Impact of UT Sassafras Restoration on Pollutant Loads, Water Quality, and Biology

Allyson Bartell, Kyle Hodgson, Sara Weglein, Brittney Flaten,
Heather Quinn, Andrew Watts, Maryn LeClair, Scott Stranko

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Project Background

- Tributary to the Sassafras River, Cecil County, MD
- 525-acre watershed, mostly agricultural land use
- Identified as a high nutrient export area in a 2009 survey by MDE
- Project funded by the Chesapeake and Atlantic Coastal Bays Trust Fund, with the primary goals to reduce sediment and nutrients from reaching the Bay.
- ShoreRivers was awarded funds for restoration
- Restoration design and implementation conducted by Ecotone Inc.

Restoration Approach: Natural Channel Design (NCD)

Pre-Restoration, Mar 2019

Post-Restoration, Dec 2019

Restoration Approach: Stage Zero

Pre-Restoration, Jan 2019
Formerly an agricultural drainage ditch

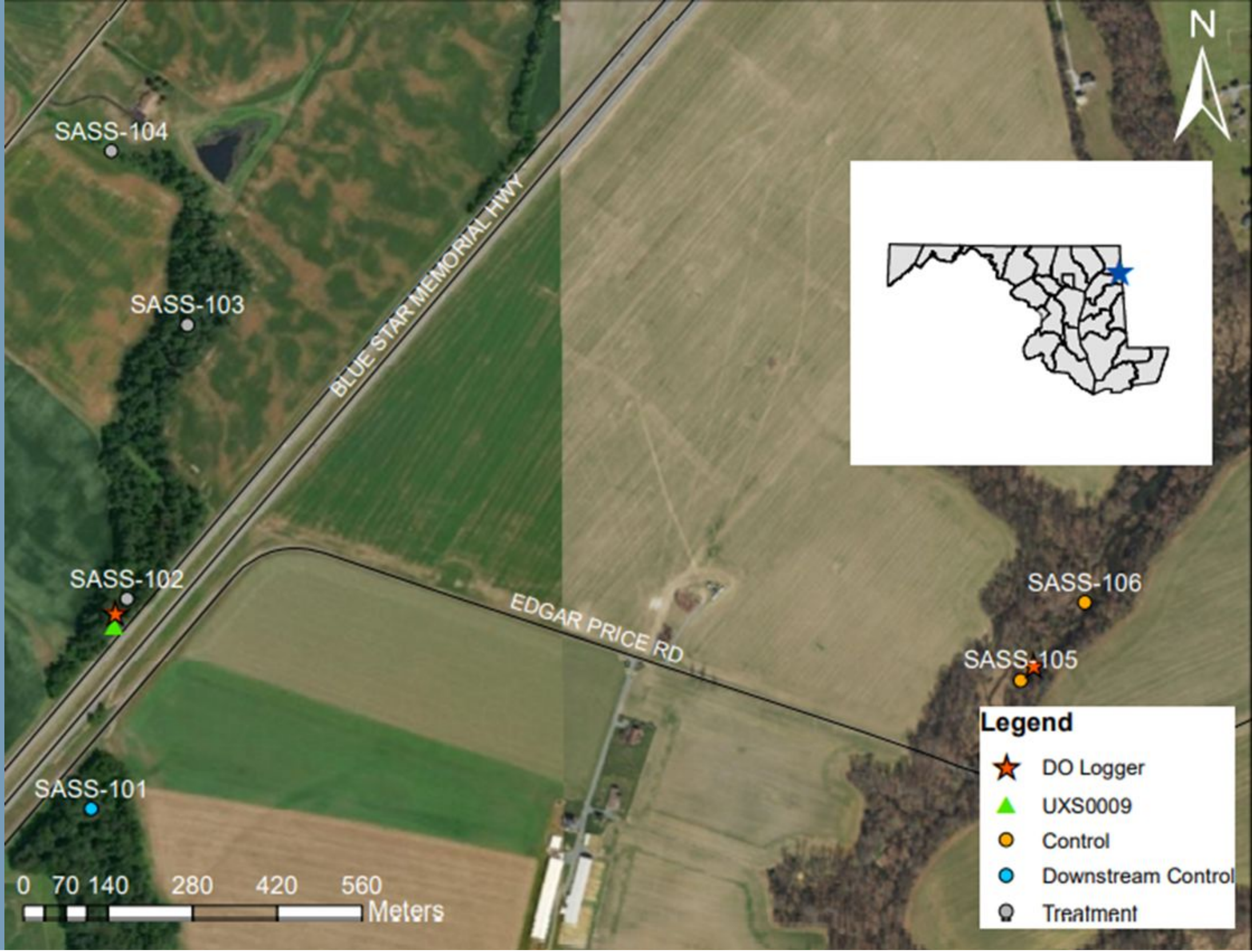
Post-Restoration, Oct 2020
Now consists of a 100 foot floodplain system with no defined channel

Monitoring Methods

- Load Monitoring (WQ, discharge, precipitation) began in 2018
  Before/After Method

- DO and Temp Monitoring began in 2018
  Before/After/Control Method

- Fish and Benthic Monitoring began in 2017
  BACI Method



MARYLAND DEPARTMENT OF NATURAL RESOURCES

Flow and Water Quality Data Collection

Combined fixed frequency and event-based sampling

- Baseflow
  - Bi-weekly
- Stormflow
  - Weekdays - we sample all events expected to produce rise in stream level
  - Weekends - we will also sample during weekends to capture events not well represented from weekday sampling

- Water Quality - ISCO Sampler and WQ Grabs - CBL
  - Sediment (TSS, SSC)
  - Nitrogen (NH_4, NO_2, NO_{23}, PN, TDN)
  - Phosphorus (PO_4, PP, TDP)
  - Carbon (PC)

Annual Load and FWMC Calculation Methods

- FLUX32 Load Estimation Software (U.S. Army Corps of Engineers)
- Requires sample concentration data and daily flow (mean Q)
- For two or more composite samples per date (storm sampling), FWMC's are used in input file, calculated by:

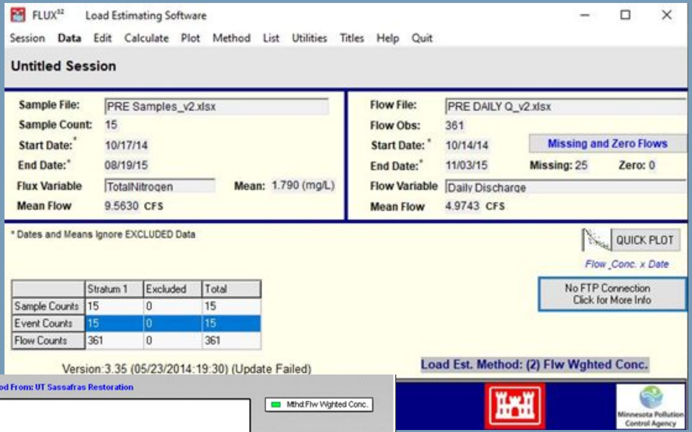
$$Sample1\,Volume = Event\,Length\,(s) * Flow\,(ft^3/s)$$

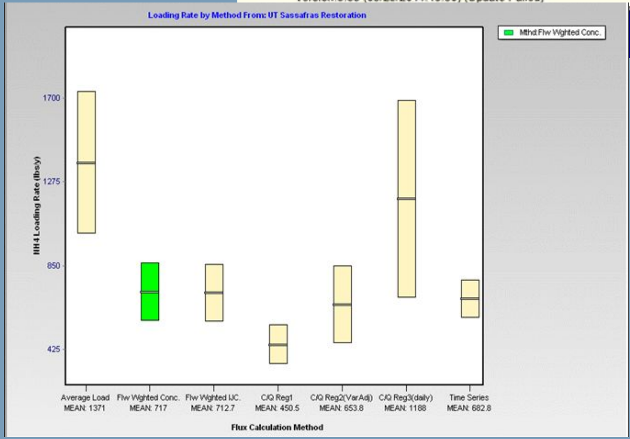
$$Sample2\,Volume = Event\,Length\,(s) * Flow\,(ft^3/s)$$

$$Sample1\,Mass = Sample1\,Concentration\left({}^{mg}/_{L}\right) * Flow\,(L)$$

$$Sample2\,Mass = Sample2\,Concentration\left({}^{mg}/_{L}\right) * Flow\,(L)$$

$$FWMC = \frac{(Sample1\,Mass + Sample2\,Mass)}{(Sample1\,Volume + Sample2\,Volume)}$$



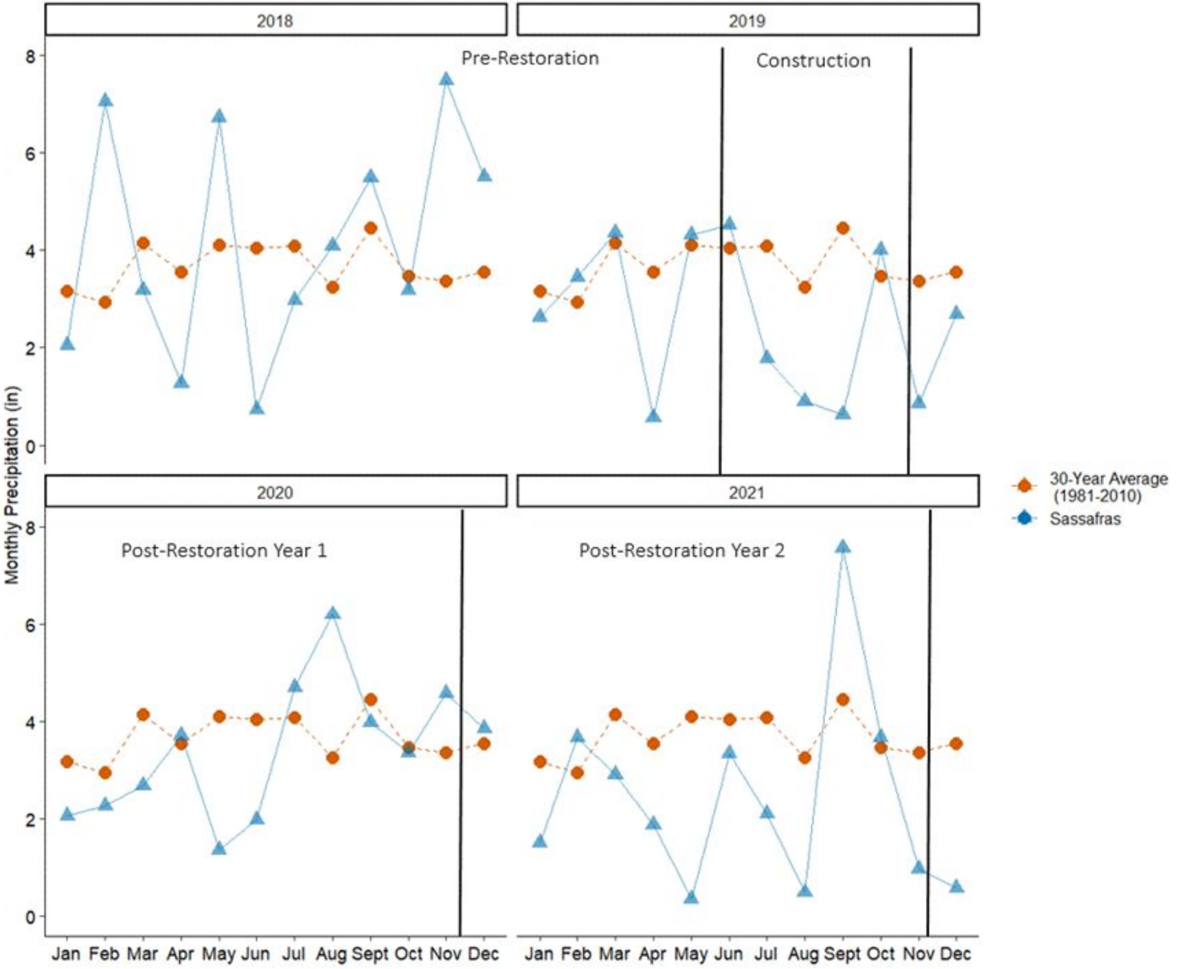


Precipitation Patterns

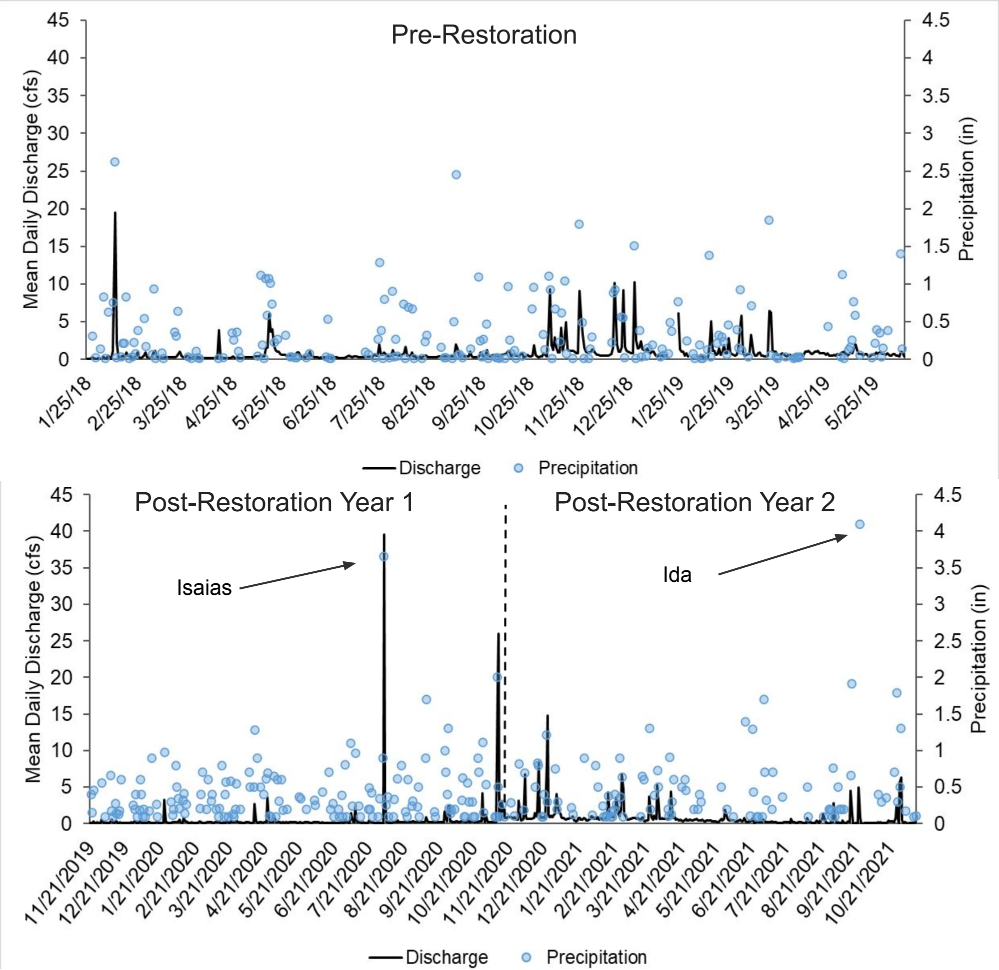
- Pre-restoration monitoring
  Jan 2018 - June 2019
  wetter than historical average

- First year post-restoration monitoring
  Nov 2019 - Nov 2020
  closer to historical average

- Second year post-restoration monitoring
  Nov 2020 - Nov 2021
  driest of all monitoring years



MARYLAND DEPARTMENT OF NATURAL RESOURCES

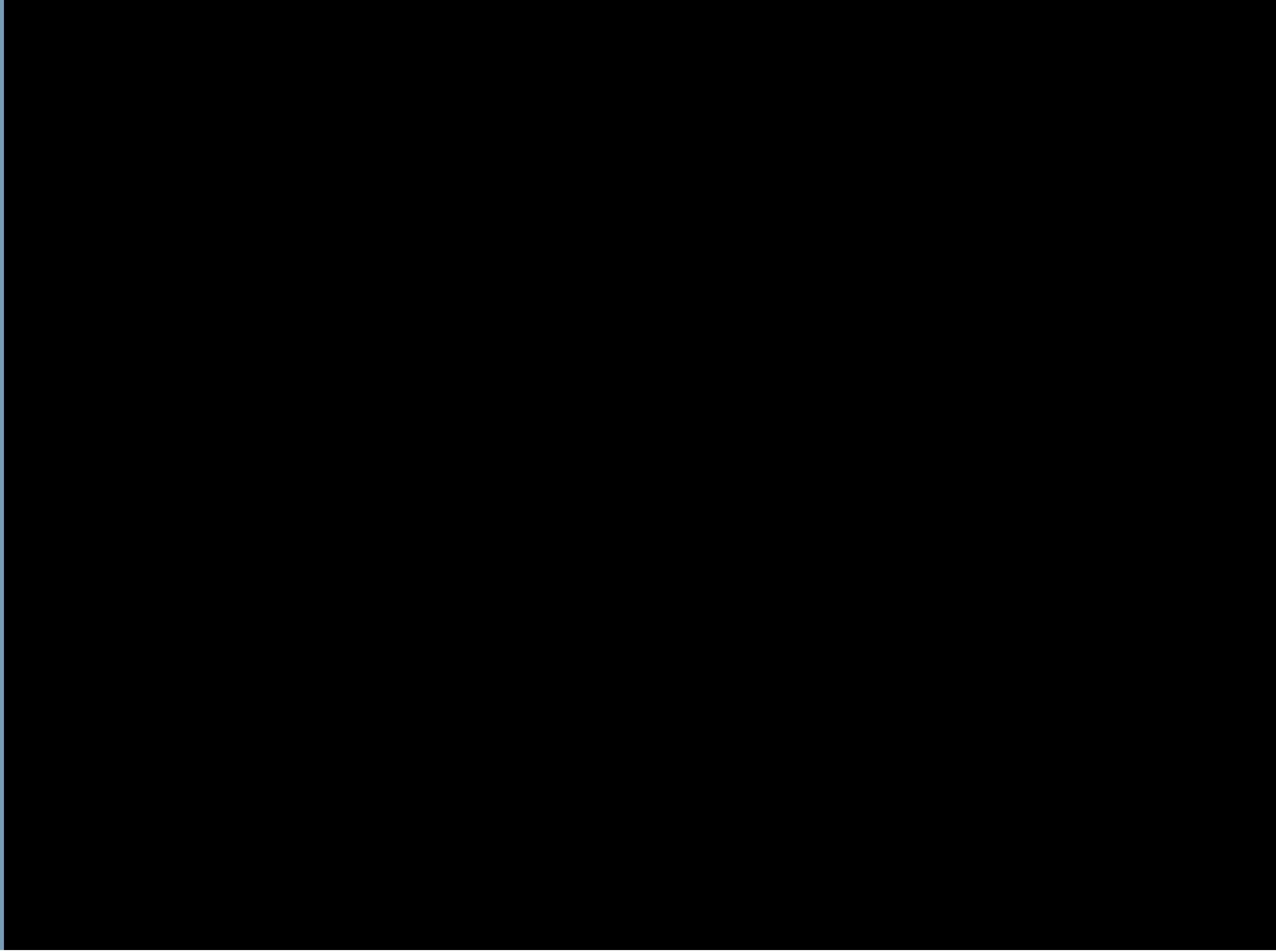


Discharge and Precipitation

- Two large tropical storms at site during post-restoration monitoring
- Post-Restoration Year 2 received most of its precipitation in winter months, which influenced discharge more than summer months

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Storm Time Lapse



Water Quality Sample Totals

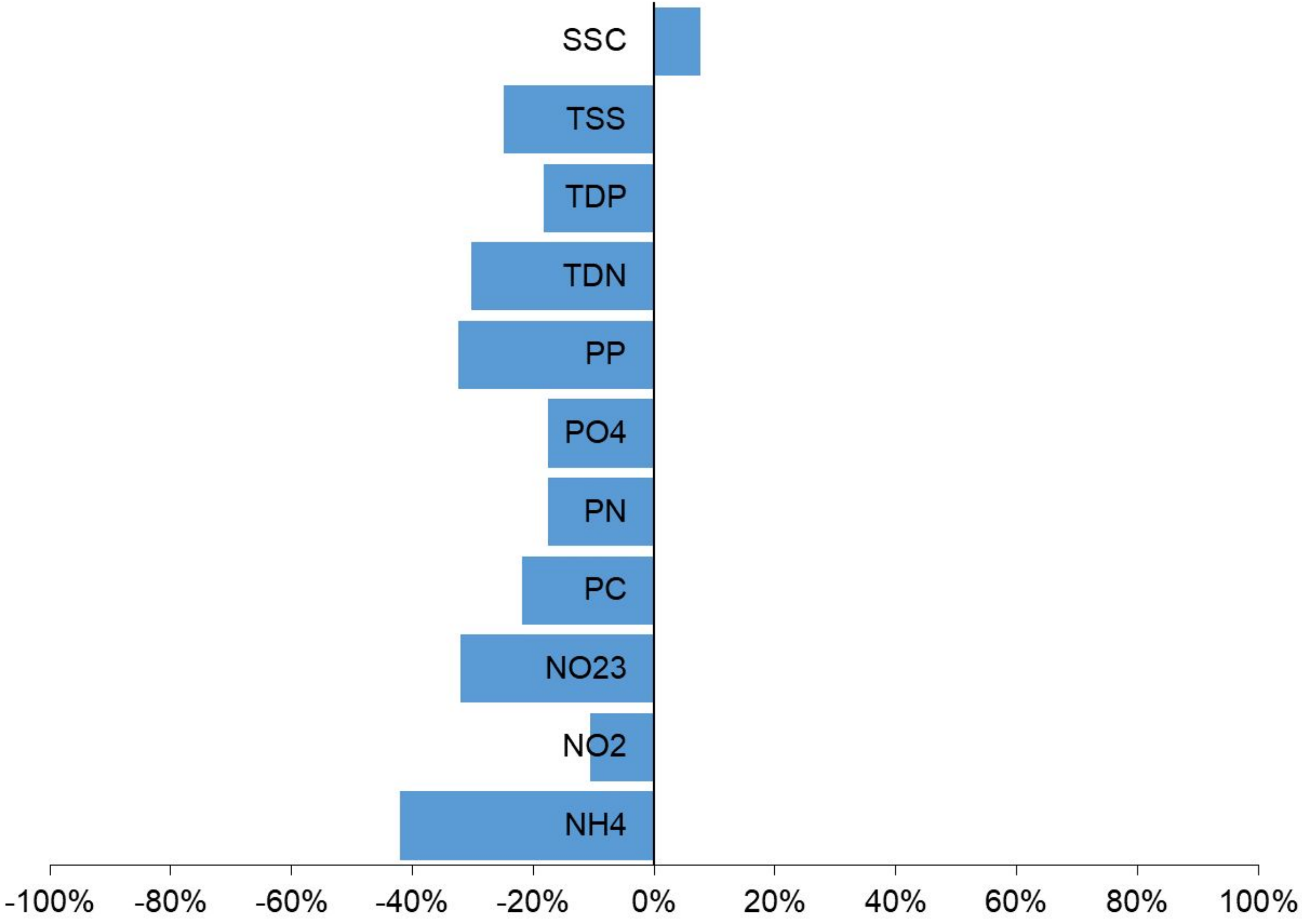
	Baseflow Samples	Stormflow Samples	Total Samples	SSC Samples
Pre-restoration	38	104	142	66
Post-restoration	44	96	140	46
Post-restoration Year 1	23	60	83	31
Post-restoration Year 2	21	36	57	15

*As of 11/12/2021

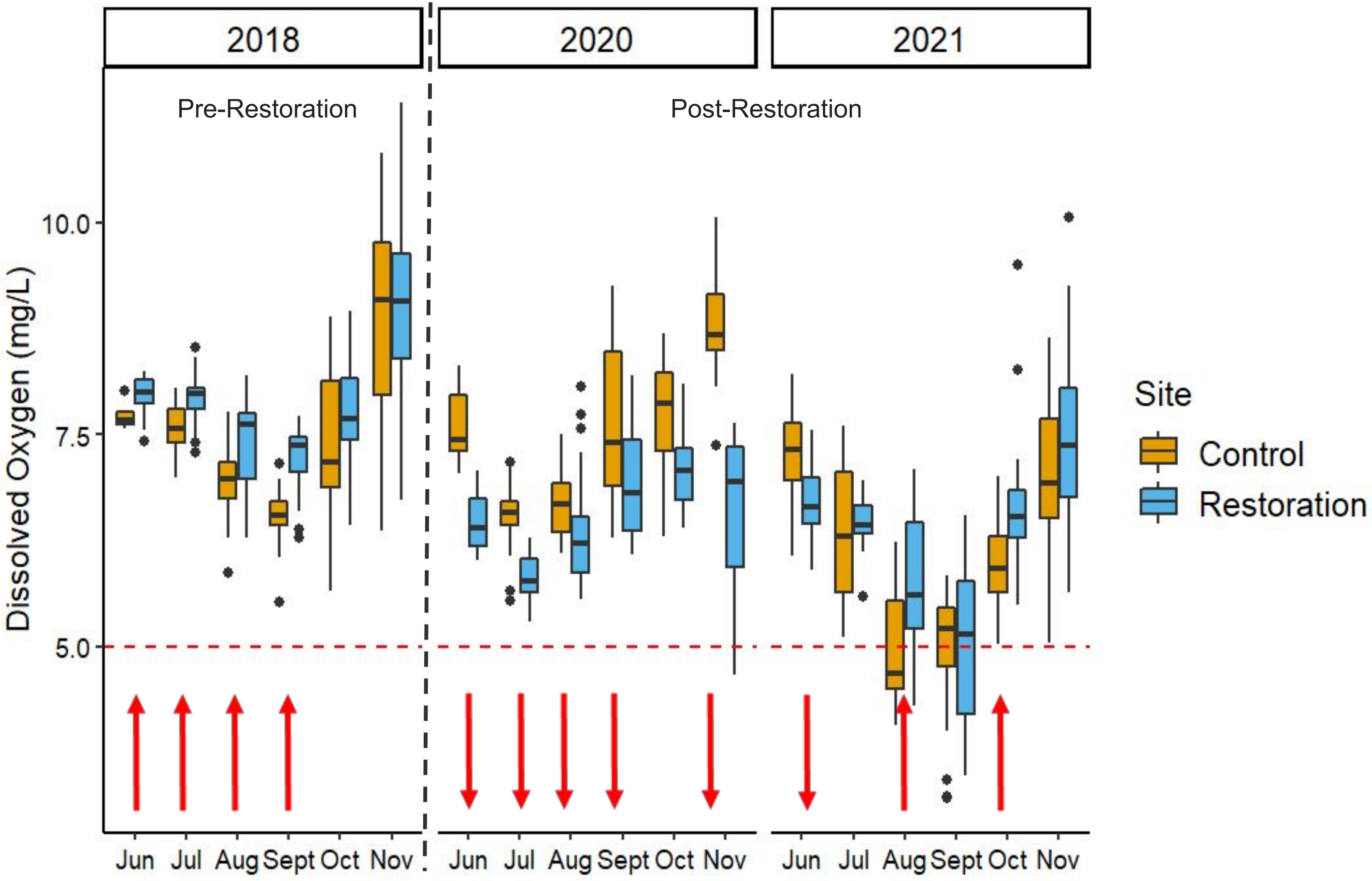
End goal is to produce annual pollutant loads/FWMC's from flow and water quality monitoring

FWMC Results

- Annual load results are misleading, especially considering precipitation differences in the pre and post-restoration periods.
- FWMCs are more reliable since they account for differences in flow.
- All FWMCs decreased in the post compared to the pre-restoration period except for SSC.



MARYLAND DEPARTMENT OF NATURAL RESOURCES



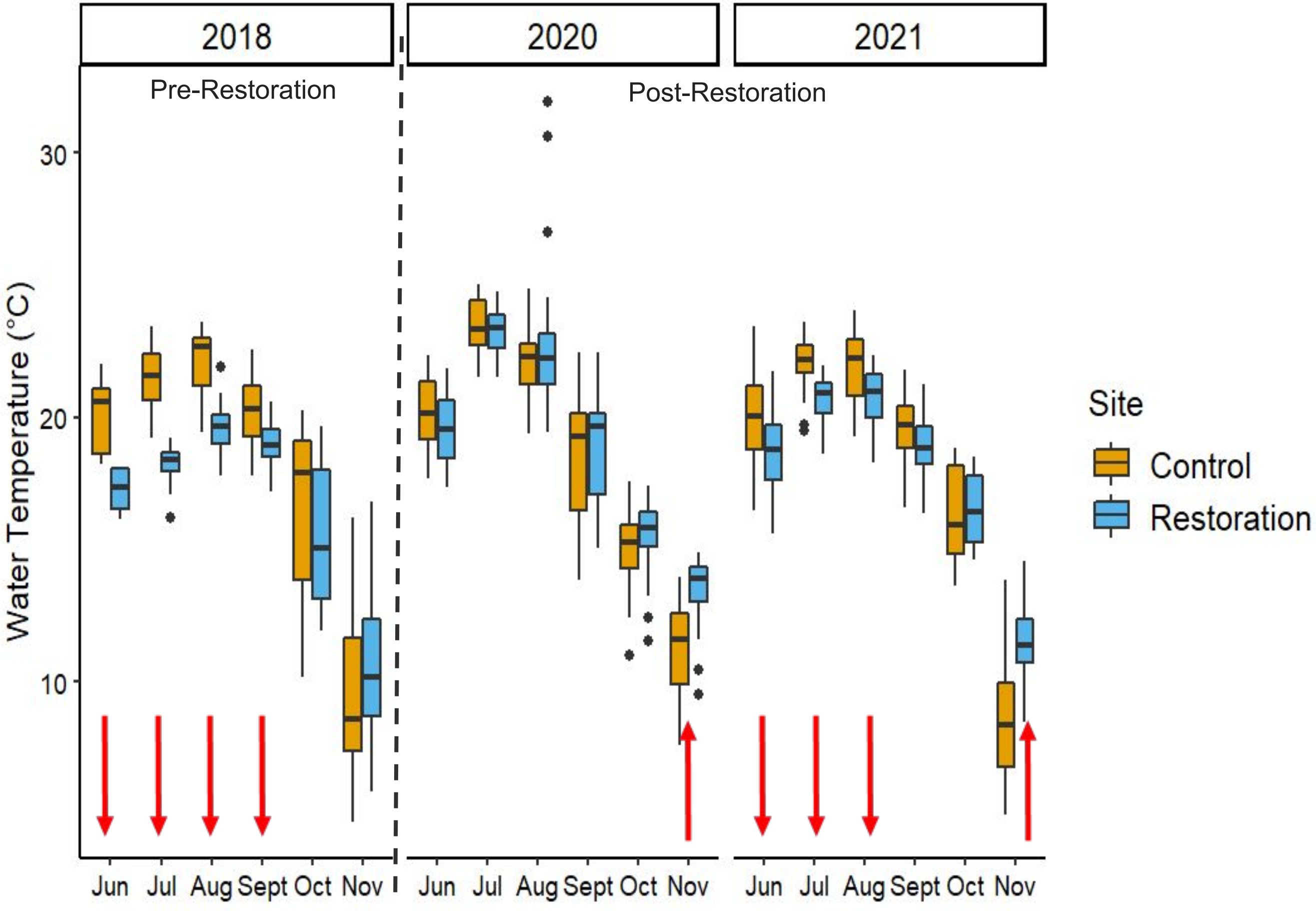
Dissolved Oxygen

- Paired t-test of daily means by month
- Arrow pointing up = restoration is significantly higher
- Arrow pointing down = restoration significantly lower
- No symbol = no difference between restoration and control

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Temperature

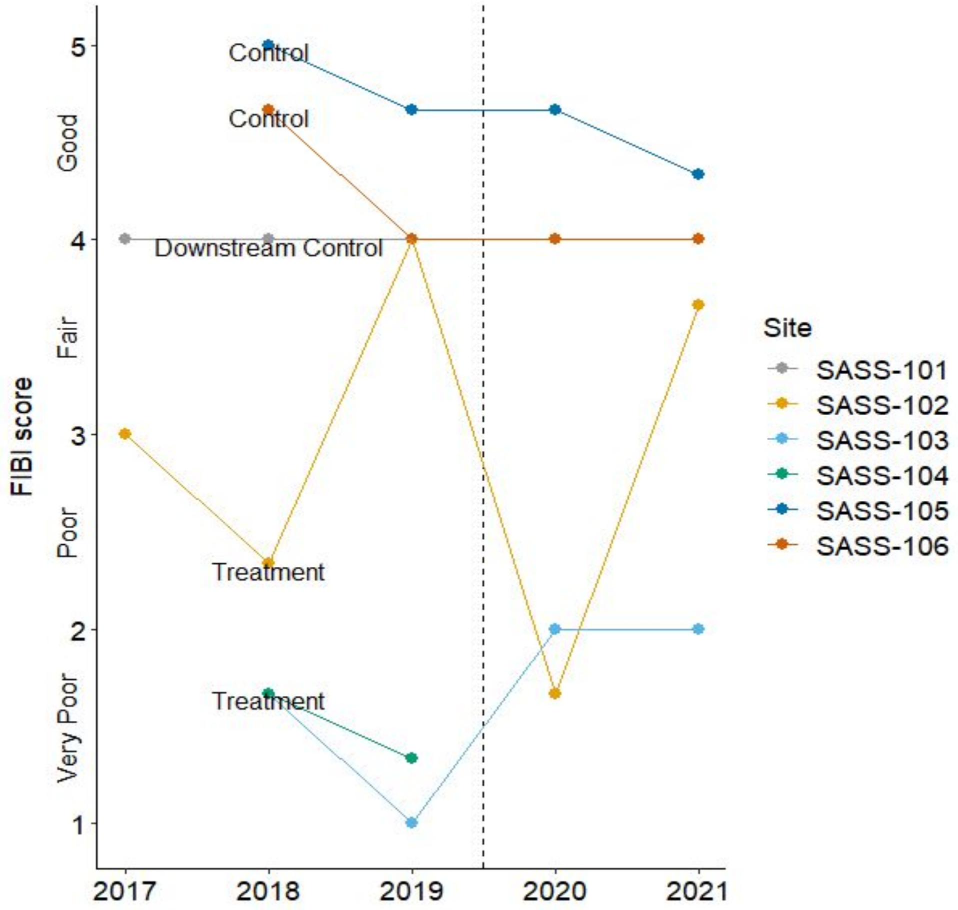
- Paired t-test of daily means by month
- Arrow pointing up = restoration is significantly higher
- Arrow pointing down = restoration significantly lower
- No symbol = no difference between restoration and control



MARYLAND DEPARTMENT OF NATURAL RESOURCES

Fish IBI Scoring

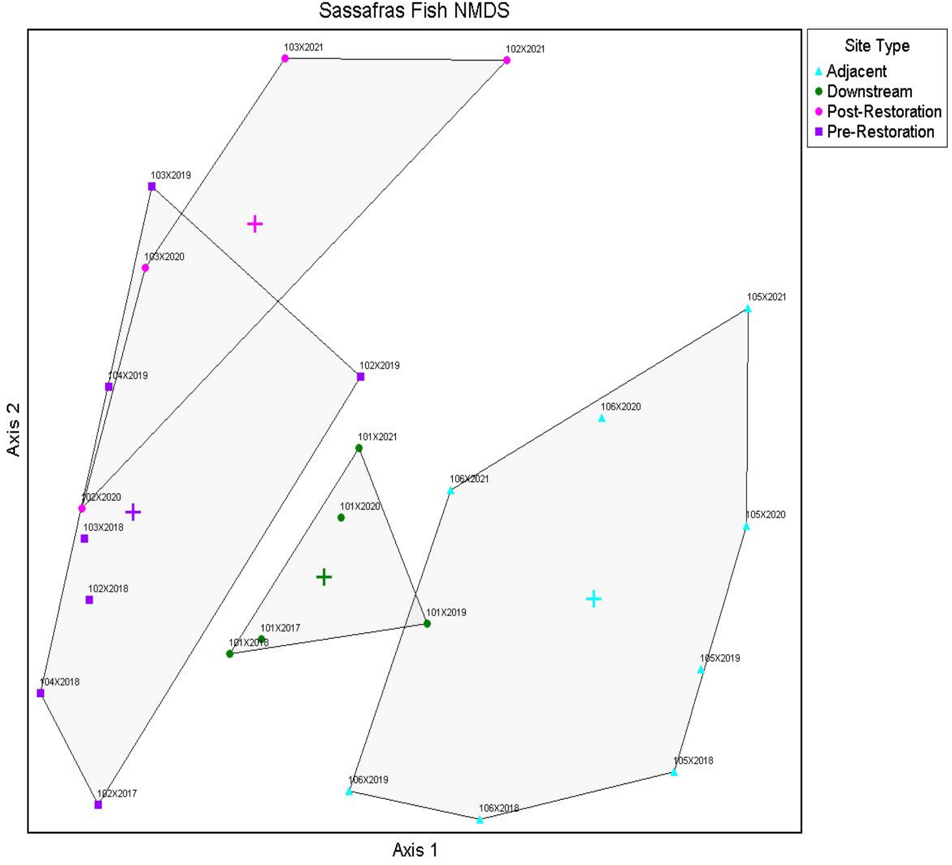
- Downstream Control received the same score (4.0) each year, not a true control site as of 2021
- SASS-104 now consistently dry in summer
- Only 2 species found at SASS-102 and SASS-103 in 2020
- 6 species at SASS-102, 3 species at SASS-103 in 2021

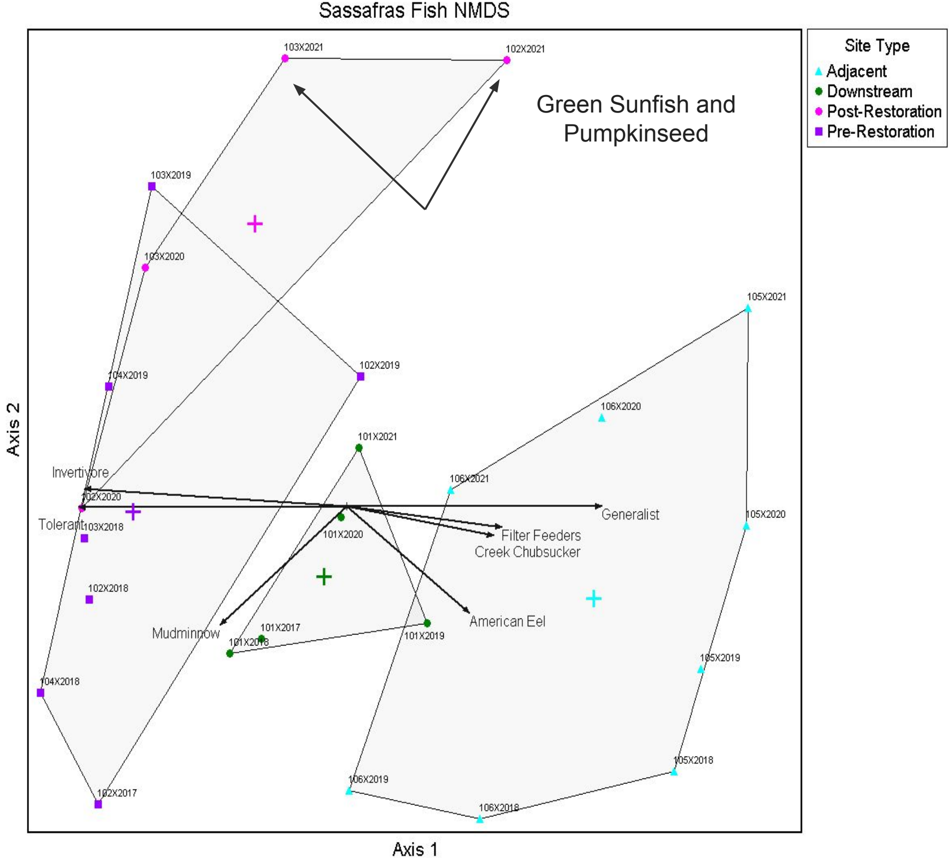


MARYLAND DEPARTMENT OF NATURAL RESOURCES

Fish Non-metric Multidimensional Scaling

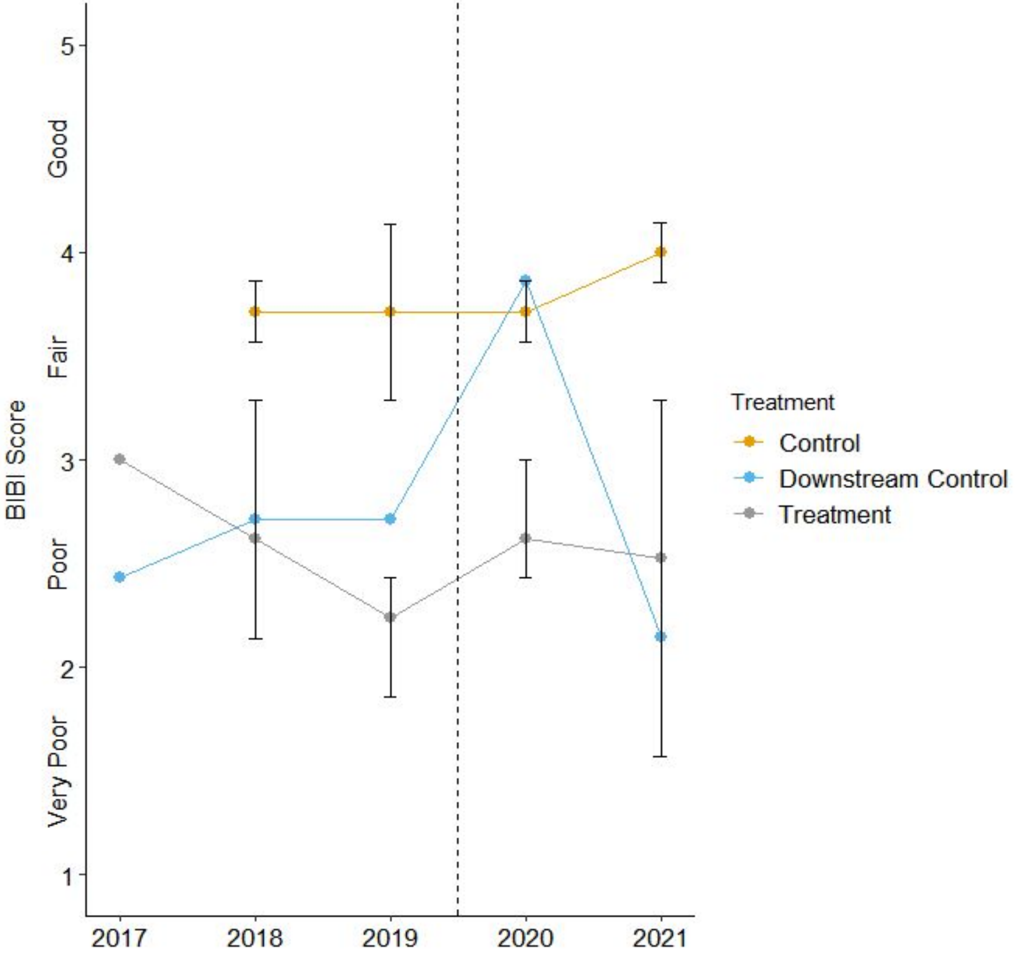
Stress = 0.09 (excellent), R^2 Cutoff = 0.5





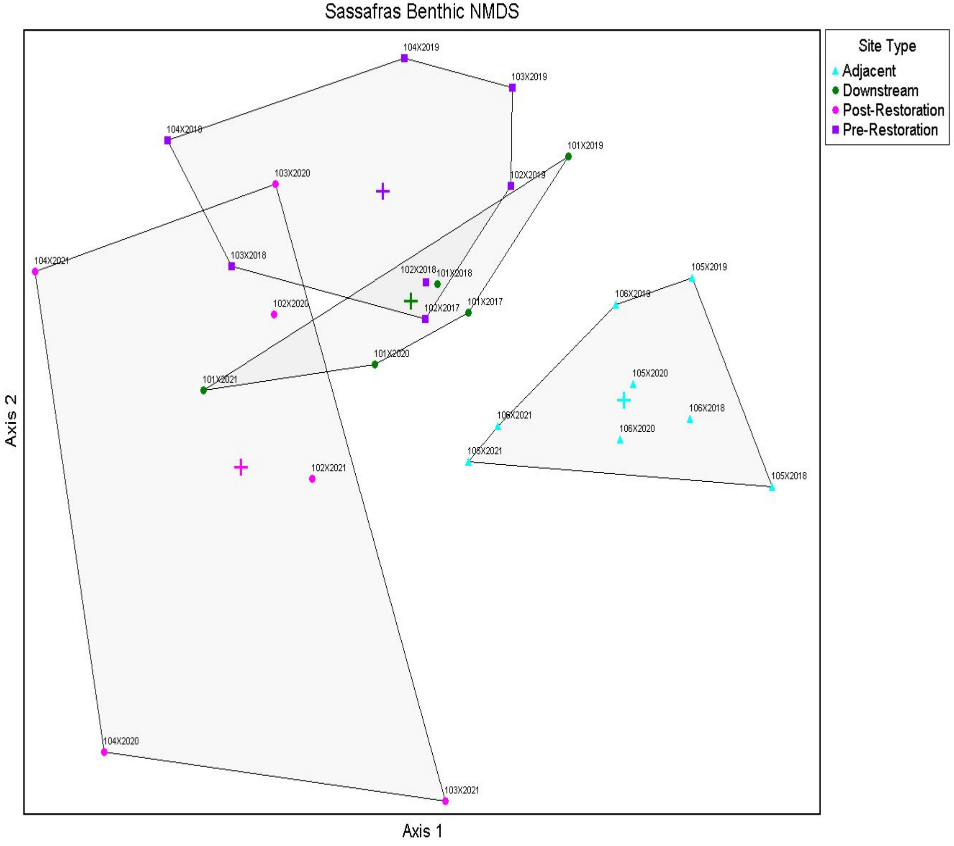
Benthic IBI Scoring

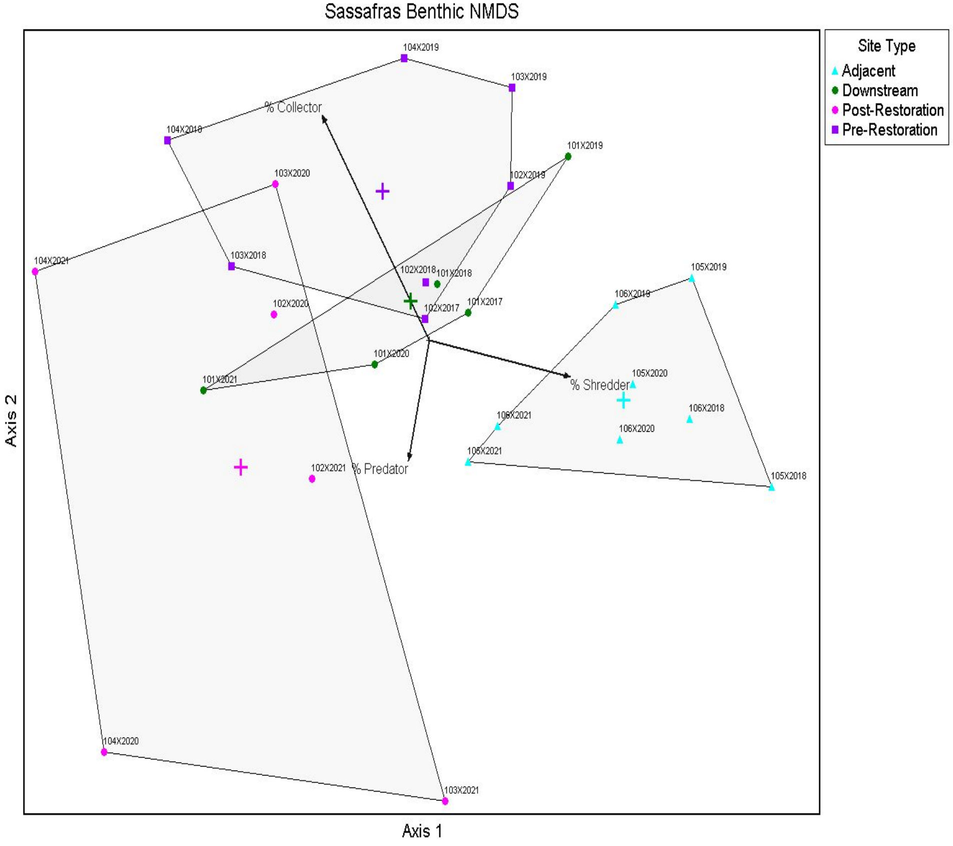
- Downstream Control scores most variable, not a true control site as of 2021
- Each dot represents mean, min and max BIBI score also included by site type
- 624 individuals were ID'ed at site SASS-102-X in 2021, this BIBI score (3.28) is provisional
- Of the post-restoration sites, the lowest % Chironomidae was 95.99% in 2021



Macroinvertebrates Non-metric Multidimensional Scaling

Stress = 0.15 (good), R^2 Cutoff = 0.5





Conclusion

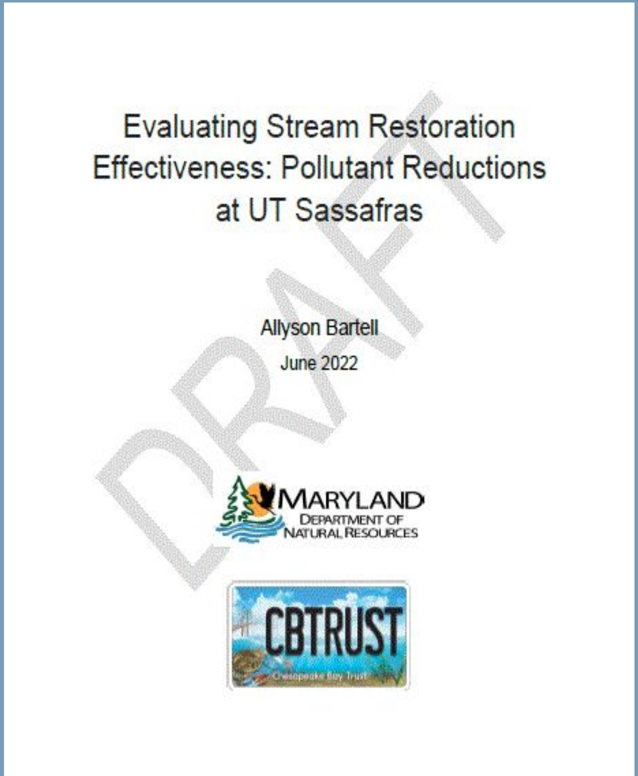
- All nutrient and sediment FWMCs decreased in the post-restoration period except SSC.
- Dissolved oxygen has decreased post-restoration; control DO data was impacted by a newly constructed beaver dam sometime in 2021.
- Temperature has increased post-restoration; control temperature data was impacted by a newly constructed beaver dam sometime in 2021.
- Mixed responses from biological communities - no clear pattern of decline or improvement after 2 years of post-restoration monitoring

Acknowledgements

Trust fund monitoring team - Andy Watts, Maryn LeClair, Heather Quinn, Allyson Bartell, Brittney Flaten, Kyle Hodgson, Sara Weglein, Scott Stranko

And everyone else within RAS who have assisted with water quality, biological and groundwater monitoring

Funding provided by the Chesapeake and Atlantic Coastal Bays Trust Fund



Evaluating Stream Restoration Effectiveness: Pollutant Reductions at UT Sassafras

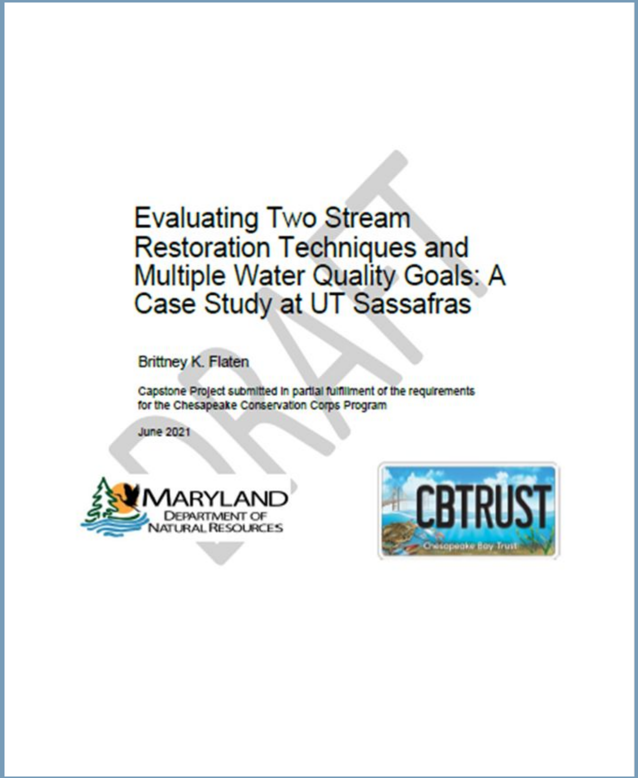
Allyson Bartell

June 2022

DRAFT

MARYLAND DEPARTMENT OF NATURAL RESOURCES

CBTRUST



Evaluating Two Stream Restoration Techniques and Multiple Water Quality Goals: A Case Study at UT Sassafras

Brittney K. Flaten

Capstone Project submitted in partial fulfillment of the requirements for the Chesapeake Conservation Corps Program

June 2021

DRAFT

MARYLAND DEPARTMENT OF NATURAL RESOURCES

CBTRUST

Questions?

References

Baldigo, B. P., A. G. Ernst, D. R. Warren, ans S. J. Miller. (2011). Variable responses of fish assemblages, habitat, and stability to natural-channel-design restoration in catskill mountain streams. Transactions of the American Fisheries Society, 139(2), 449-467.

Ernst, A. G., D. R. Warren, and B. P. Baldigo. (2011). Natural-Channel-Design restorations that changed geomorphology have little effect on macroinvertebrate communities in headwater streams. Restoration Ecology, 20(4), 532-540.

Hilderbrand, R., J. Acord, T.J. Nuttle, and R. Ewing. (2019). Final report: Quantifying the ecological uplift and effectiveness of differing stream restoration approaches in Maryland. Chesapeake Bay Trust Grant #13141.

Hill, C.R. and M.J. Pieper. (2019). Brampton Hills stream restoration post-construction monitoring: Priority pollutant load reductions, 2018 annual report. Howard County Department of Public Works, Bureau of Environmental Services, Stormwater Management Division, Columbia, Maryland.

Lave, R. (2009). The controversy over natural channel design: Substantive explanations and potential avenues for resolution. Journal of the American Water Resources Association, 45, 1519-1532.

Palmer, M.A., H.L. Menninger, and E. Bernhardt. (2010). River restoration, habitat heterogeneity, and biodiversity: A failure of theory or practice? Freshwater Biology 55: 205-222.

Roni, P., K. Hanson, and T. Beechie. (2008). Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. North American Journal of Fisheries Management, 28(3), 856–890. doi:10.1577/M06-169.1

Stranko, S., D. Boward. J. Killian, A. Becker, M. Ashton, M. Southerland, B. Franks, W. Harbold, and J. Cessna. (2019). Maryland Biological Stream Survey: Round Four Field Sampling Manual. https://dnr.maryland.gov/streams/Publications/R4Manual.pdf