CENTER FOR
WATERSHED
PROTECTION

# Management Approaches to Reduce Stressors of Stream Health

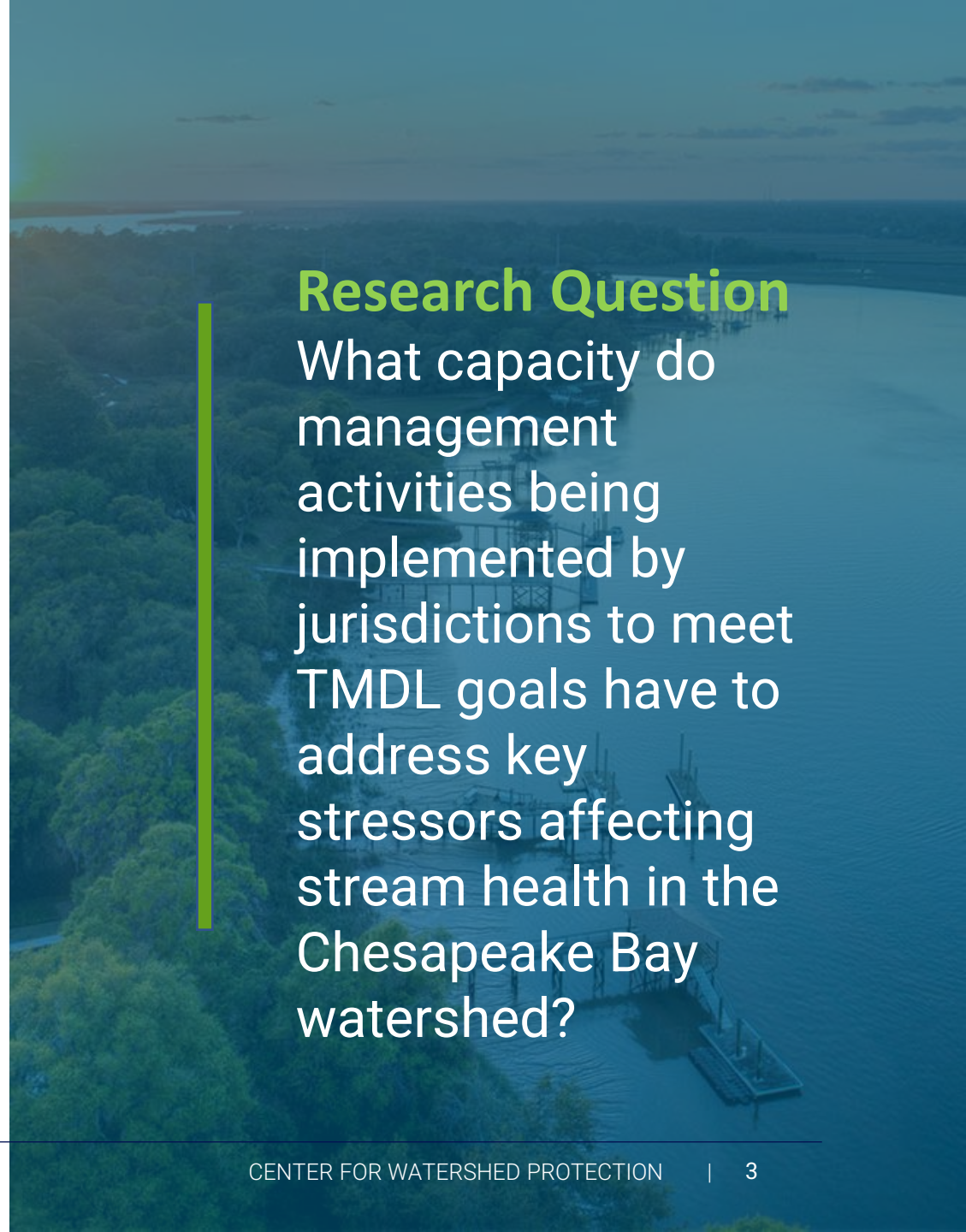
## Final Results

**Stream Health Workgroup Meeting**
**8/12/2022**

# Motivation & Background

# Rationale

- Chesapeake Bay TMDL
  - sediment & nutrients (N,P)
- Stormwater BMPs
  - sediment & nutrients
- Stream health?
  - key stressors?
- Ancillary benefits from BMPs?



## Research Question

What capacity do management activities being implemented by jurisdictions to meet TMDL goals have to address key stressors affecting stream health in the Chesapeake Bay watershed?

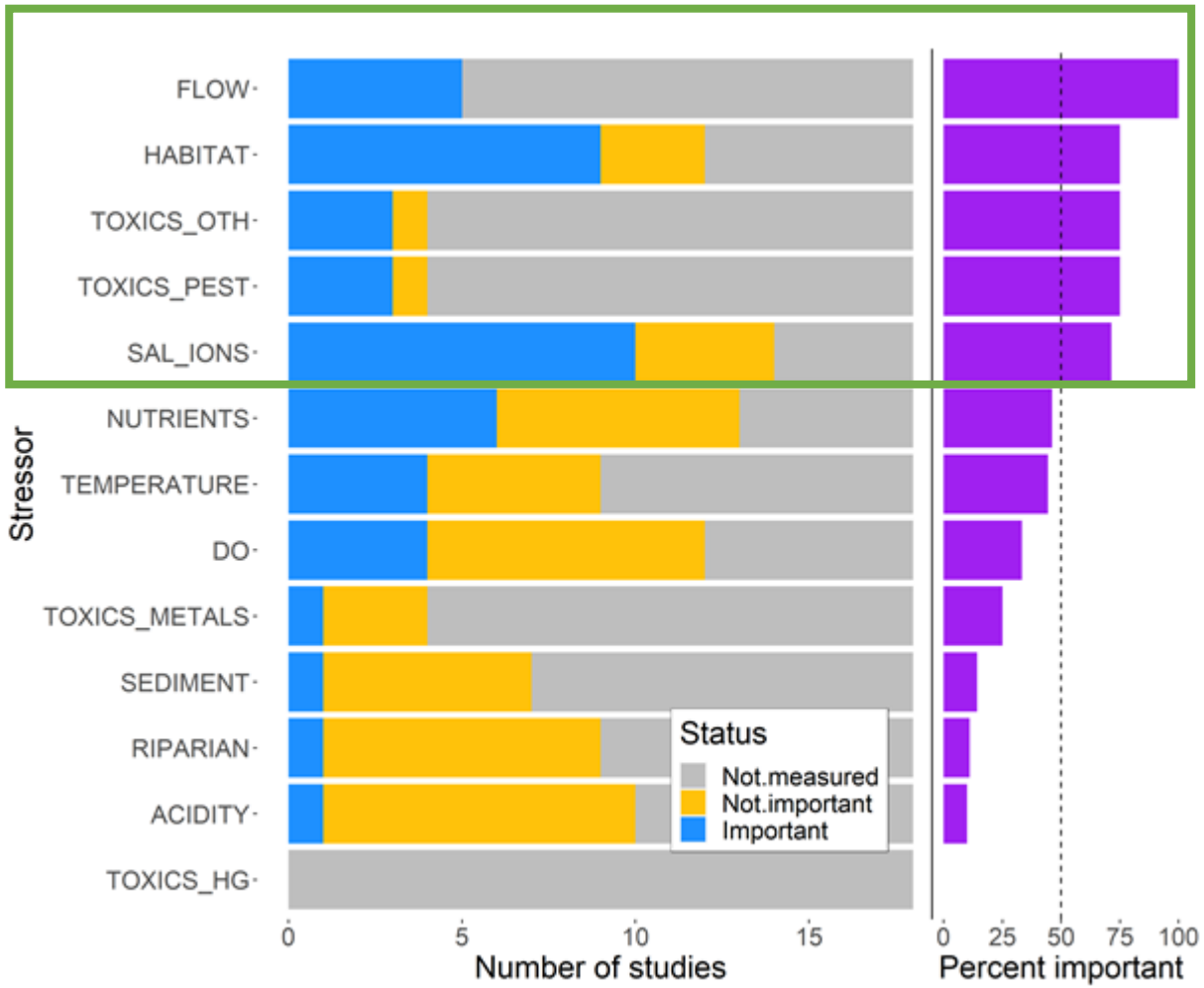
# Three-part Research Program

| | |
|---|---|
| 1. Identify key stressors to stream health (benthic macroinvertebrate health) | Conducted by USGS |
| **2. Assess capacity of BMPs to reduce stressors** | **Present study** |
| 3. Monitoring and tracking | Not started yet |

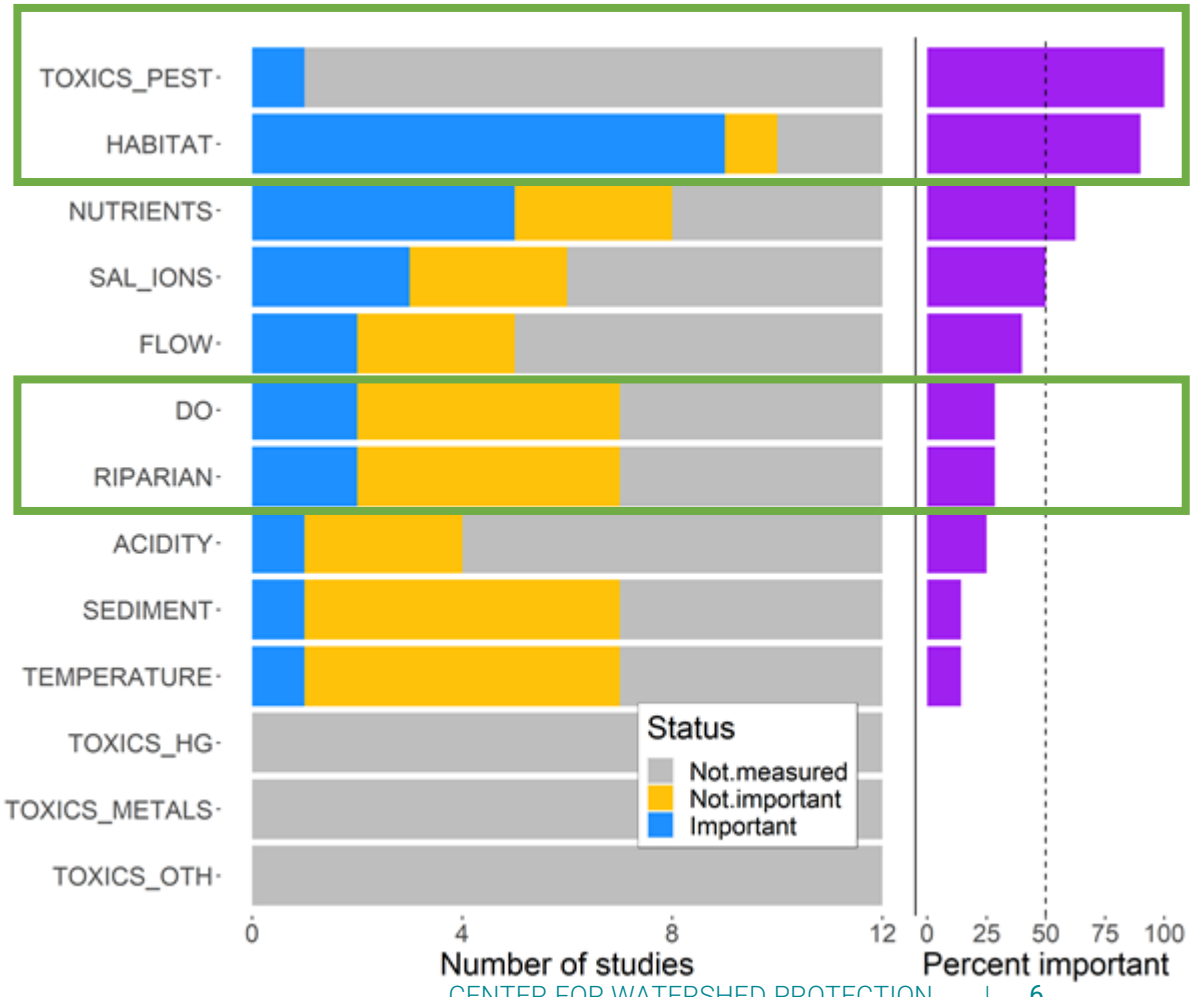
# Stressors & BMPs

# Stressors Important to Stream Health (from USGS; Fanelli et al., in review)

## Urban/Suburban




## Agricultural



# Urban/Suburban BMPs

Selected BMPs from Chesapeake Assessment and Scenario Tool (CAST)

| Coarse BMP Groups | Fine BMP Groups |
|---|---|
| Wetponds & Wetlands | Wet Ponds & Wetlands |
| | Floating Treatment Wetlands |
| Dry Ponds | Dry Ponds |
| | Extended Dry Ponds |
| (Bio)(in)filtration | Infiltration Practices |
| | Filtering Practices |
| | BioRetention |
| | BioSwale |
| | Vegetated Open Channel |
| Urban Forest Buffers | Urban Forest Buffers |
| Urban Tree Planting | Urban Tree Planting |
| | Urban Forest Planting |
| Urban Stream Restoration | Urban Stream Restoration |

# Agricultural BMPs

Selected BMPs from Chesapeake Assessment and Scenario Tool (CAST)

| Coarse BMP Groups | Fine BMP Groups |
|---|---|
| No Till & Cover Crops | Conservation Tillage |
| | High Residue Tillage |
| | Low Residue Tillage |
| | Cover Crop |
| | Cover Crop with Fall Nutrients |
| | Commodity Cover Crop |
| Pasture Management | Pasture Alternative Watering |
| | Prescribed Grazing |
| | Horse Pasture Management |
| | Forest Buffers on Fenced Pasture Corridor |
| | Grass Buffers on Fenced Pasture Corridor |
| Vegetated Buffers | Forest Buffers |
| | Grass Buffers |
| Ag Drainage Management | Agricultural Drainage Management |
| | Barnyard Runoff Control + Loafing Lot Management |
| Ag Stream Restoration | Non Urban Stream Restoration |
| Wetlands | Wetland Restoration |
| | Wetland Creation |
| | Wetland Enhancement and Rehabilitation |

# Methods

# Literature Review

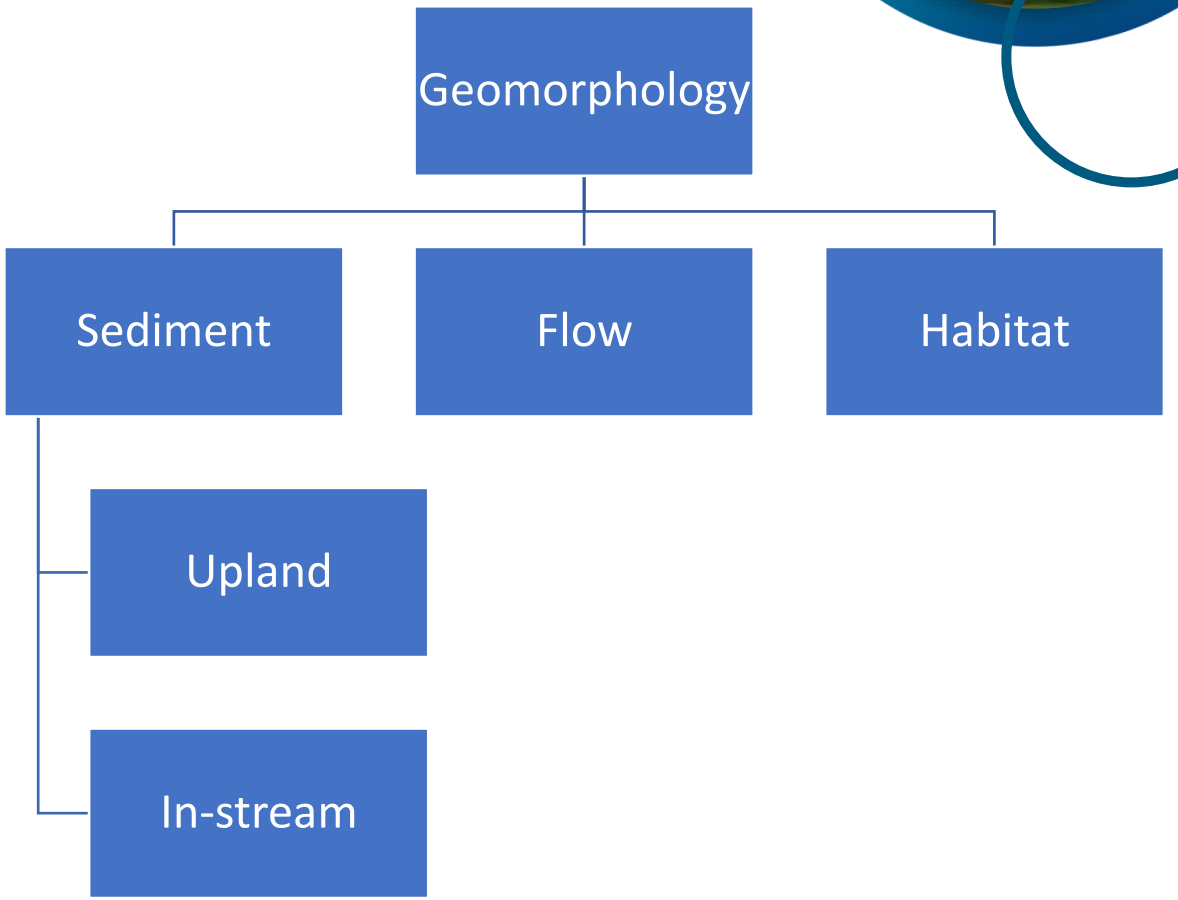
- 188 total papers found
- 125 reviewed

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| Setting | BMP Name | Other Toxics | Flow | Salinity | Pesticides | Geomorphology | |
| | | | | | | Habitat | Sediment |
| Urban | Wet Ponds and Wetlands | | | | | | |
| | Dry Ponds | | | | | | |
| | Bioinfiltration | | | | | | |
| | Urban Forest Buffers | | | | | | |
| | Urban Tree Planting | | | | | | |
| | Urban Stream Restoration | | | | | | |
| Agricultural | No Till and Cover Crops | Not key stressors in agricultural settings | | | | | |
| | Pasture Management | | | | | | |
| | Vegetated Buffers | | | | | | |
| | Agricultural Drainage Management | | | | | | |
| | Agricultural Stream Restoration | | | | | | |
| | Wetlands | | | | | | |

# Effectiveness Ratings

## High, Medium, Low

- Efficiency
  - Other toxics, flow, pesticides
  - Compare parameter before/after, in/out, control/treatment
  - Grouped by 33rd and 67th percentile of all data
- Qualitative
  - Salinity, geomorphology
  - Efficiency did not adequately describe complexity
  - Professional judgement based on research findings



# Data Analysis & Synthesis

- Data points
  - Each practice, model, or paper contributed a data point
- Weighting
  - weighted by study type;
    - field/review = 1, mesocosm = 0.75, modelling = 0.5
  - Weighted median
- Confidence intervals
  - Bootstrapping applied to sets with at least 3 data points

# Results

# BMP Effectiveness

**Legend**

**Effectiveness**

- high
- medium
- low

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| Setting | BMP Name | Other Toxics | Flow | Salinity | Pesticides | Geomorphology | |
| | | | | | | Habitat | Sediment |
| Urban | Wet Ponds and Wetlands | high | medium | low | high | low | medium |
| | Dry Ponds | medium | medium | low | low | low | low |
| | Bioinfiltration | high | high | low | high | low | medium |
| | Urban Forest Buffers | medium | low | low | medium | low | low |
| | Urban Tree Planting | | high | low | | low | low |
| | Urban Stream Restoration | | | low | | high | high |
| Agricultural | No Till and Cover Crops | Not key stressors in agricultural settings | | | low | low | low |
| | Pasture Management | | | | low | low | low |
| | Vegetated Buffers | | | | high | low | medium |
| | Agricultural Drainage Management | | | | medium | low | low |
| | Agricultural Stream Restoration | | | | | high | high |
| | Wetlands | | | | high | low | low |

- Wetponds/Wetlands and Bioinfiltration broadly effective urban BMPs

**Legend**

**Effectiveness**

★ high
½★ medium
☆ low

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Geomorphology | |
| **Setting** | **BMP Name** | Other Toxics | Flow | Salinity | Pesticides | Habitat | Sediment |
| **Urban** | Wet Ponds and Wetlands | ★ | ½★ | ☆ | ★ | ☆ | ½★ |
| | Dry Ponds | ½★ | ½★ | ☆ | ☆ | ☆ | ☆ |
| | Bioinfiltration | ★ | ★ | ☆ | ★ | ☆ | ½★ |
| | Urban Forest Buffers | ½★ | ☆ | ☆ | ½★ | ☆ | ☆ |
| | Urban Tree Planting | | ★ | ☆ | | ☆ | ☆ |
| | Urban Stream Restoration | | | ☆ | | ★ | ★ |
| **Agricultural** | No Till and Cover Crops | Not key stressors in agricultural settings | | | ☆ | ☆ | ☆ |
| | Pasture Management | | | | ☆ | ☆ | ☆ |
| | Vegetated Buffers | | | | ★ | ☆ | ½★ |
| | Agricultural Drainage Management | | | | ½★ | ☆ | ☆ |
| | Agricultural Stream Restoration | | | | | ★ | ★ |
| | Wetlands | | | | ★ | ☆ | ☆ |

- Many BMPs effective for Pesticides and Other Toxics
- Sedimentation & Infiltration

**Legend**

**Effectiveness**

★ high
½★ medium
☆ low

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Geomorphology | |
| **Setting** | **BMP Name** | Other Toxics | Flow | Salinity | Pesticides | Habitat | Sediment |
| **Urban** | Wet Ponds and Wetlands | ★ | ½★ | ☆ | ★ | ☆ | ½★ |
| | Dry Ponds | ½★ | ½★ | ☆ | ☆ | ☆ | ☆ |
| | Bioinfiltration | ★ | ★ | ☆ | ★ | ☆ | ½★ |
| | Urban Forest Buffers | ½★ | ☆ | ☆ | ½★ | ☆ | ☆ |
| | Urban Tree Planting | | ★ | ☆ | | ☆ | ☆ |
| | Urban Stream Restoration | | | ☆ | | ★ | ★ |
| **Agricultural** | No Till and Cover Crops | Not key stressors in agricultural settings | | | ☆ | ☆ | ☆ |
| | Pasture Management | | | | ☆ | ☆ | ☆ |
| | Vegetated Buffers | | | | ★ | ☆ | ½★ |
| | Agricultural Drainage Management | | | | ½★ | ☆ | ☆ |
| | Agricultural Stream Restoration | | | | | ★ | ★ |
| | Wetlands | | | | ★ | ☆ | ☆ |

- Limited capacity to mitigate Salinity
- Only studied select structural BMPs (see CWP 2019 for non-structural)

**Legend**

**Effectiveness**

★ high
½★ medium
☆ low

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| Setting | BMP Name | Other Toxics | Flow | Salinity | Pesticides | Geomorphology | |
| | | | | | | Habitat | Sediment |
| Urban | Wet Ponds and Wetlands | ★ | ½★ | ☆ | ★ | ☆ | ½★ |
| | Dry Ponds | ½★ | ½★ | ☆ | ☆ | ☆ | ☆ |
| | Bioinfiltration | ★ | ★ | ☆ | ★ | ☆ | ½★ |
| | Urban Forest Buffers | ½★ | ☆ | ☆ | ½★ | ☆ | ☆ |
| | Urban Tree Planting | | ★ | ☆ | | ☆ | ☆ |
| | Urban Stream Restoration | | | ☆ | | ★ | ★ |
| Agricultural | No Till and Cover Crops | Not key stressors in agricultural settings | | | ☆ | ☆ | ☆ |
| | Pasture Management | | | | ☆ | ☆ | ☆ |
| | Vegetated Buffers | | | | ★ | ☆ | ½★ |
| | Agricultural Drainage Management | | | | ½★ | ☆ | ☆ |
| | Agricultural Stream Restoration | | | | | ★ | ★ |
| | Wetlands | | | | ★ | ☆ | ☆ |

- Only stream restoration highly effective for geomorphology
- Others reduce upland sediment, but impact is limited

**Legend**

**Effectiveness**

- ★ high
- ⯪ medium
- ☆ low

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Geomorphology | |
| **Setting** | **BMP Name** | Other Toxics | Flow | Salinity | Pesticides | Habitat | Sediment |
| **Urban** | Wet Ponds and Wetlands | ★ | ⯪ | ☆ | ★ | ☆ | ⯪ |
| | Dry Ponds | ⯪ | ⯪ | ☆ | ☆ | ☆ | ☆ |
| | Bioinfiltration | ★ | ★ | ☆ | ★ | ☆ | ⯪ |
| | Urban Forest Buffers | ⯪ | ☆ | ☆ | ⯪ | ☆ | ☆ |
| | Urban Tree Planting | | ★ | ☆ | | ☆ | ☆ |
| | Urban Stream Restoration | | | ☆ | | ★ | ★ |
| **Agricultural** | No Till and Cover Crops | Not key stressors in agricultural settings | | | ☆ | ☆ | ☆ |
| | Pasture Management | | | | ☆ | ☆ | ☆ |
| | Vegetated Buffers | | | | ★ | ☆ | ⯪ |
| | Agricultural Drainage Management | | | | ⯪ | ☆ | ☆ |
| | Agricultural Stream Restoration | | | | | ★ | ★ |
| | Wetlands | | | | ★ | ☆ | ☆ |

- Combinations of BMPs may be effective
- In-stream, riparian, and upland BMPs

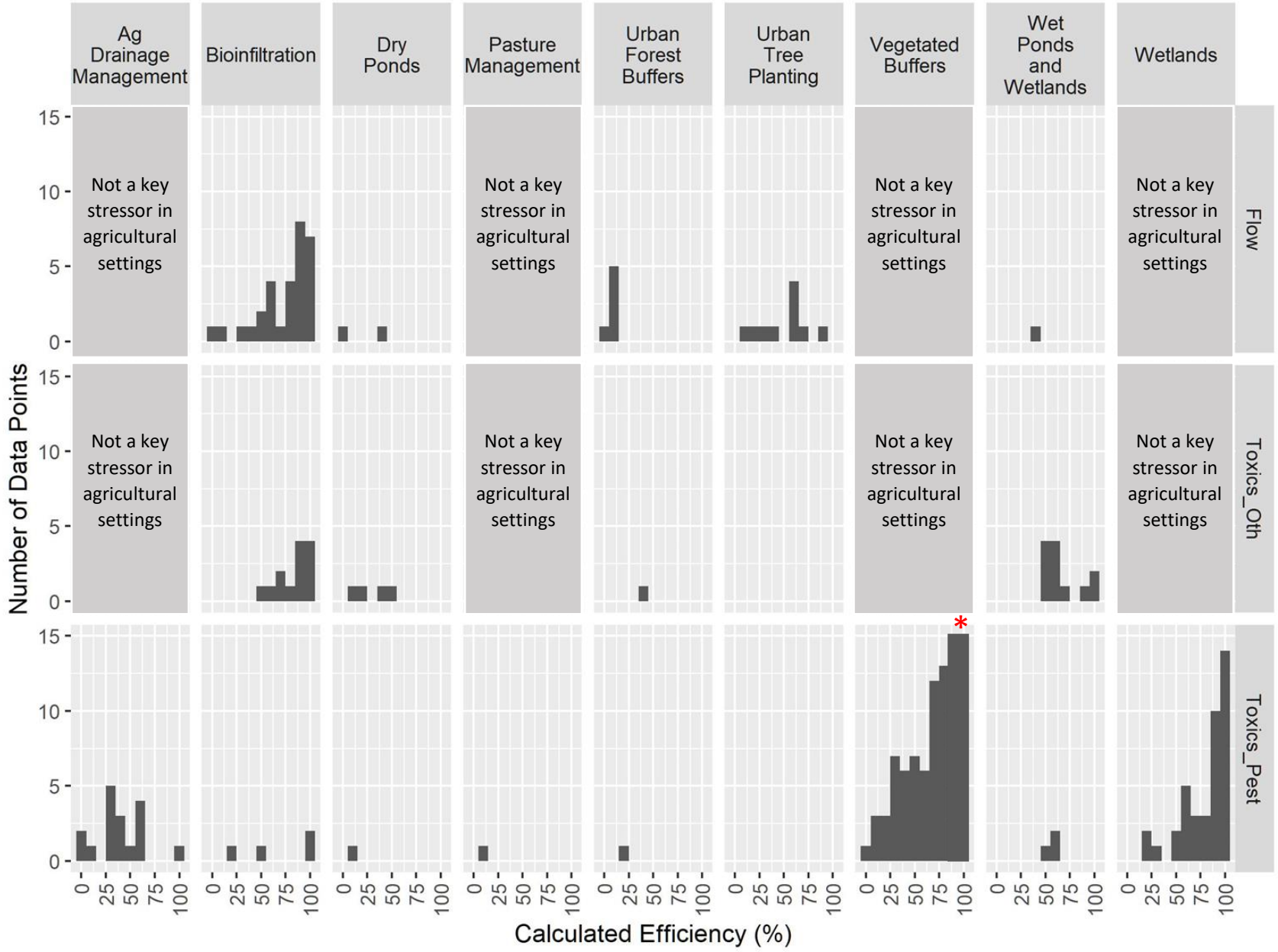
**Legend**

**Effectiveness**

★ high
½★ medium
☆ low

| BMP Type | | Stressors Important to Stream Health | | | | | |
|---|---|---|---|---|---|---|---|
| Setting | BMP Name | Other Toxics | Flow | Salinity | Pesticides | Geomorphology | |
| | | | | | | Habitat | Sediment |
| Urban | Wet Ponds and Wetlands | ★ | ½★ | ☆ | ★ | ☆ | ½★ |
| | Dry Ponds | ½★ | ½★ | ☆ | ☆ | ☆ | ☆ |
| | Bioinfiltration | ★ | ★ | ☆ | ★ | ☆ | ½★ |
| | Urban Forest Buffers | ½★ | ☆ | ☆ | ½★ | ☆ | ☆ |
| | Urban Tree Planting | | ★ | ☆ | | ☆ | ☆ |
| | Urban Stream Restoration | | | ☆ | | ★ | ★ |
| Agricultural | No Till and Cover Crops | Not key stressors in agricultural settings | | | ☆ | ☆ | ☆ |
| | Pasture Management | | | | ☆ | ☆ | ☆ |
| | Vegetated Buffers | | | | ★ | ☆ | ½★ |
| | Agricultural Drainage Management | | | | ½★ | ☆ | ☆ |
| | Agricultural Stream Restoration | | | | | ★ | ★ |
| | Wetlands | | | | ★ | ☆ | ☆ |

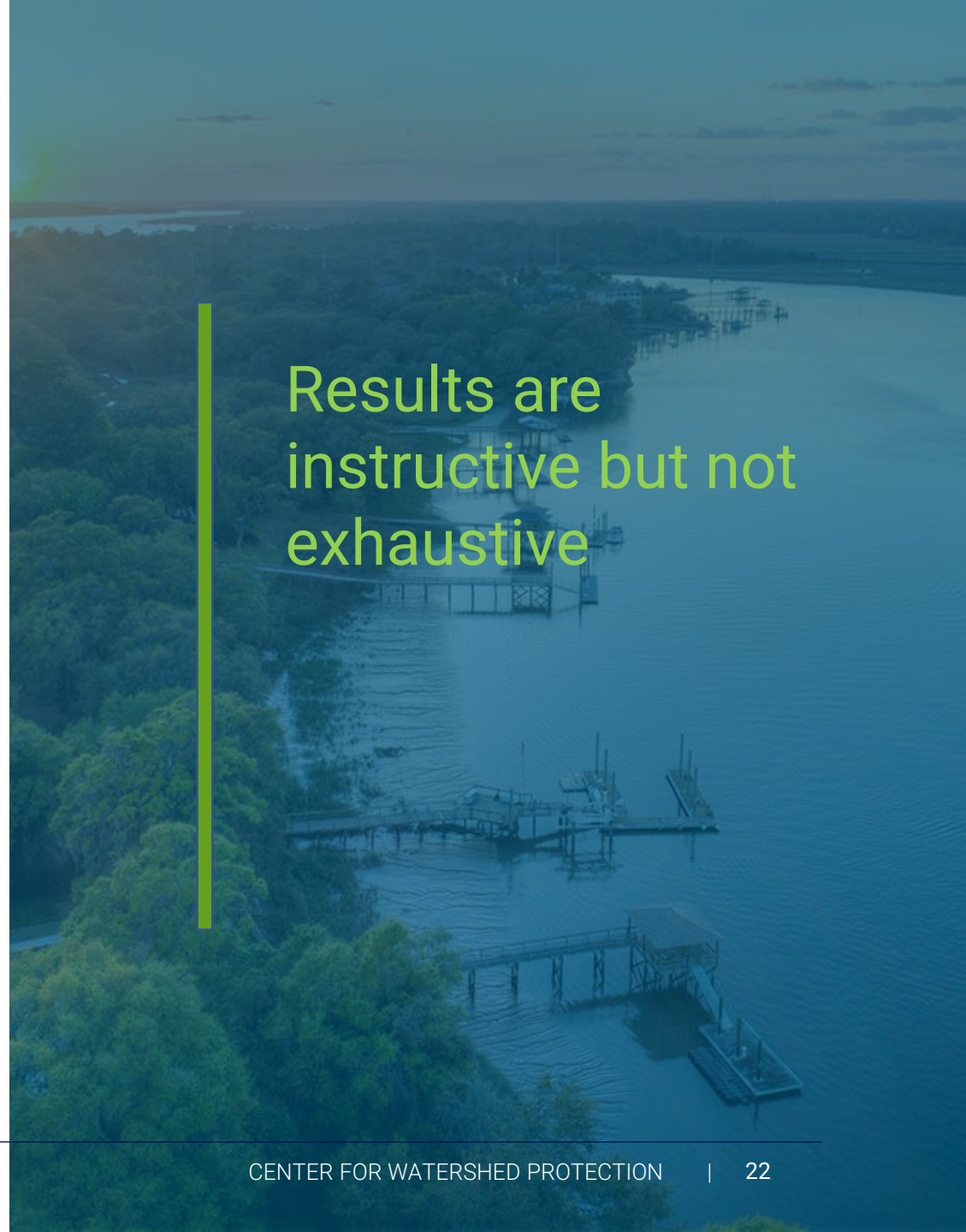
# Data Richness



# Conclusions & Caveats

# Conclusions and Caveats

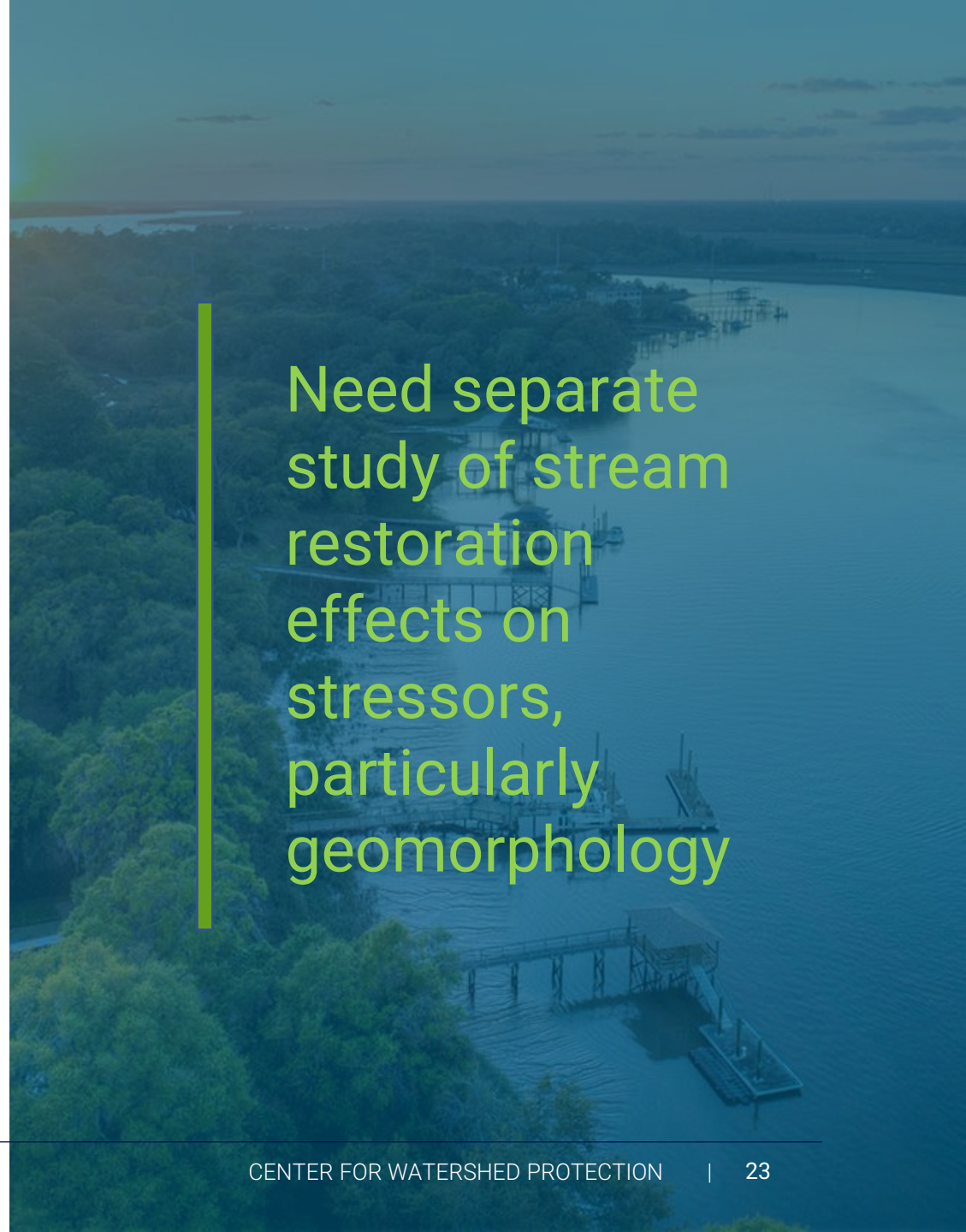
- Sediment removal and runoff reduction are effective mechanisms for addressing multiple stressors
- Multi-BMP approach may be effective for multi-stressor degradation
- BMP extent/placement and area/loading is limited – design and placement matters
- The structural BMPs studied have limited capacity to mitigate salinity
- Rebuilding habitat may not be enough to support the recovery of biotic communities



Results are instructive but not exhaustive

# Conclusions and Caveats

- Complexity of geomorphology/ habitat inhibited quantitatively summarizing BMP effectiveness via a single descriptive statistic
- Disparate metrics may be combined with science-based weighting or other method
- Only stream restoration directly affects geomorphology and habitat
  - Stream restoration outcomes vary by restoration approach and metric



Need separate study of stream restoration effects on stressors, particularly geomorphology

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# References

Fanelli, R., M. Cashman, and A. Porter. "Identifying key stressors driving biological impairment in freshwater streams in the Chesapeake Bay watershed, USA". In review at Environmental Management.

Center for Watershed Protection (CWP). 2019. Literature Review of Winter Maintenance Best Practices.