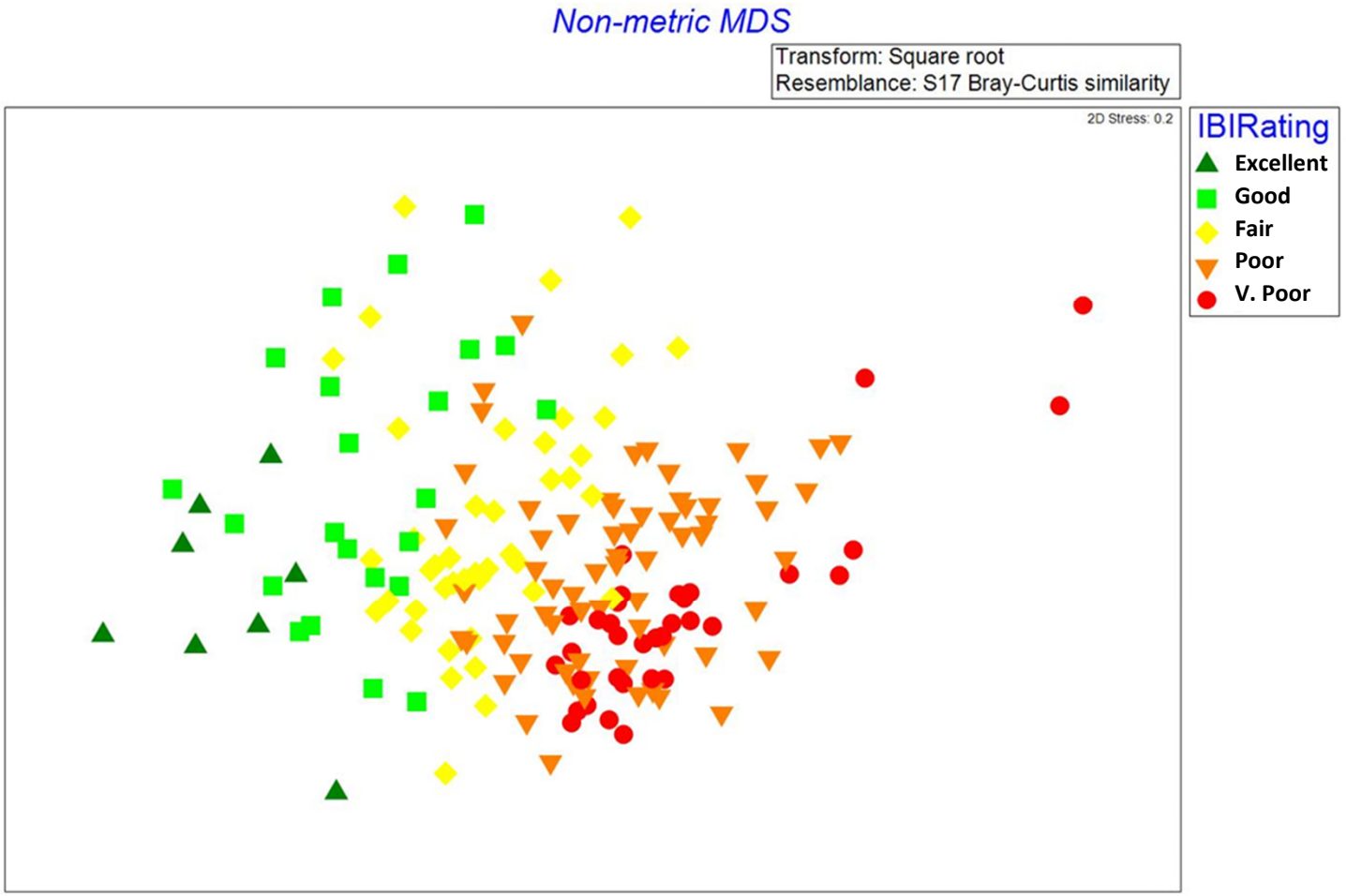
The closer points are in space, the more similar their taxonomic community composition

Objective 1: Characterize benthic communities



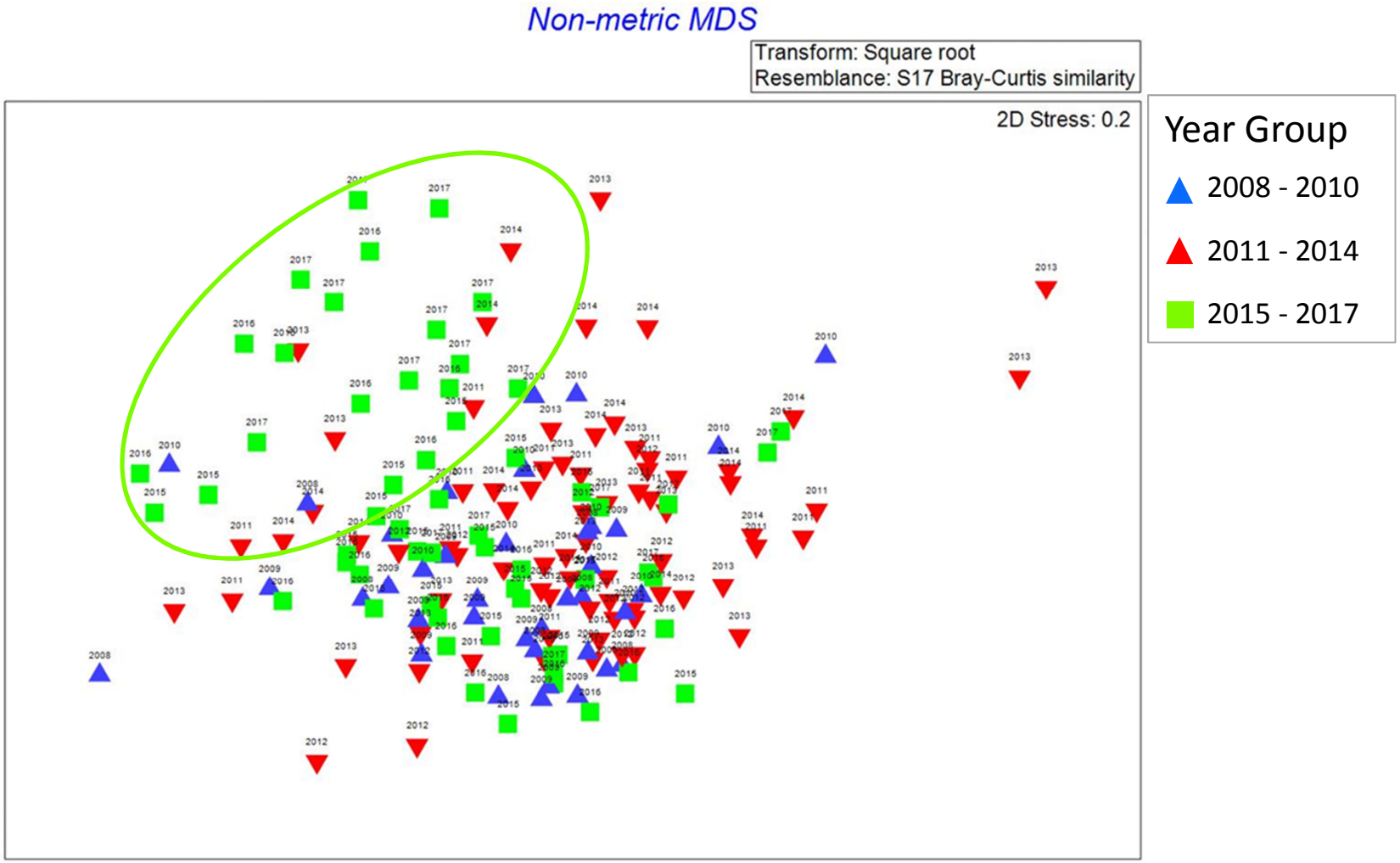
1. Communities are different in the 3 physiographic provinces
   - Physiography determines community composition & structure

Objective 1: Characterize benthic communities



2. Index of Biotic Integrity (IBI) – *Healthy* sites have varied community structures, *degraded* sites converge on a like community

Objective 1: Characterize benthic communities



3. Communities appear to be changing over time at some sites…

Objective 2: – Detect any trends over time

Methods:

1. Used benthic taxa data to calculate 20 commonly used metrics:

METRIC CATEGORIES & INDIVIDUAL METRICS

% Composition (of a sample)	**Richness** (# unique taxa)	**Overall Condition**
% EPT	EPT richness	% Dominance
% COTE	COTE richness	Total Taxa
% CCH	CCH richness	Index of Biological Integrity (IBI)*
% Filter Feeders	Filter Feeders richness	
% Predators	Predators richness	
% Scrapers	Scrapers richness	
% Gastropoda	*Gastropoda* richness	
% Odonata	*Odonata* richness	
% Chironomids & *Oligochetes*		

* multi-metric index

Tolerant & ***Intolerant*** - sensitivity to pollution, ecological perturbances and modifications

Metrics –measures of various aspects of ecological functions and structure

Objective 2: – Detect any trends over time

Methods:

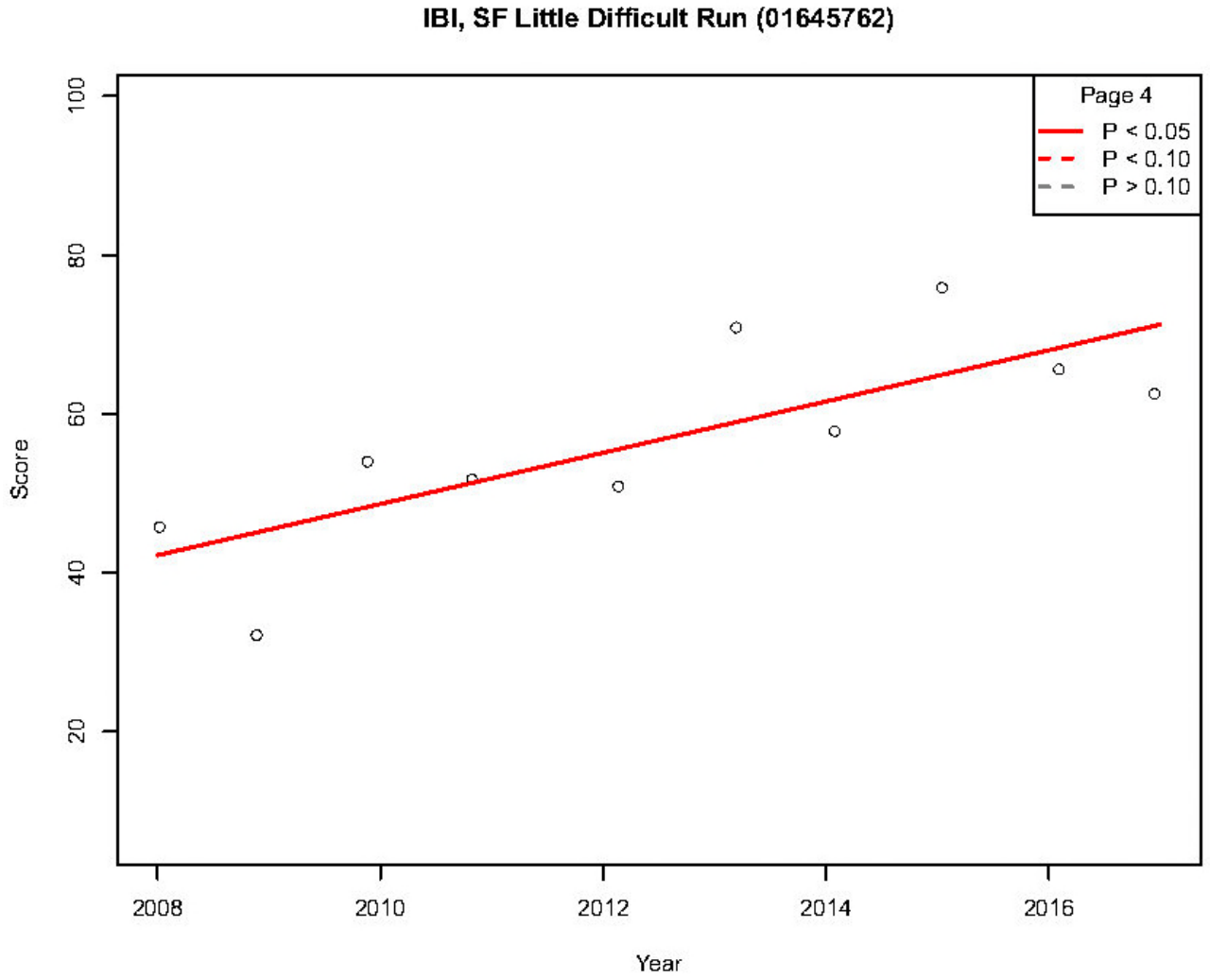
2. Models run for each of the 20 metrics for original 14 network sites

   - at **individual sites** (traditional regression models)
   - **network-wide**, as a whole (mixed effect models)

   – Yielded 300 models/plots
   – Trends over time were considered significant if $P < 0.05$.
   – To look at network-wide trends, random effects models accounted for variation in the trends over time across sites (random slopes and intercepts)

* models were evaluated using the "lme4" and "lmerTest" packages in R (Bates et al. 2015, Kuznetsova et al. 2017, R Core Team 2018)

Objective 2: – Detect any trends over time



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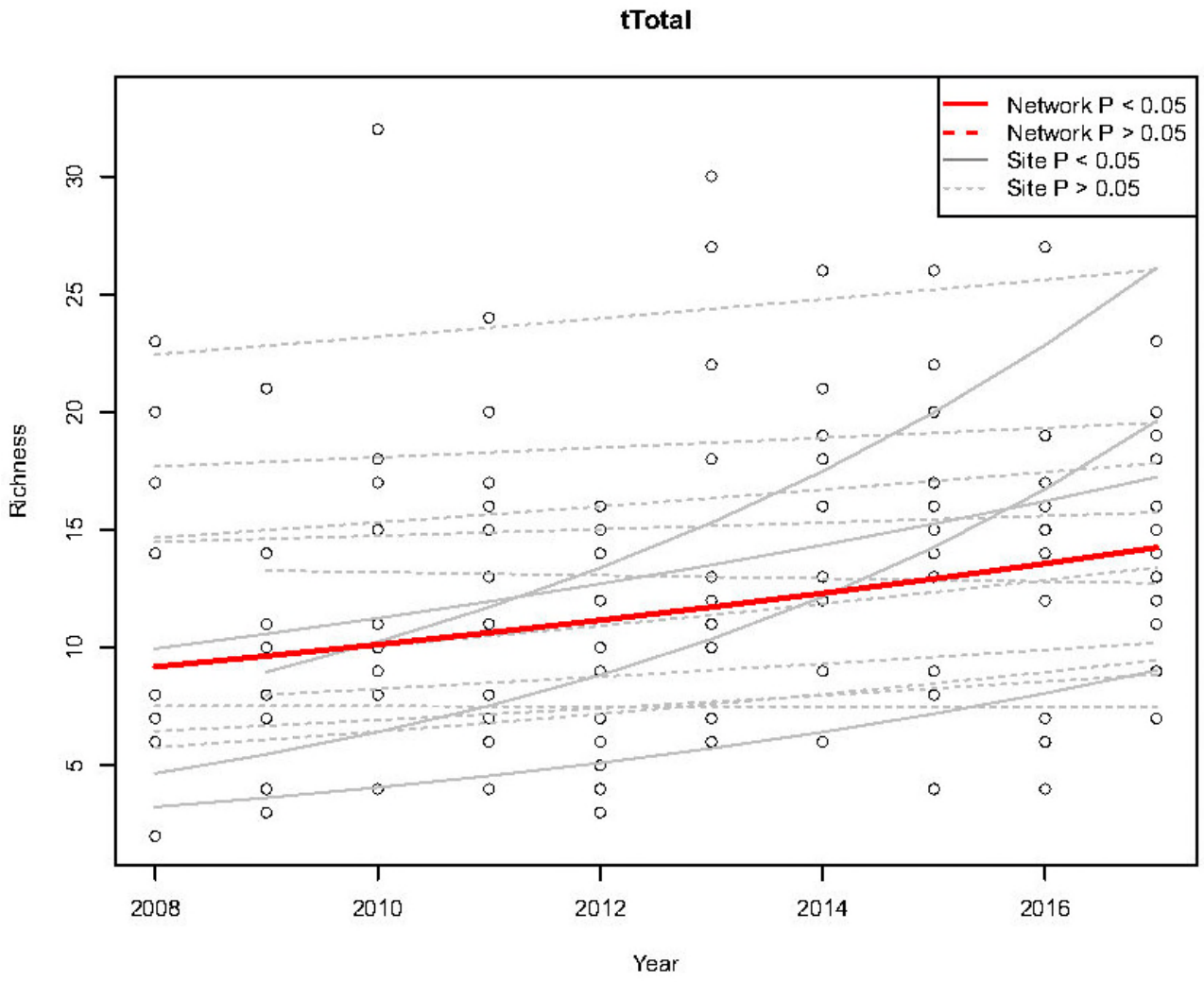

Solid lines: significant

Gray lines: individual sites

Red line: network-wide model

Objective 2: – Detect any trends over time

Results:

At **individua**l sites, trend significance varied for each metric

- Did not see significant trends at every site
- Some sites had significant trends in degrading metrics

Network-wide we noted significant trends of improvement in 19 of the 20 metrics

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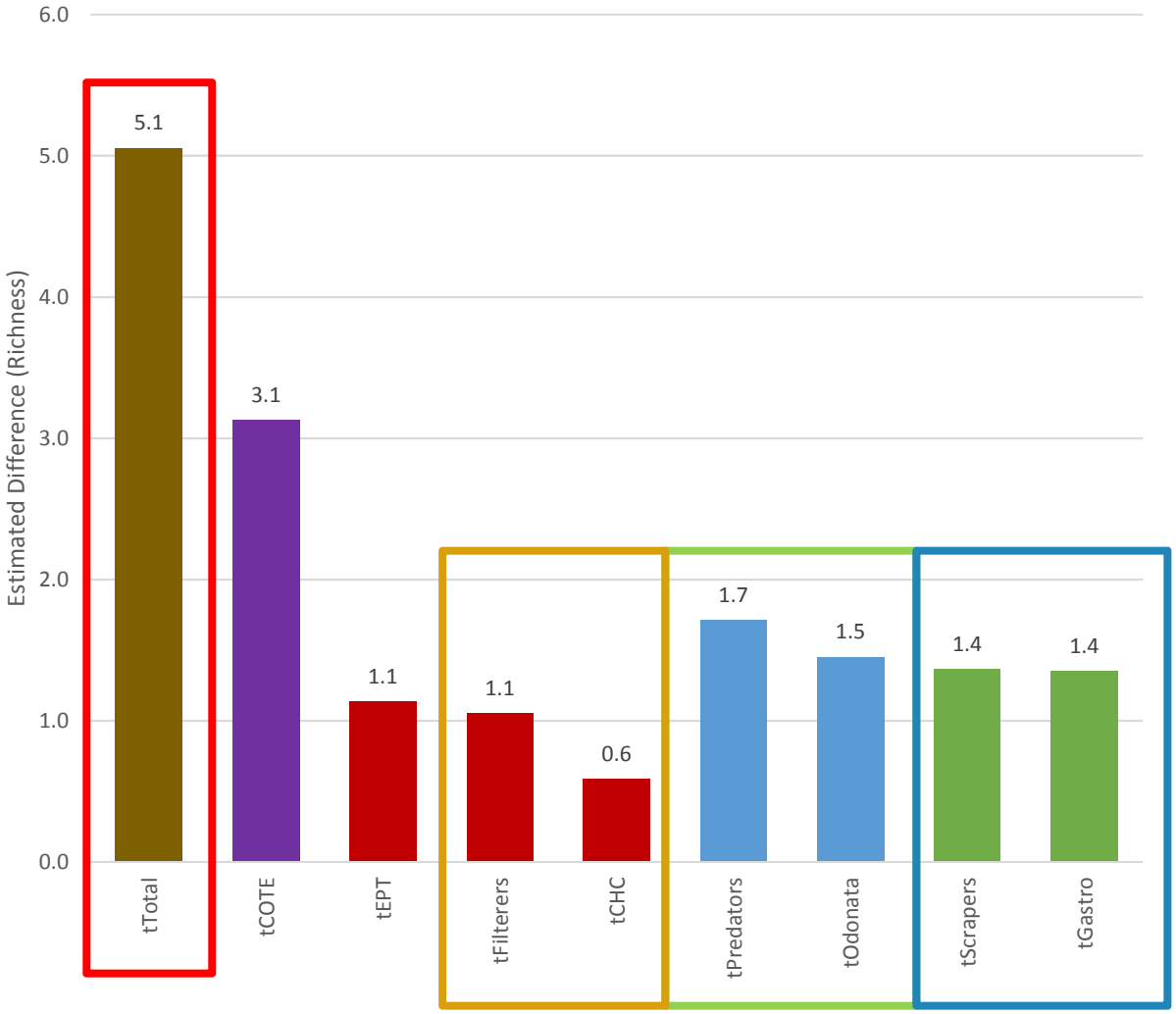
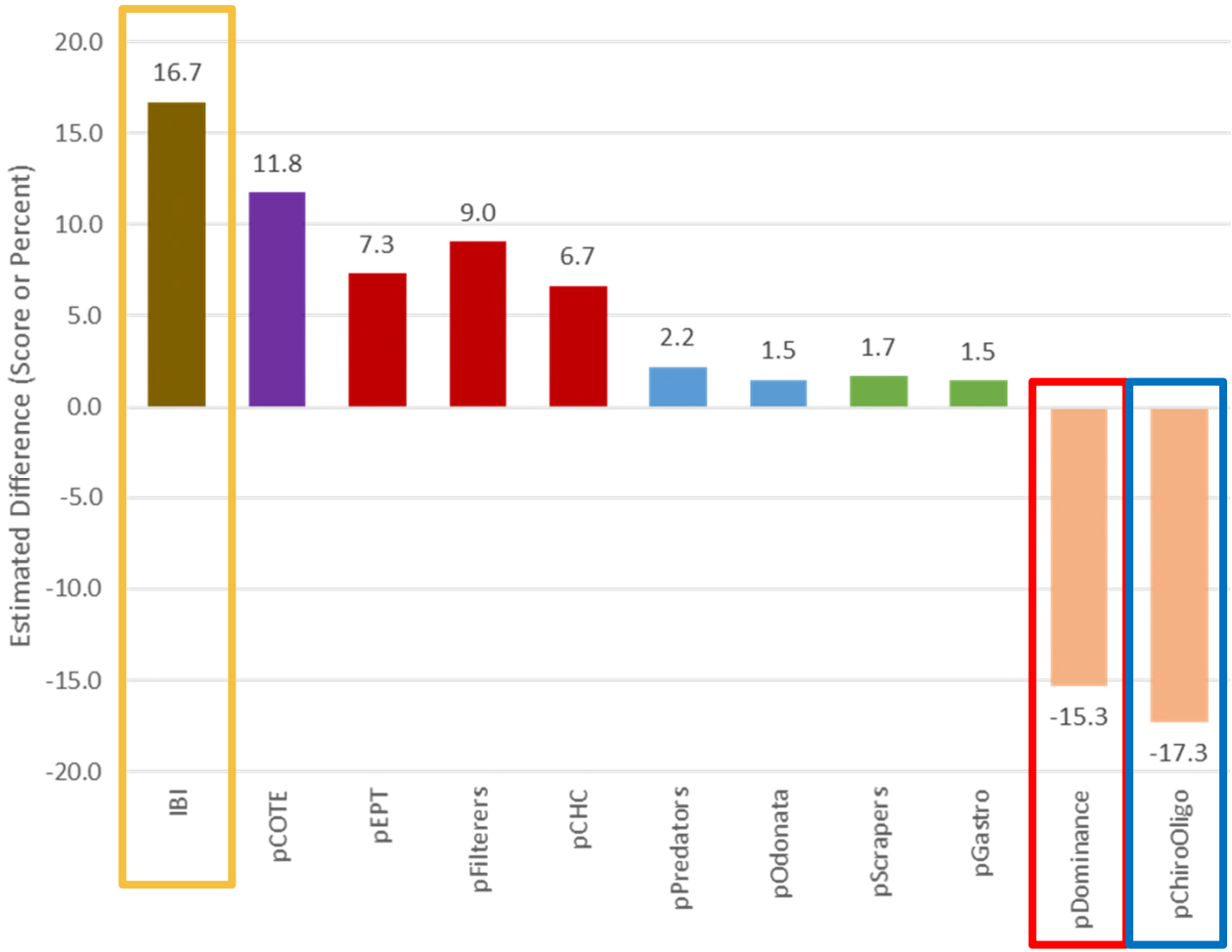


1. Total Taxa **richness** improved by 5 taxa network-wide.

This increased diversity mostly being driven by increased **richness** of:

2. less-sensitive Caddisflies (filterers)
3. Odonates (predators)
4. Gastropods (scrapers) – typically tolerant Snails

Objective 2: – Detect any trends over time



Network-wide, **percent composition** metrics exhibited likewise improvements and relationships:

1. Dominance decreased by 15% network-wide
2. % abundance of midges and worms (highly tolerant) decreased by 17%

Plus:

1. IBI increased by about 17 points - almost one whole rating category: **Poor -> Fair**

Network Biological Analyses – Discussion

These changes together suggest that

- The biodiversity, function, and condition of streams in Fairfax County is improving

BUT:

- many of these "improvements" are being driven by increased diversity and percent composition of moderately tolerant taxa

- Like going from a grade of F to a D+…

Biological Analyses - Questions

So…

- Are we improving towards a modified “improved condition”?
- Are we creating conditions highly favorable for recovery of “urban tolerant” taxa?
- Can an urban stream truly recover to like-reference biological conditions?
- Many urban systems are irrevocably changed and should be viewed/managed differently… how much “biological lift” is achievable…?
- Should we be considering an *urban stream standard* for targeting desired (and realistic) levels of system recovery?

What's Next?: Benthic Translocation Study

- Seeding restored streams with benthic fauna from less-disturbed streams
- Utilize "Habitubes" – coir mesh sleeves packed with forest organic detritus. Organisms colonize and/or feed on tubes
- Before/After/Control Investigation (BACI)
- Can answer several questions:
  1. Can we successfully re-establish lost fauna (and functions)?
  2. Are stream restorations improving without "reseeding"?
  3. What are limiting factors to ecological lift in restored stream projects?

Additional Information

For additional information, please contact

Shannon Curtis, Chief, Watershed Assessment Branch

703-324-5500

shannon.curtis@fairfaxcounty.gov

www.fairfaxcounty.gov/dpwes

Gage Network Partnership: https://va.water.usgs.gov/fairfax/index.html