Stressors and their impact on stream health and restoration outcomes in the Chesapeake Bay Watershed

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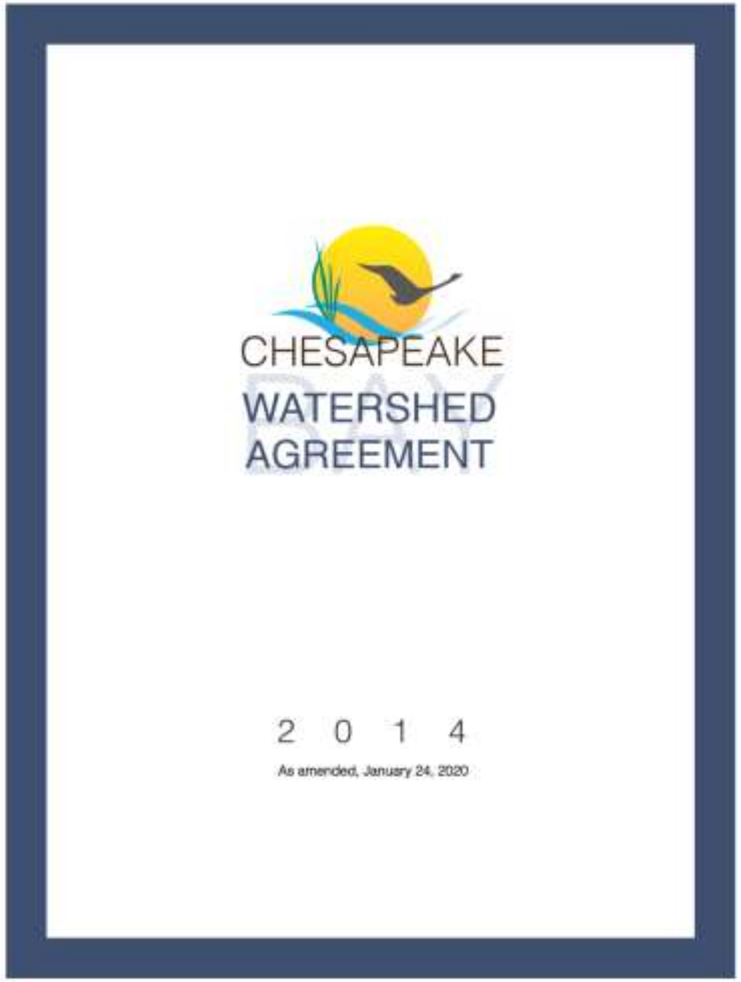
Outline

- Overview of Chesapeake Bay Program and Stream Health
- Major Stressors Impacting Stream Health
- Modeling Recovery
- Monitoring for Recovery: Fairfax County Case Study
- Conclusions

Stream Health and The Chesapeake Bay Program

CHESAPEAKE BAY PROGRAM

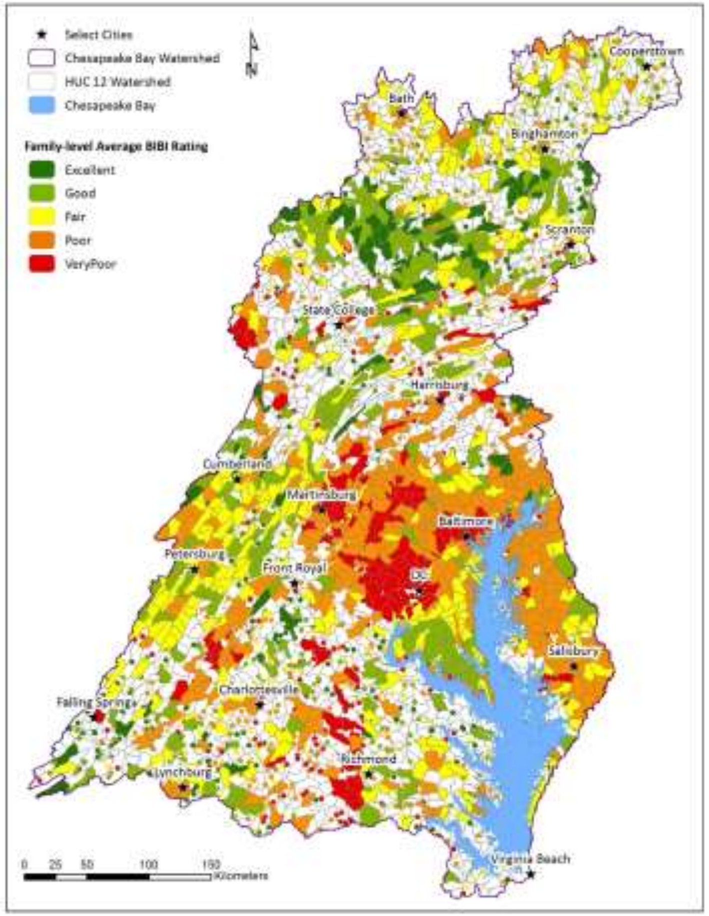
- A regional partnership working together to meet the goals of the **Chesapeake Bay Watershed Agreement**
- **Agreement** includes 10 goals, 31 outcomes that are managed by 6 Goal Implementation Teams and their Work Groups



Stream Health and The Chesapeake Bay Program

STREAM HEALTH OUTCOME

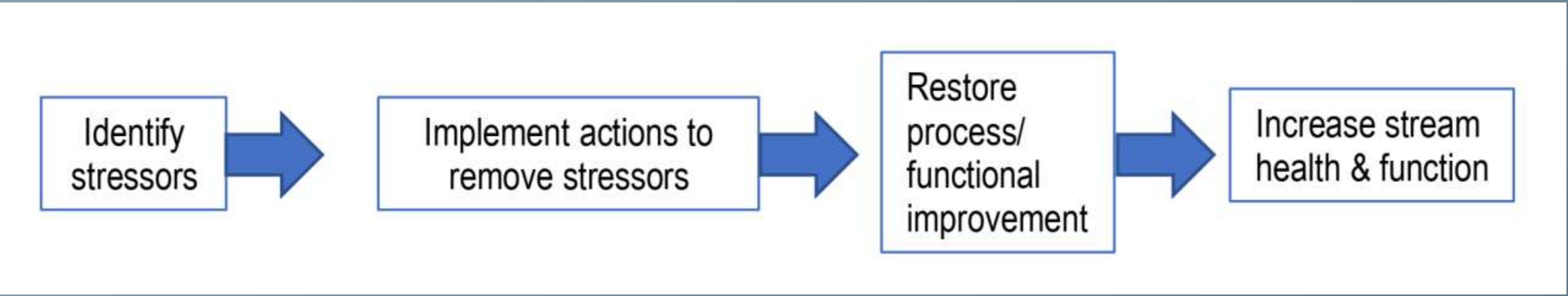
- Continually improve *stream health and function* throughout the watershed. Improve health and function of 10 percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed.
- Stream health measured and tracked by the “Chessie BIBI”
  - A benthic, multi-metric indicator of stream health



Chesapeake Bay TMDL

- Adopted in 2010 through Executive Order 13508, the Chesapeake Bay TMDL set pollutant load reduction targets for nitrogen, phosphorus and sediment
- Stream restoration is a key management action to reduce nutrient loads in the agricultural and urban land use sectors
  - Over 950 miles (or ~ 1% of total stream miles) of stream restoration implemented or planned from 2010 – 2025
  - Significant investments by Federal, State and local jurisdictions
  - Variable outcomes

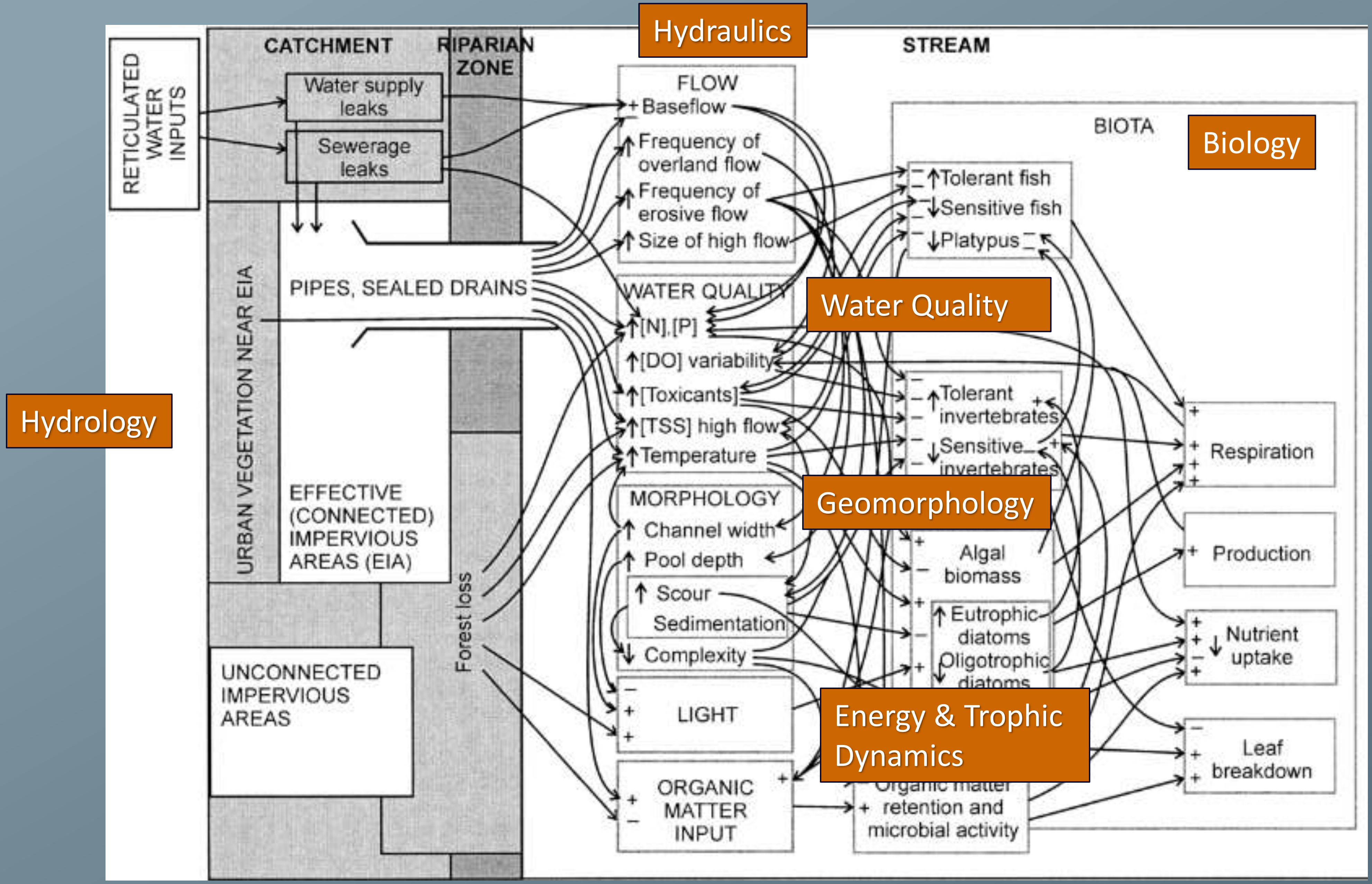
The impact of stream restoration to restore stream functions and health is debated



Phase 1: Which stressors and drivers are most affecting stream health?

Phase 2: Which of these stressors and drivers can be changed through management actions?

Phase 3: Following implementation of management efforts, how is stream health changing? How can we better characterize the response through both biological and non-biological metrics?

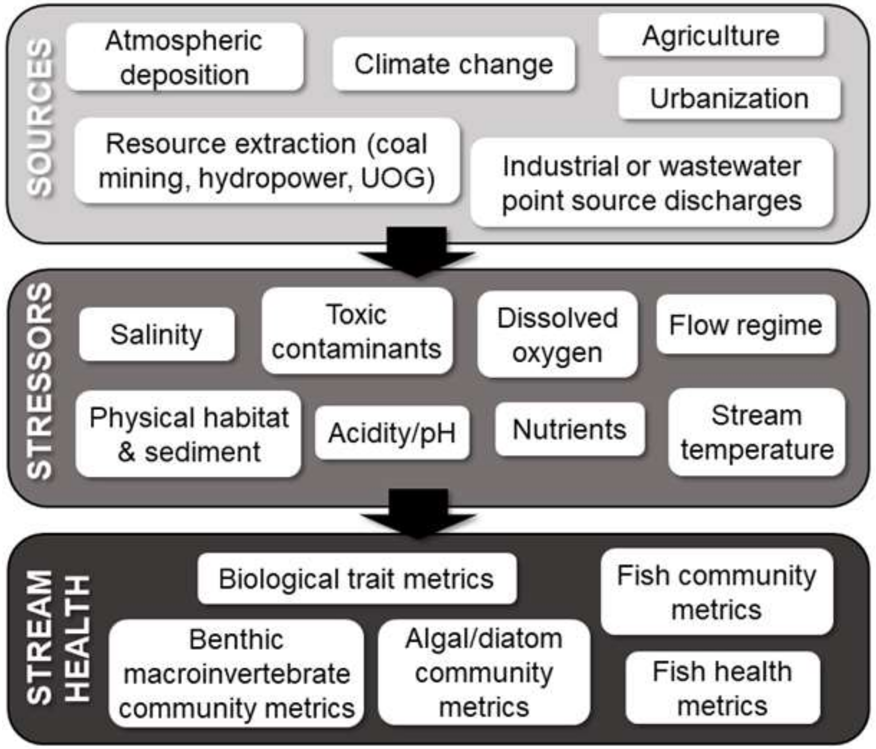


Walsh et al 2005

What are the Key Stressors Impacting Stream Health?

Key Stressors Impacting Stream Health

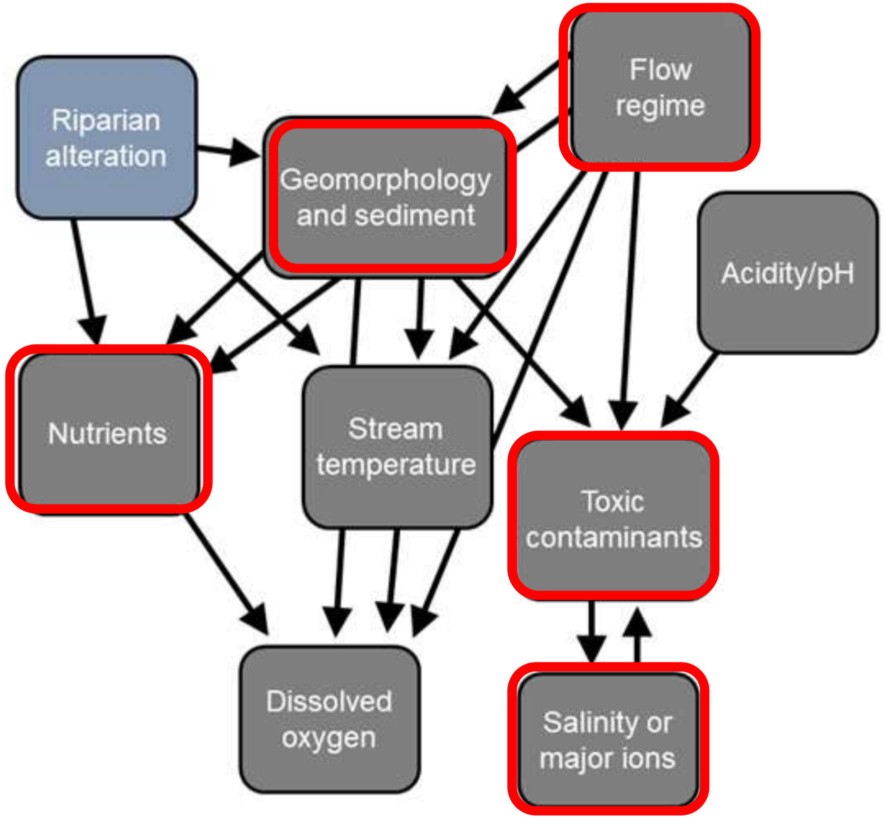
- Collaboration with the USGS* and SHWG
- Meta-analysis of literature review and database of regulatory impaired streams (ATTAINS)



* Fanelli, R, M. Cashman and A. Porter. 2022. Identifying key stressors driving biological impairment in freshwater streams in the Chesapeake Bay watershed, USA. In Review.

USGS Study Results

- Sources
  - Urbanization, agriculture, mining, industrial point sources and wastewater
- ALL studies
  - Salinity or major ions, geomorphology and toxic contaminants
- AGRICULTURAL studies
  - Toxic contaminants, geomorphology and nutrients
- URBAN studies
  - Flow, salinity or major ions, toxic contaminants and geomorphology



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Modeling Stream Restoration Outcomes

What is the impact of stream restoration and the removal of stressors on stream health?

- Modeling approach to simulate stream's functional response to removal of stressor(s)
  - How do the interrelationships amongst stream functions and stressors impact the success of reach-scale restoration and its time frame?
- 5 scenarios were tested* representing different levels of stress and initial conditions

*Ibrahim, Y., B. Amir-Faryar and N. Law. 2022. Complex adaptive system approach for studying the impact of externalities on the success of restoring stream functions. J. Hydrol. Eng, 27(6):04022009

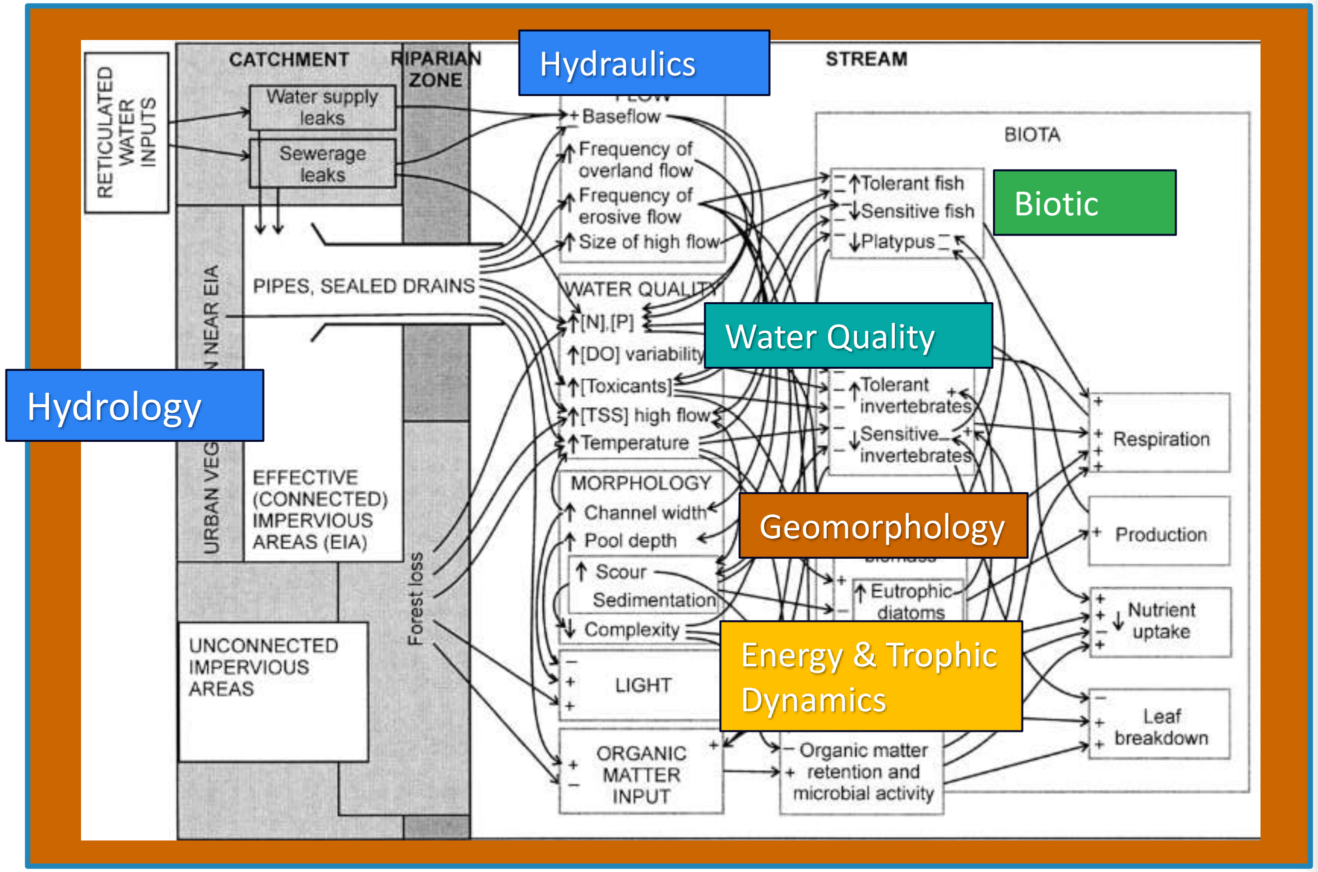
Modeling Stream Restoration Outcomes (& Expectations)

Table 1. Functions and their order of interactions

(based on Fischenich, 2006)

Function	Agent/function
1	General hydrodynamic balance
2	Maintain stream evolution processes
3	Surface water storage processes
4	Sediment community
5	Provide for riparian succession
6	Energy management processes
7	Maintain substrate and structural processes
8	Quality and quantity of sediments
9	Biological communities and processes
10	Surface/subsurface water connections
11	Maintain water and soil quality
12	Maintain landscape pathways
13	Maintain trophic structures and processes
14	Chemical processes and nutrient cycles
15	Provide necessary habitats

N



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11	Maintain water and soil quality ■
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15	Provide necessary habitats ■ ▲

Geomorphology and sediment

Flow regime

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Modeling Stream Restoration Outcomes (& Expectations)

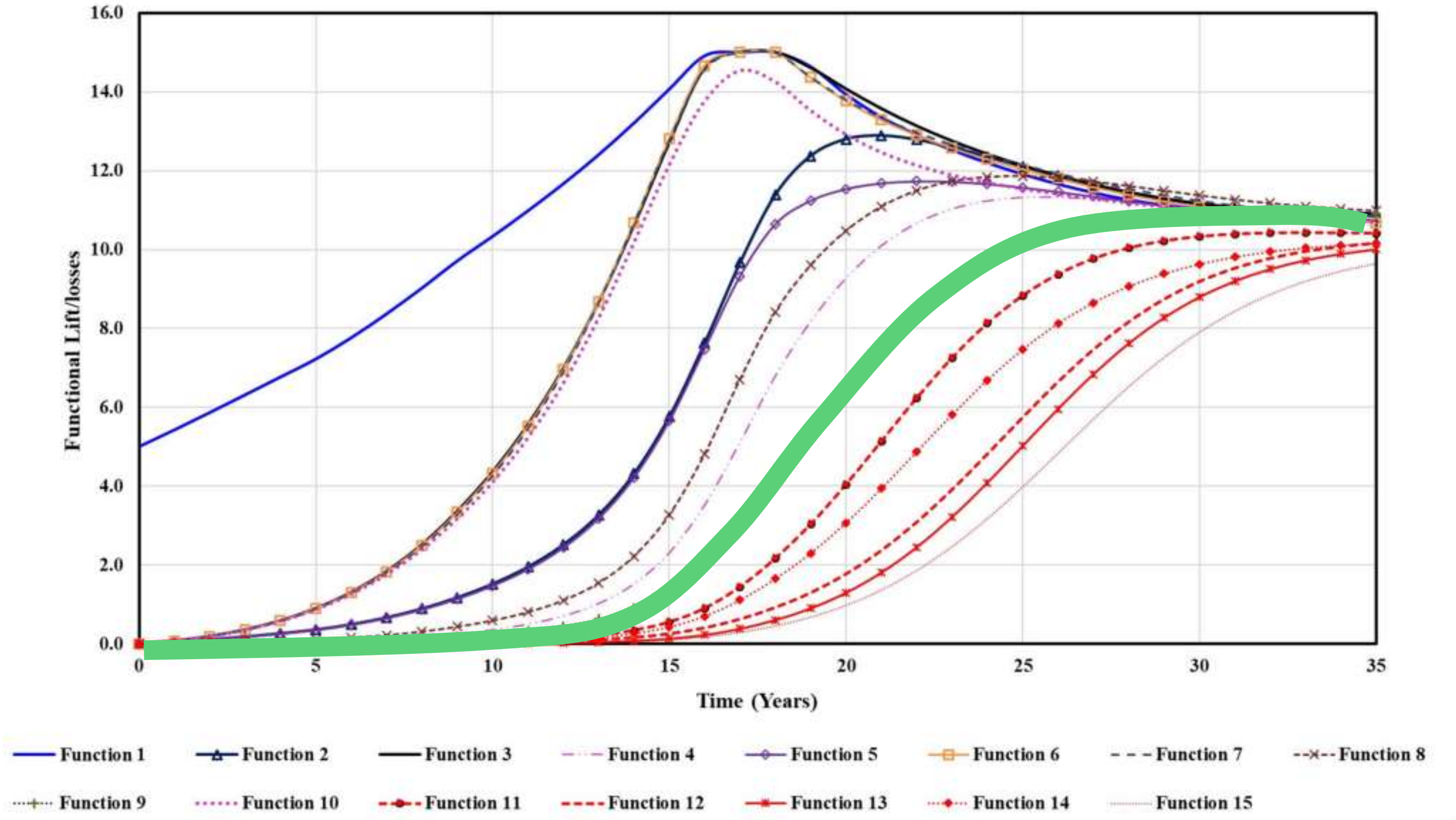
Table 1. Functions and their order of interactions (from Fischenich, 2006)

Function	Agent/function	$k = 1$	$k = 2$	$k = 3$	$k = 4$	$k = 5$	$k = 6$	$k = 7$	$k = 8$	$k = 9$	$k = 10$	$k = 11$	$k = 12$	$k = 13$	$k = 14$
1	General hydrodynamic balance	2	3	4	5	6	7	8	9	10	11	12	14	15	13
2	Maintain stream evolution processes	1	3	4	5	6	7	8	10	11	12	14	15	9	13
3	Surface water storage processes	1	4	6	10	11	12	14	15	2	5	7	8	9	13
4	Sediment community	3	5	6	7	8	9	11	15	1	13	14	—	—	—
5	Provide for riparian succession	1	2	3	4	6	12	14	15	9	13	—	—	—	—
6	Energy management processes	1	2	3	4	5	7	8	15	—	—	—	—	—	—
7	Maintain substrate and structural processes	1	2	4	6	7	10	15	5	9	11	13	—	—	—
8	Quality and quantity of sediments	2	4	5	6	7	10	15	1	9	11	14	—	—	—
9	Biological communities and processes	5	11	13	14	15	1	2	3	7	8	10	12	—	—
10	Surface/subsurface water connections	1	5	11	15	3	9	12	13	—	—	—	—	—	—
11	Maintain water and soil quality	8	9	13	14	5	—	—	—	—	—	—	—	—	—
12	Maintain landscape pathways	9	13	14	15	6	—	—	—	—	—	—	—	—	—
13	Maintain trophic structures and processes	9	11	14	8	—	—	—	—	—	—	—	—	—	—
14	Chemical processes and nutrient cycles	8	9	13	6	—	—	—	—	—	—	—	—	—	—
15	Provide necessary habitats	9	12	13	—	—	—	—	—	—	—	—	—	—	—

Note: k = degree of connectivity among functions.

Example Scenario Modeled

- Scenario 1: Strategy of focusing on lower-level functions such as the hydrodynamic function

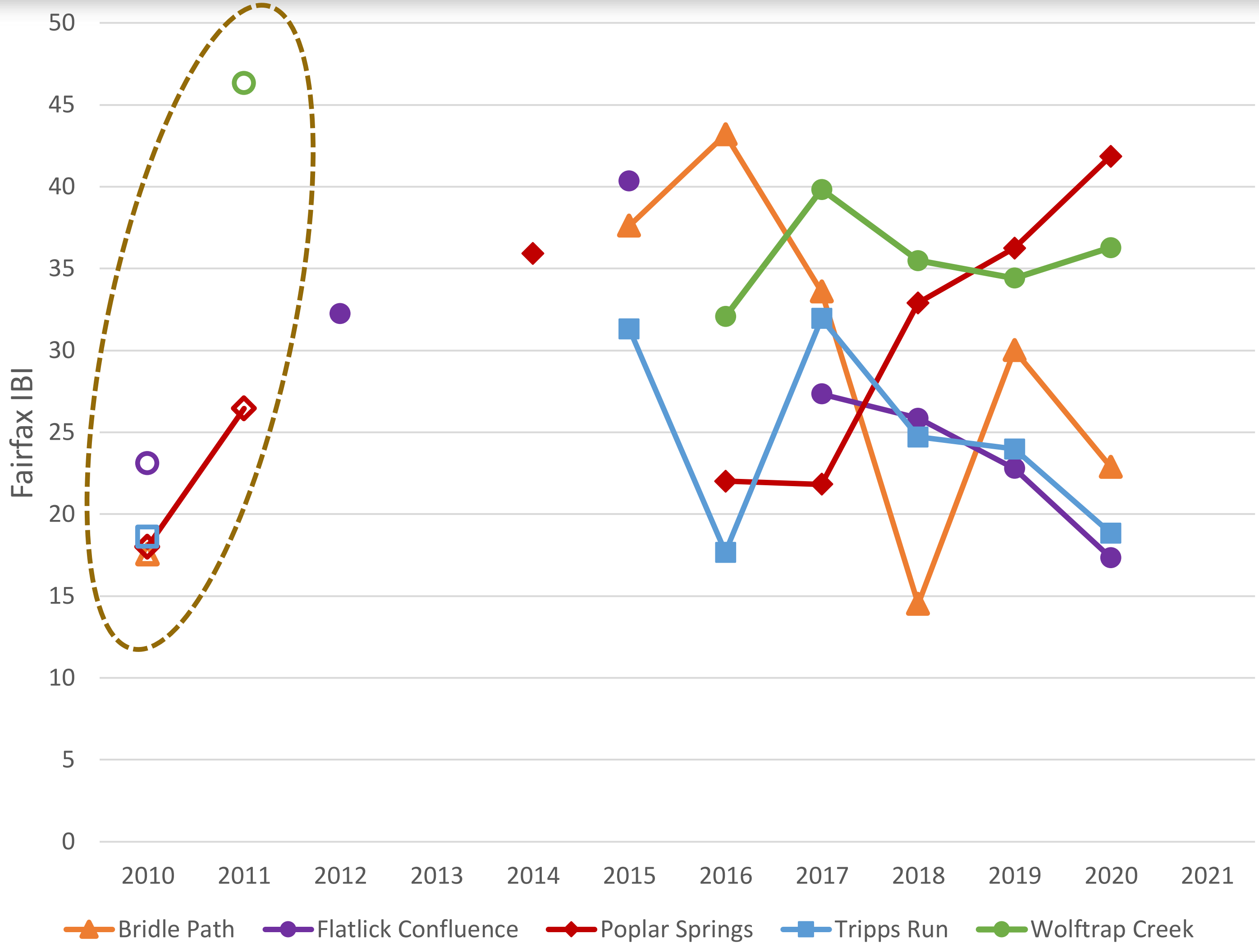


Monitoring for Recovery: Fairfax County, VA Case Study

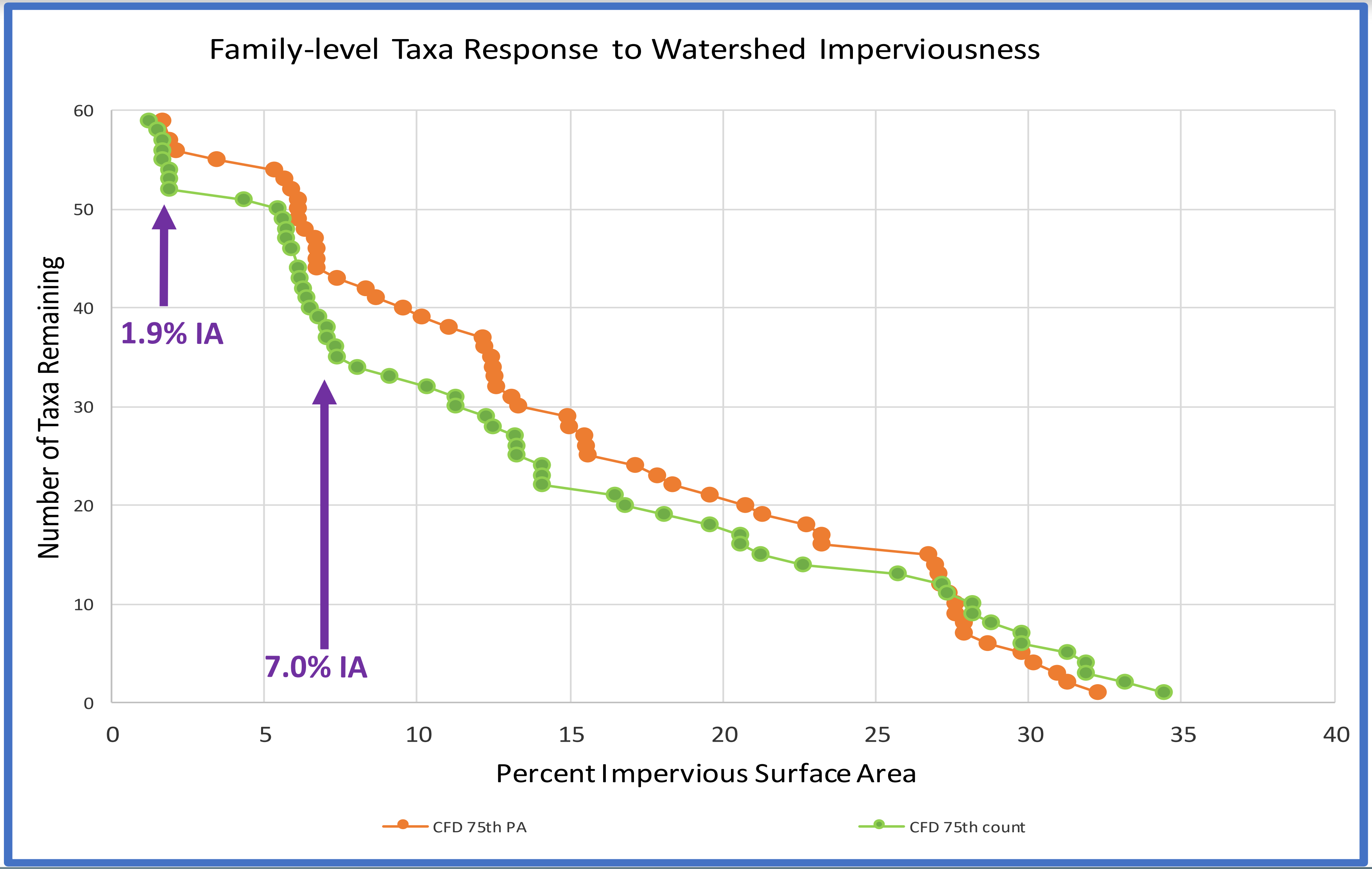
Monitoring for Biological Recovery – Index of Biotic Integrity (Pre-Post)

Stream Restoration	Pre	N,pre	Post	N,post	Min,post
Bridle Path	17.6	1	30.3	6	14.5
CU9214B Big Rocky PhII	43.2	1	53.0	3	38.9
DE9244G1	30.9	3	42.6	2	35.6
DF82-0008	64.6	1	60.9	2	53.5
Flatlick Confluence	23.1	1	27.7	6	17.3
Poplar Springs	26.8	2	31.0	6	21.8
Tripps Run	18.6	1	24.7	6	17.7
Wolftrap Creek	46.3	1	35.6	6	32.1

Flatlick Phase II	**40.8**	**10**	**50.4**	**3**	**45.1**



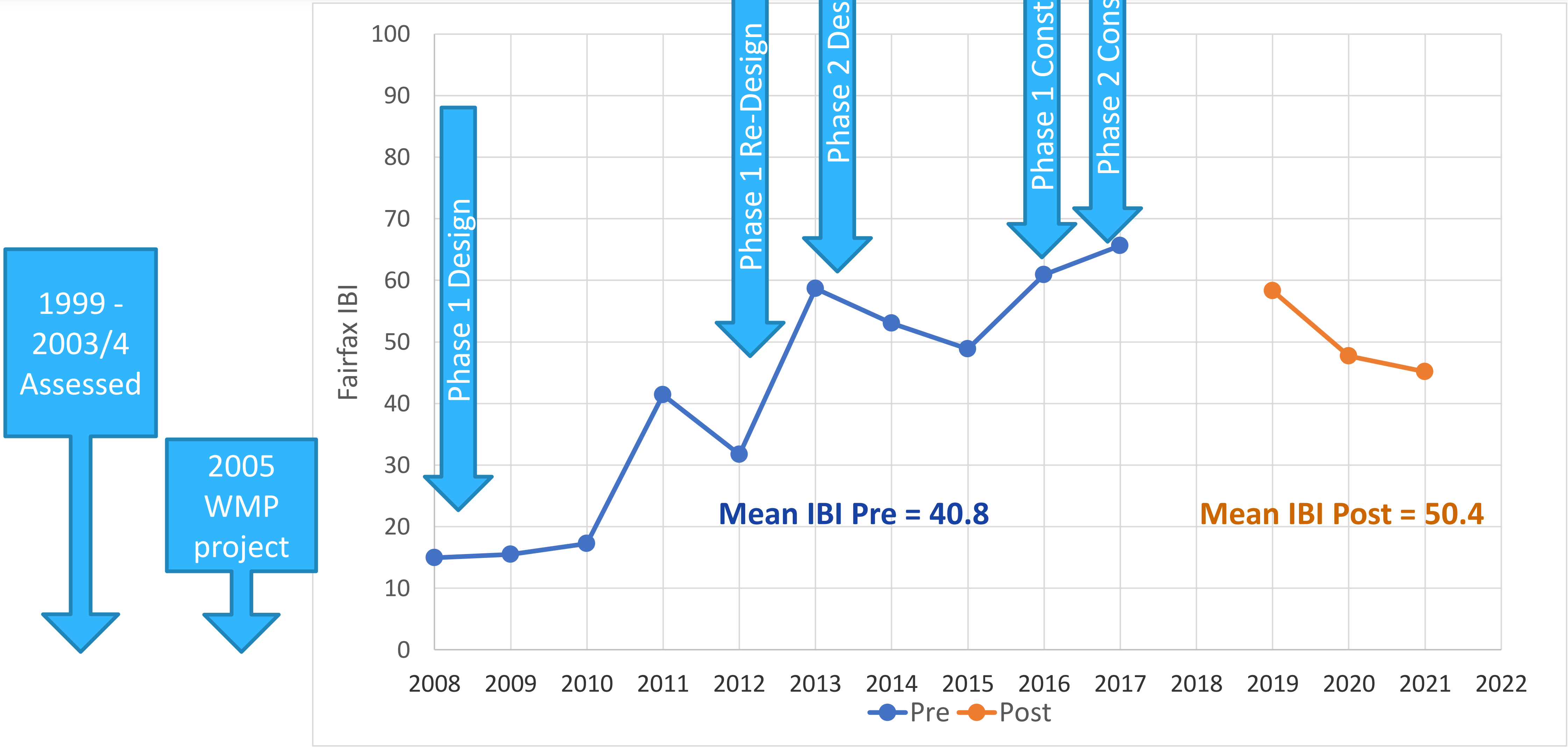
Benthic Macroinvertebrate Taxa vs Stressor (% Imp Area), 59 taxa



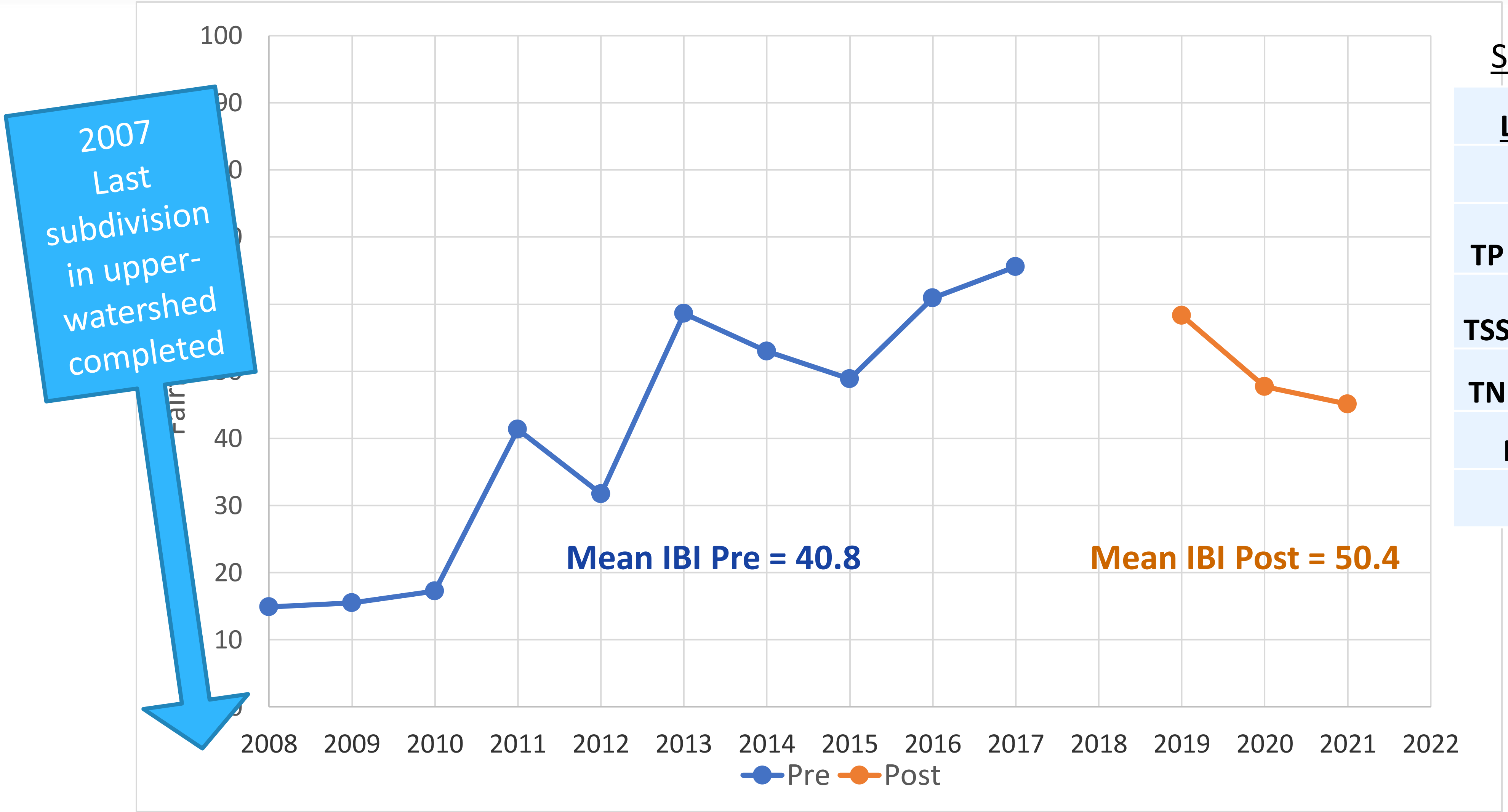
Flatlick Branch Stream Restoration (Phases 1 & 2)

- Stressors Addressed through restoration design
  - Geomorphology & (Sediment)
  - Flow regime
  - Nutrients
- Flatlick Branch
  - Phase 1 – 1850lf
  - Phase 2 – 4600lf
- Phase 1 & 2 are credited with the following reductions:
  - P – 490 lbs/yr
  - N – 4,387 lbs/yr
  - Sediment – 95 tons/yr
- USGS gage on-site

Flatlick Branch - Phase 2 Stream Restoration



Flatlick Branch - Phase 2 Stream Restoration - Stressors



Spearman Correlations

Loads/Q	IBI
TN	-0.34
TP prior year	-0.42
TSS prior year	-0.46
TN prior year	-0.35
Mean Q	-0.19
Peak Q	-0.14

Wrap- Up and Closing Remarks

- Understanding of stream ecosystems continues to evolve
- Multiple stressors impacting stream health
- Management practices that focus on singular impairments/sources/stressor may limit holistic restoration outcomes
- Uncertainty of restoration outcomes
- Recognize that regulatory and non-regulatory drivers of stream restoration impact restoration approach
- Need for robust monitoring, particularly linked expected restoration outcomes

Additional Information

For additional information, please contact

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