Hydrological and biological responses to restoration of dynamic alluvial valleys at Robinson Fork, PA

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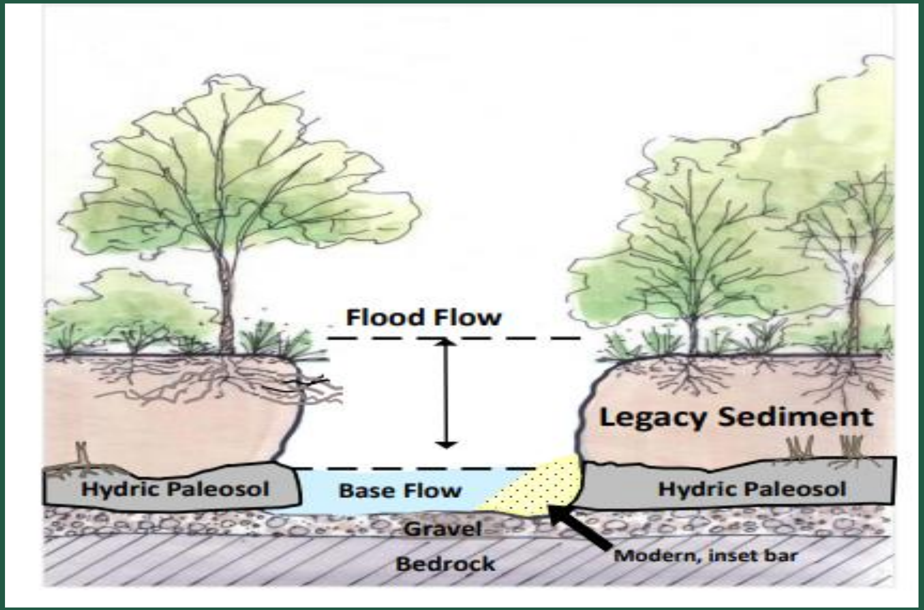
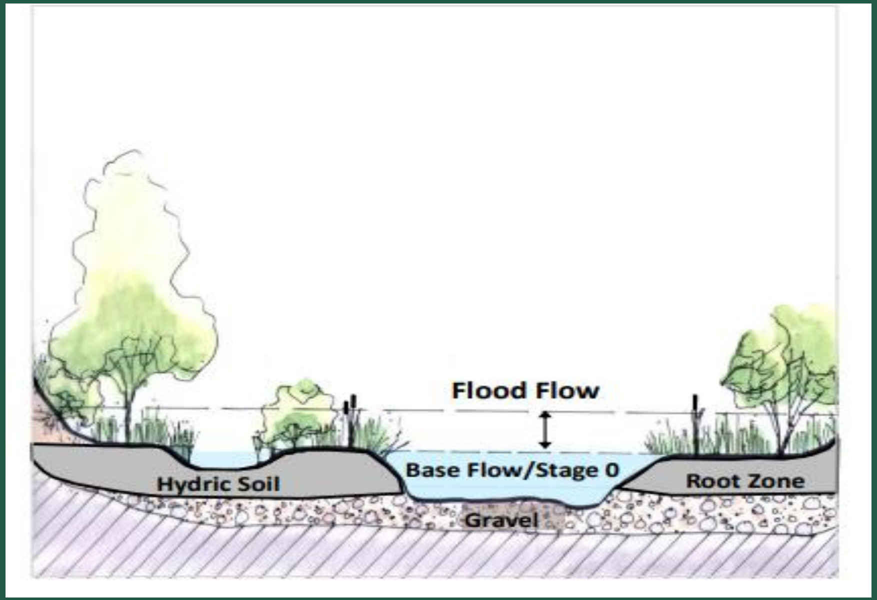
* Students (graduate or undergraduate)

Ohio University, Athens OH

Typical midwestern stream

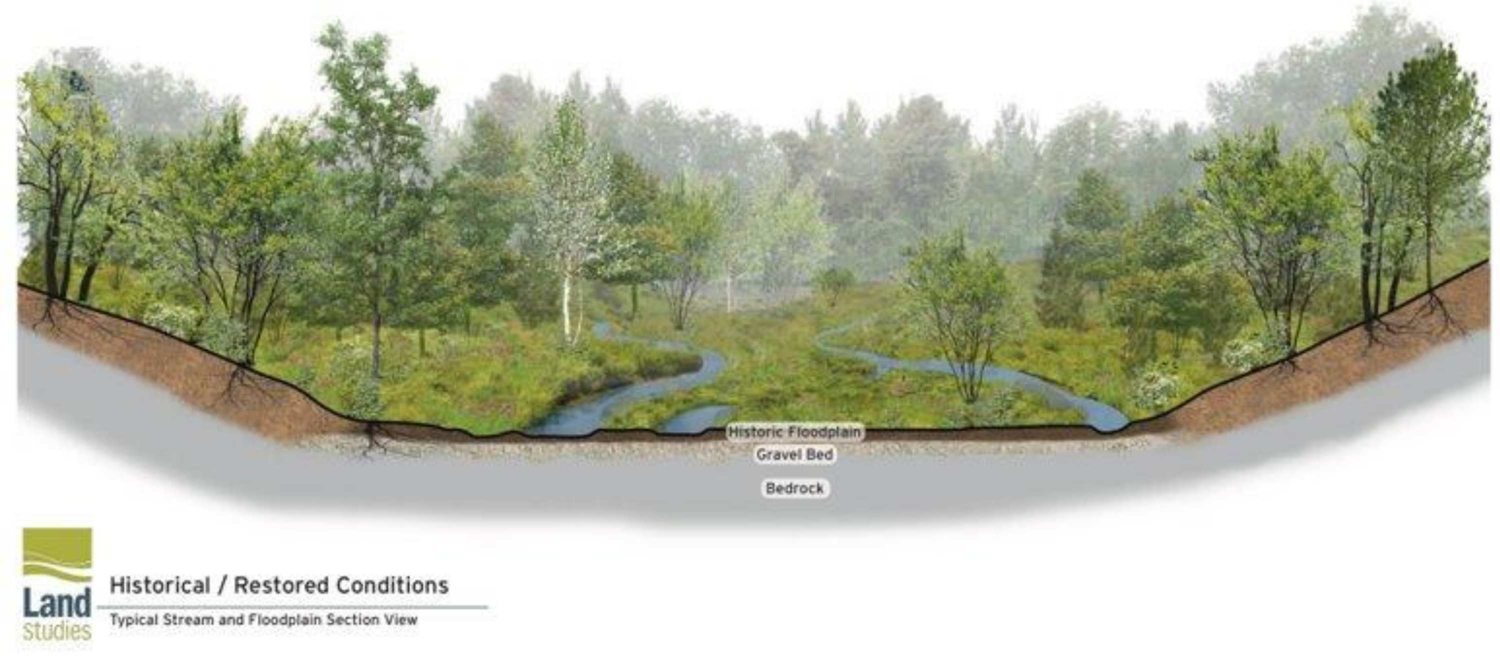


Restored stream-wetland complex



Images from J. Hartranft PA Legacy Sediment Workgroup

Restoration of dynamic alluvial valley should



- Increase water storage during peak and low flows
- Reduce erosion/improve sediment retention
- Enhance geochemical cycling (longer inundation periods)
- Reduce nutrient export
- Create mosaic of habitat types (flows, velocity, depth) for biodiversity
- Support high secondary production, biodiversity

(Flitcroft et al. 2022, Leberg and Topping 2023, Goerman et al. 2013, Kaushal et al 2014, Parola and Hansen 2011)

Need more post-restoration monitoring of key functional processes

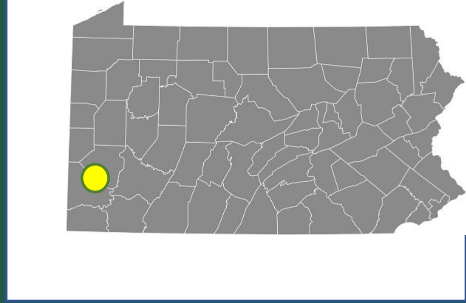
Flitcroft et al. 2023, Braccia et al 2023

- hydrology
- sediment retention
- nutrient retention/cycling
- organic matter processing

Challenges:

- Stream-complexes have wetland and stream features
- Stream biotic indices not designed for wetlands
- Biotic indices don't always reveal 'function'
- Unclear what to use as 'reference'

Robinson Fork Stream Mitigation area



- 14.4 square miles in Western PA, Western Alleghany Plateau
- Forest cover 70%, 5.67% urban development, and 0.23% impervious surface
- Some historical agriculture, timbering and coal mining
- Designed/Implemented by LandStudies & RES in 2016-17
- Monitored 3-4 years post-restoration (2019-25)

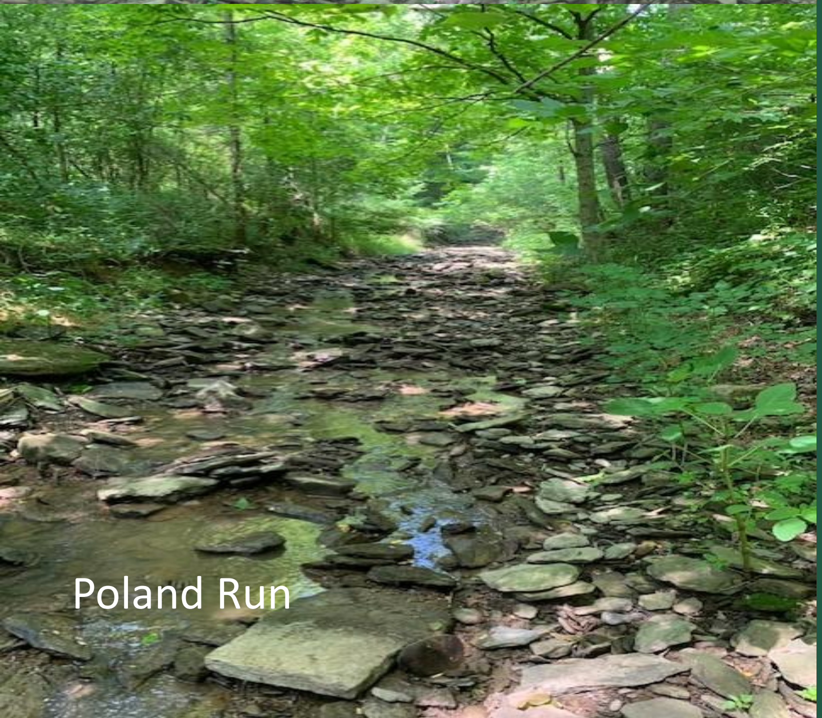
6 restored sites (Robinson Fork)

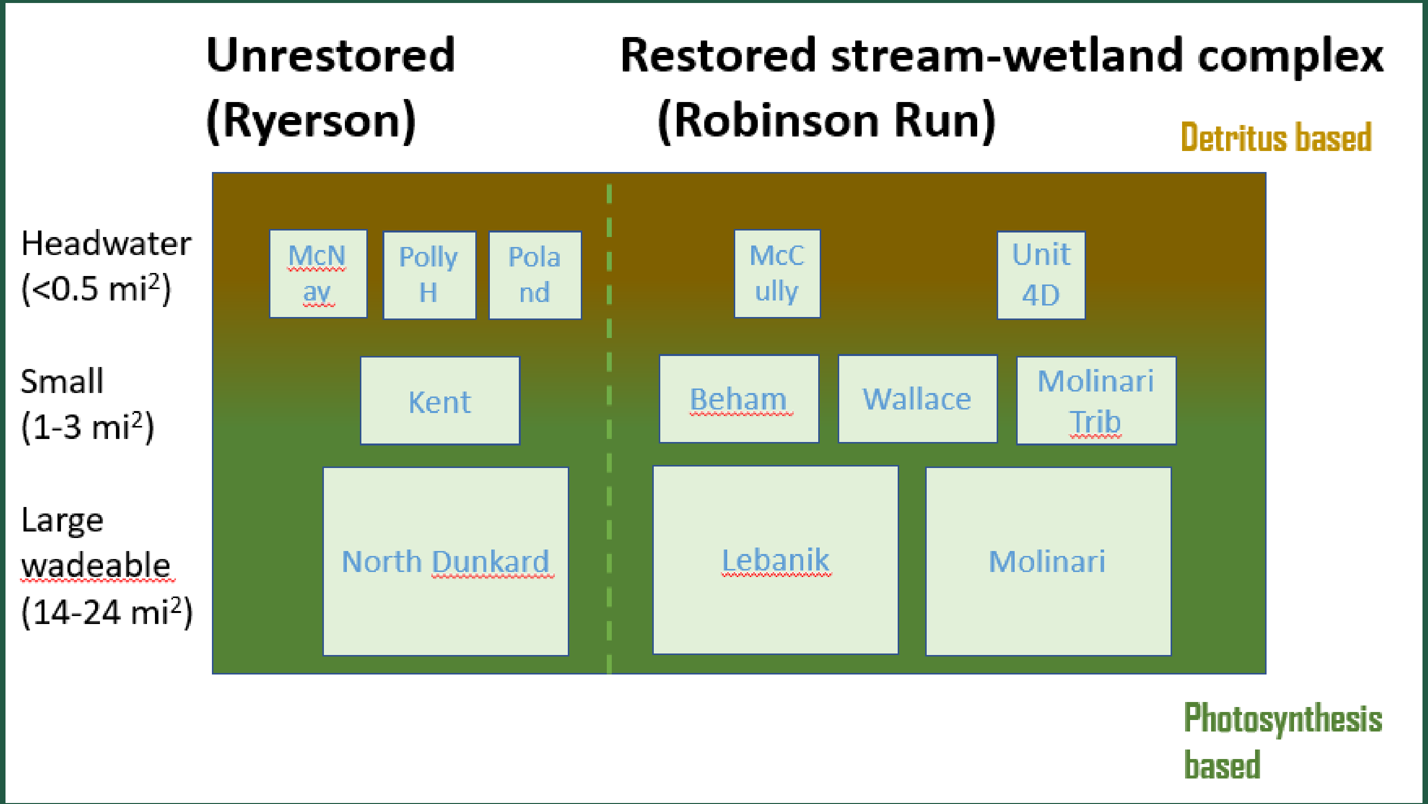
Modified from DEP DRAFT AQUATIC USE ASSESSMENT (2025)

4 unrestored single channels (Ryerson)

Ryerson Station State Park unrestored single channel streams

- 76% forest cover, 5.74% urban development, 0.24% impervious
- Historical mining, timbering





Ohio University Monitoring

1. Discharge during precipitation events (pre- and post)
   - Sediment retention
   - Sediment and water chemistry (nutrients N and P)

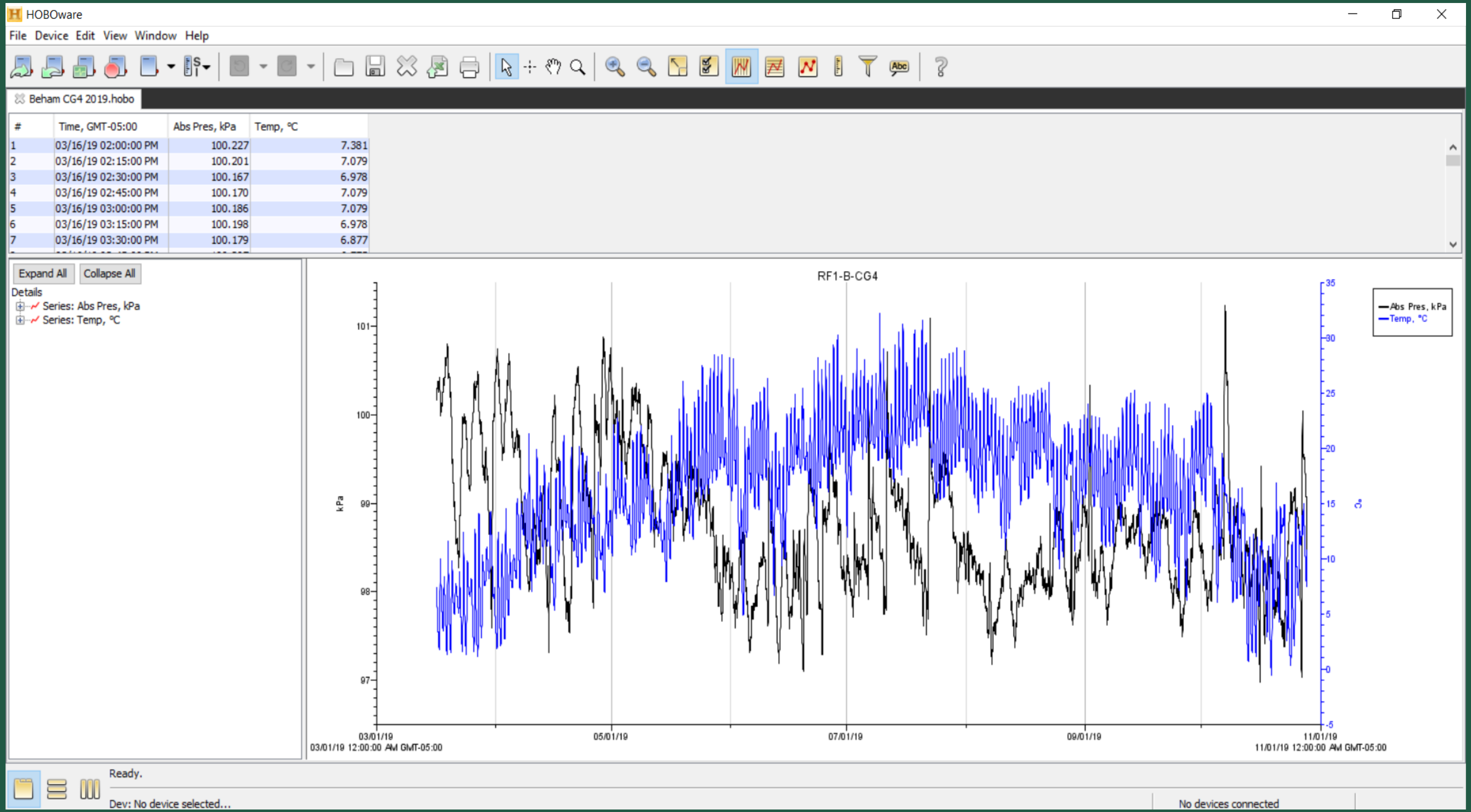
2. In-stream primary production (periphyton)
   - Macroinvertebrate assemblage diversity and biomass

3. Carbon accumulation and retention (terrestrial litter inputs, decomposition rates, soil organic content)

4. Wet/dry cycles (frequency & duration)

5. 2025 PA DEP Aquatic use assessment

Continuous Water Level Monitoring



HOBO depth loggers

upstream – downstream

15 min intervals

2014-2025 (11 years)

Quarterly:

(2021-2025)

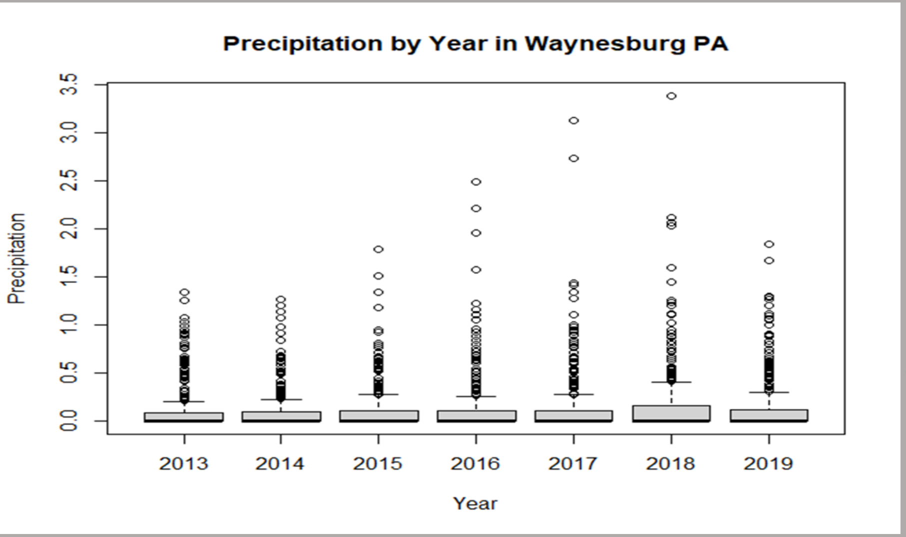
- pH, specific conductivity,
- TSS, N, P, TOC
- Channel flows with flume, SonTek, or pygmy
- Salt tracing to measure transient flow and estimate water storage
- Sediment grain size and nutrients

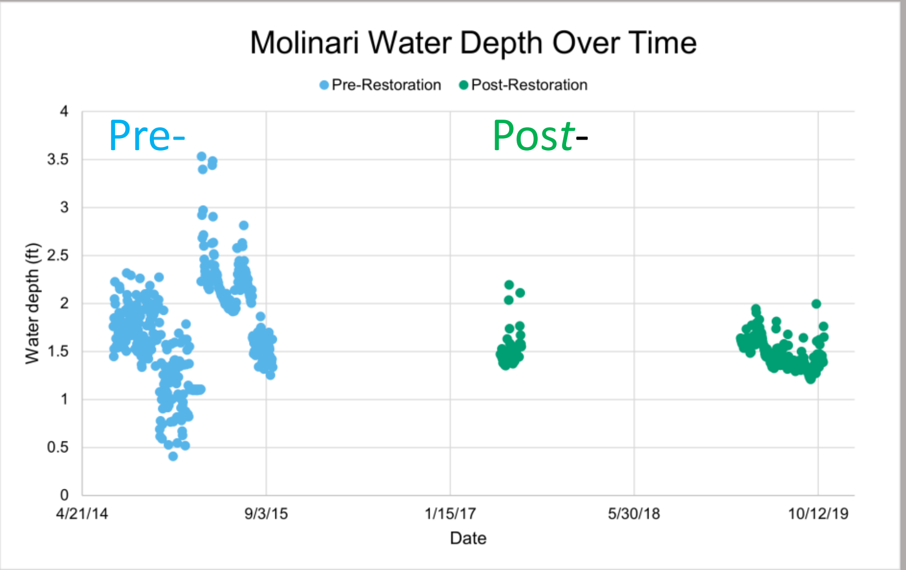
Hydrological Responsiveness to Precipitation

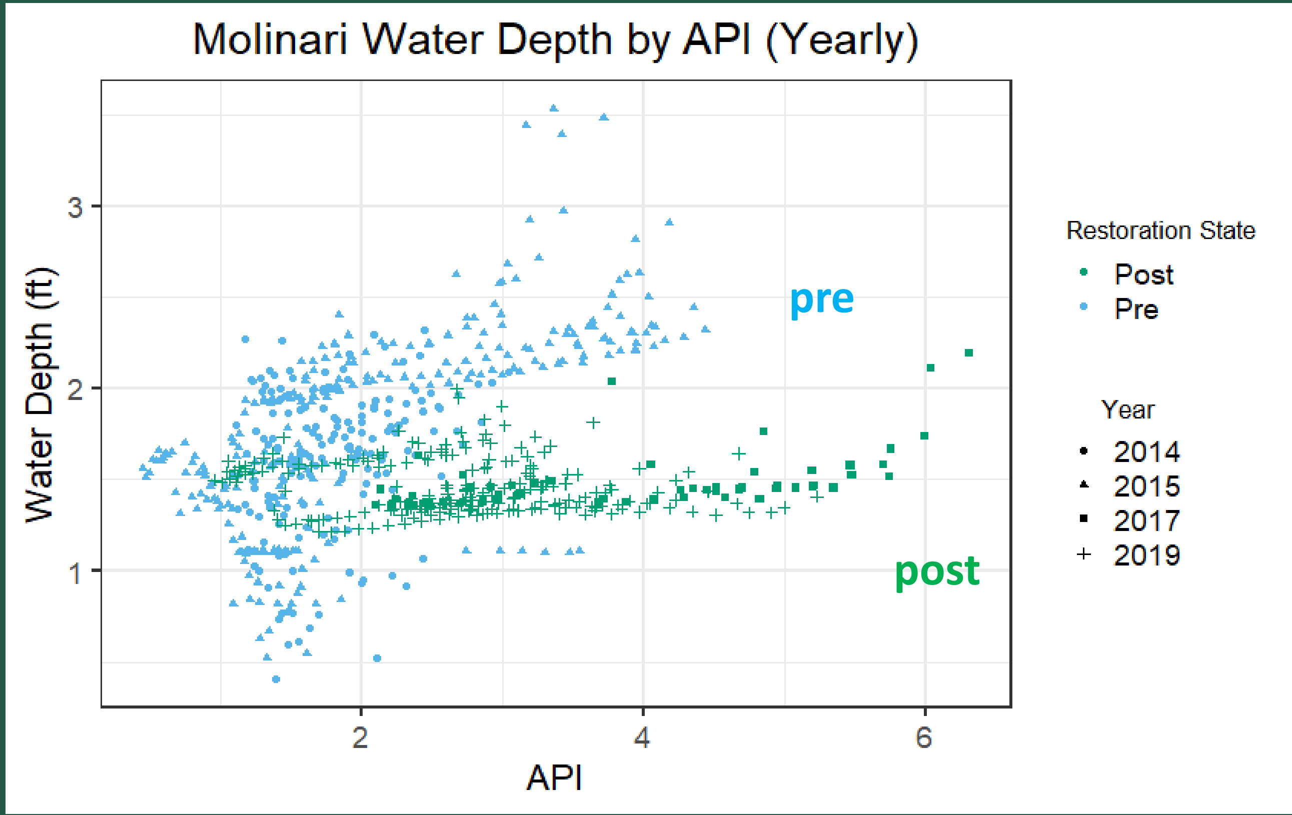
Large wadeable site (Lebanik) flood event

Responsiveness of sites to precipitation (pre- and post)

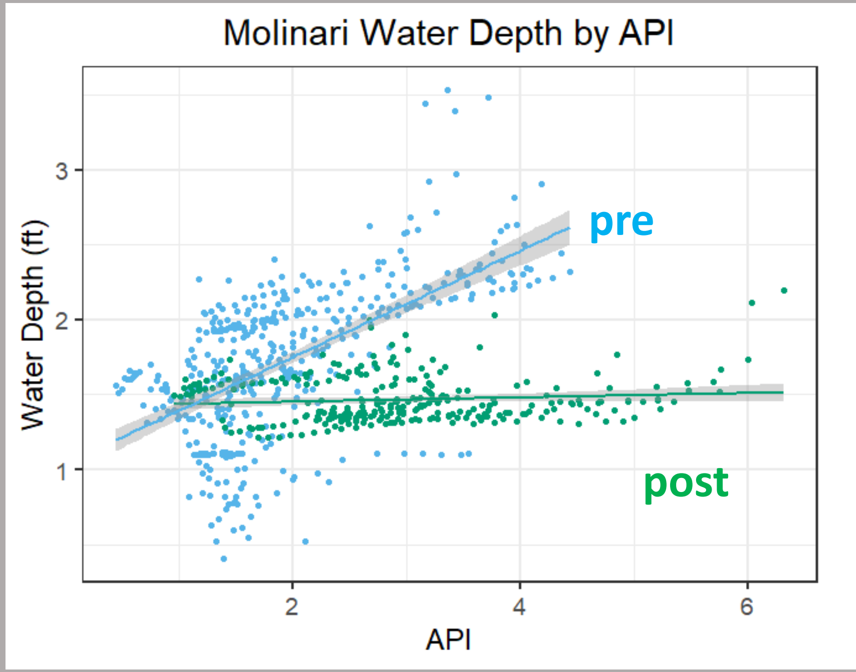
Estimated from daily precipitation data and water level monitoring

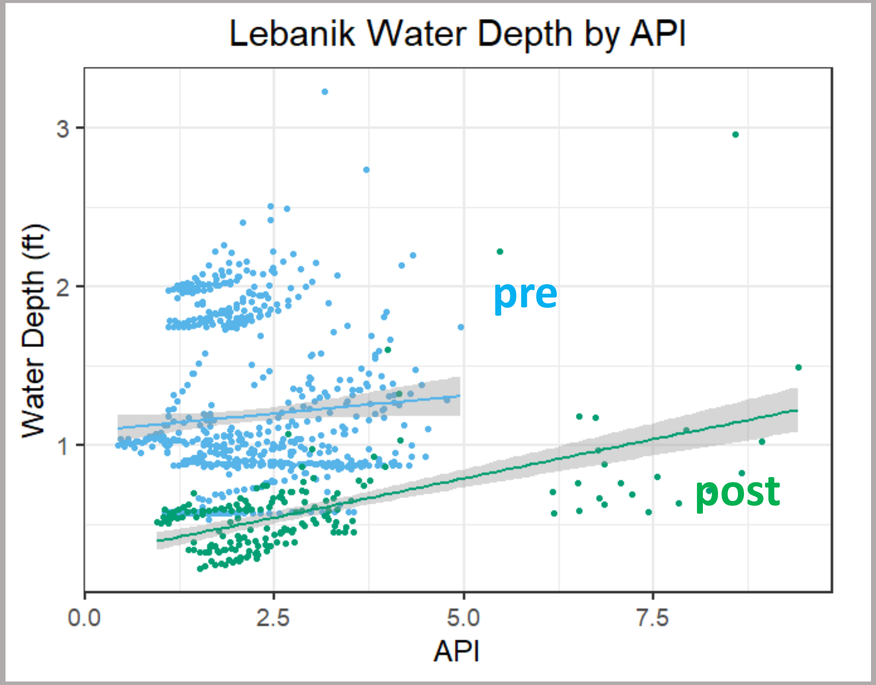






Flatter slope post-restoration (green) indicates water level was less influenced by periods of high precipitation as pre-restoration (blue)



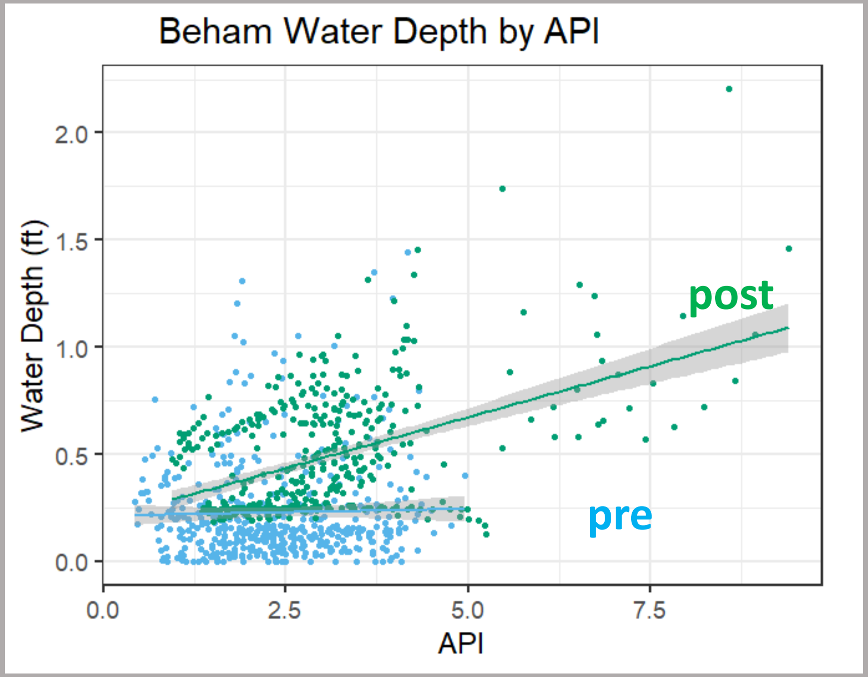


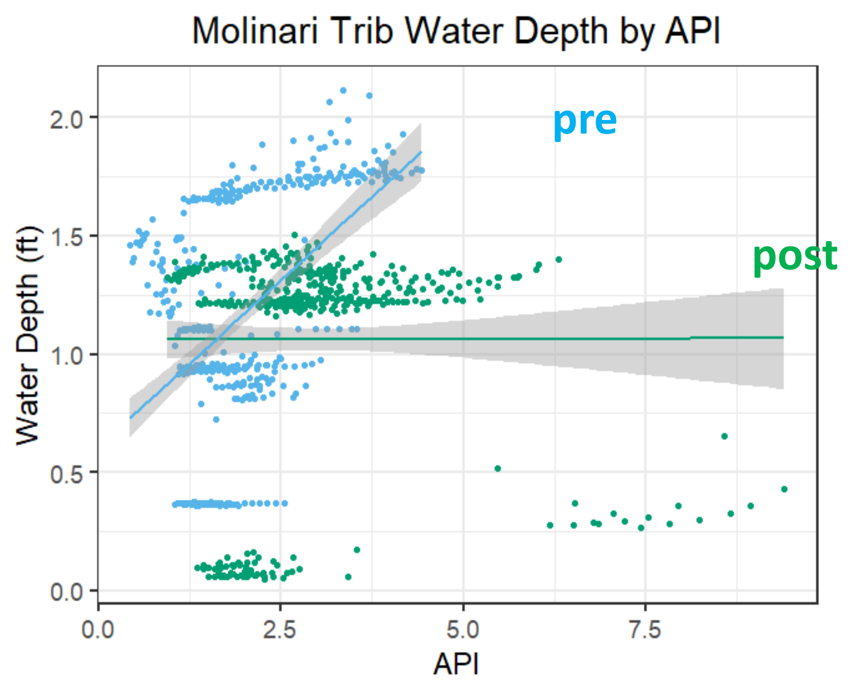
Wadeable (large) streams

Molinari – 14.2 mi ^{2} – Slope of line decreased post-restoration. Water level stays consistent over a wide range of wetness and is not influenced by periods of high precipitation as much as it was pre-restoration. Less flashy

Lebanik – 20.9 mi ^{2} - Water level was lower post-restoration. It behaves oppositely Molinari: slope of line increases post-restoration. Water level was more influenced by periods of high precipitation after restoration

More flashy





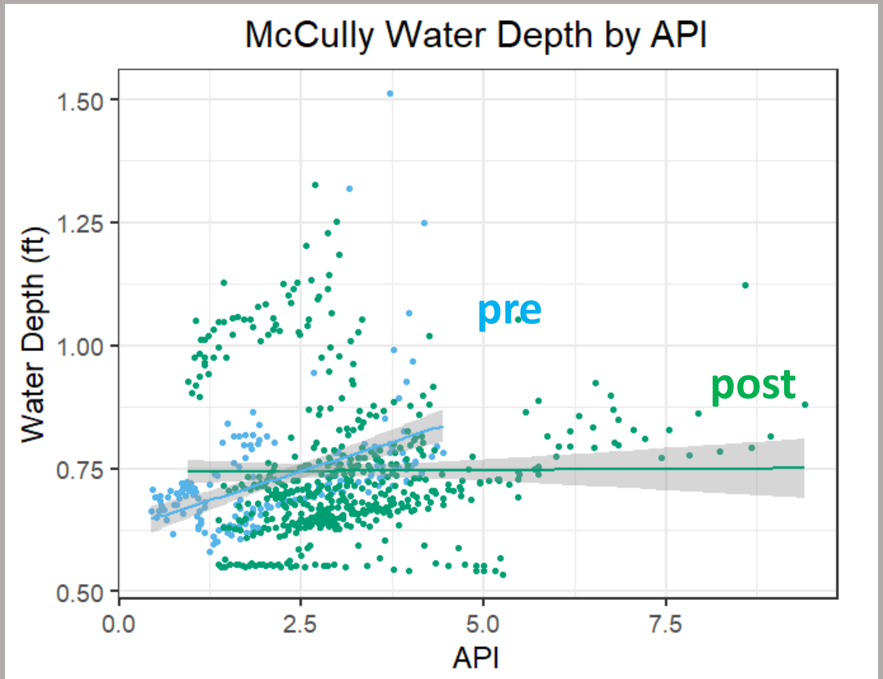
Midsized headwater streams

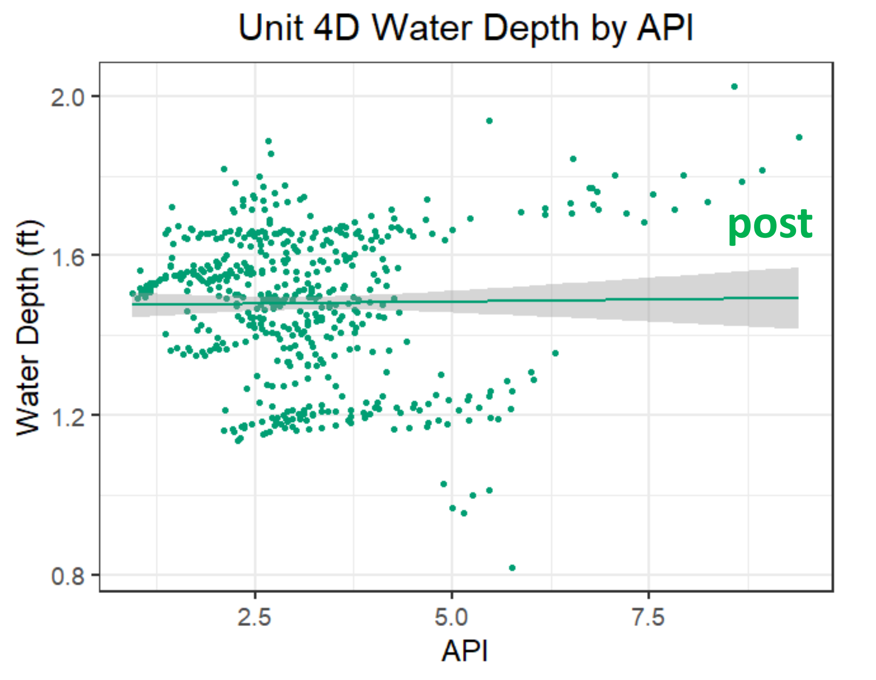
Beham – 3.0 mi ^{2} -Water level was higher post-restoration. Slope of line increased post-restoration.

More flashy

Molinari Trib – 0.83 mi ^{2} - Slope of line decreased post-restoration. Water level is not influenced by periods of high precipitation as much as it was pre-restoration.

Less flashy





Smallest (Primary) headwaters

McCulley – 0.05 mi ^{2} - Slope decreased post-restoration

Less flashy

Unit 4D – 0.05 mi ^{2} - no pre-restoration data, but the trendline is flat like most of the other sites post-restoration, so likely a decrease

Likely less flashy

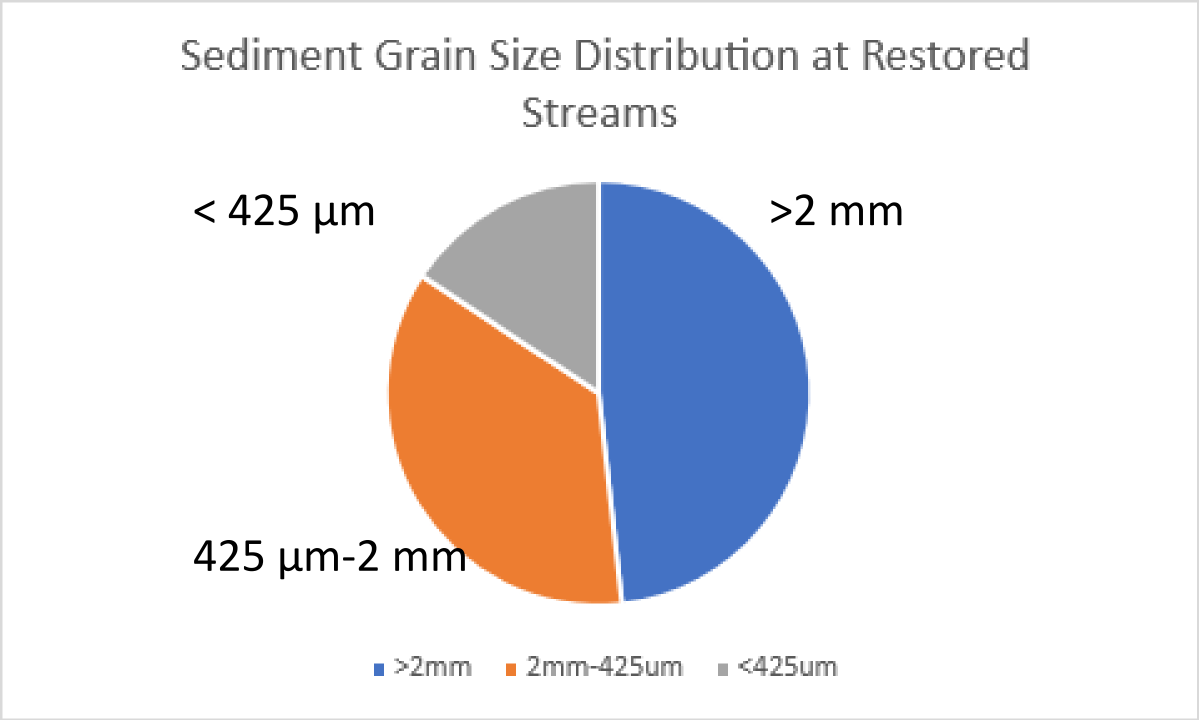
Sediment Dynamics

- Sediment pit traps at downstream sites
- Trowel method when needed
- Grain size distribution
- TN and TP concentrations

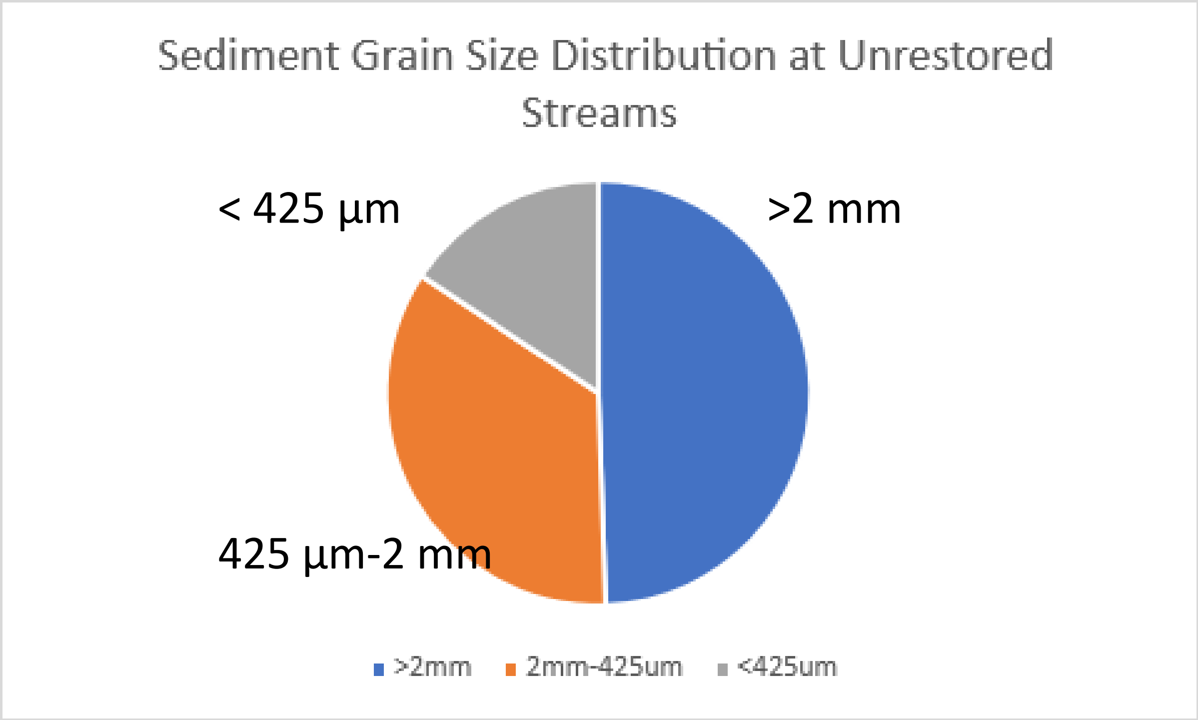
Sediment retention did not differ

3 years of data (July 2020-Aug 2023)

Restored stream complexes
N=53 samples



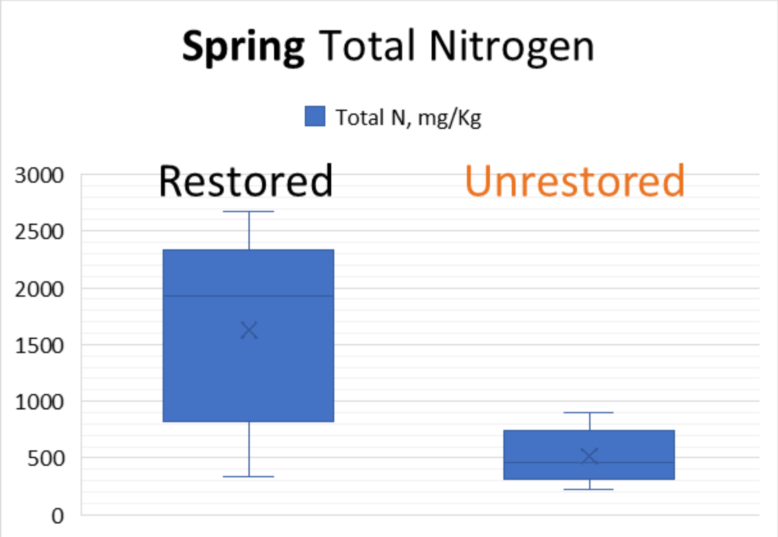
Unrestored (Forested channel)
N=29 samples

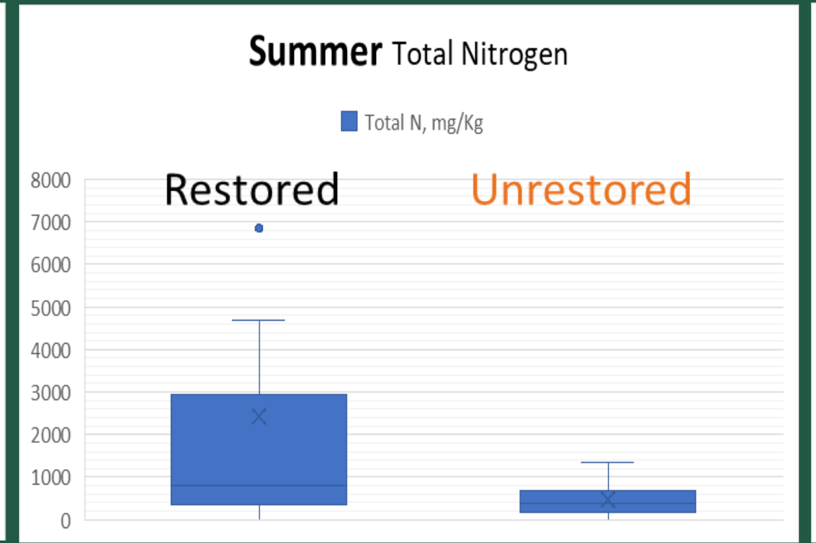


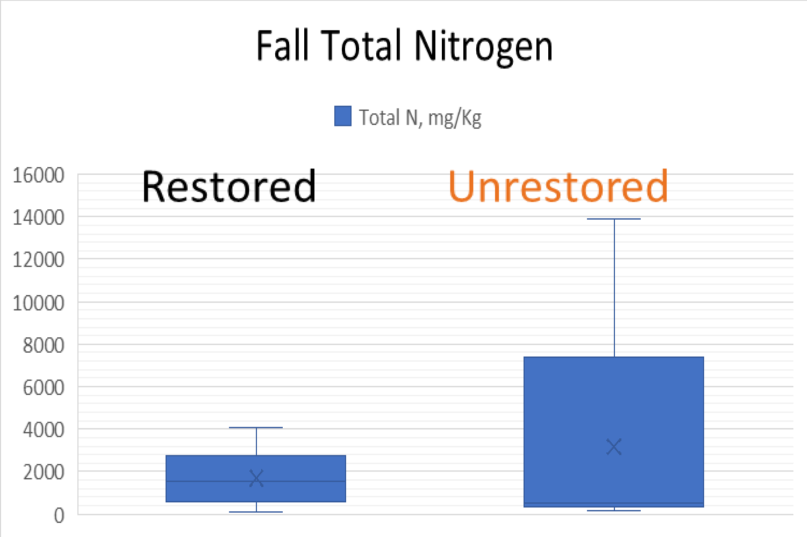
Sediment Nitrogen

3 years of data (July 2020-Aug 2023)

- Trend toward higher total N in sediments restored sites
- But also a seasonal component



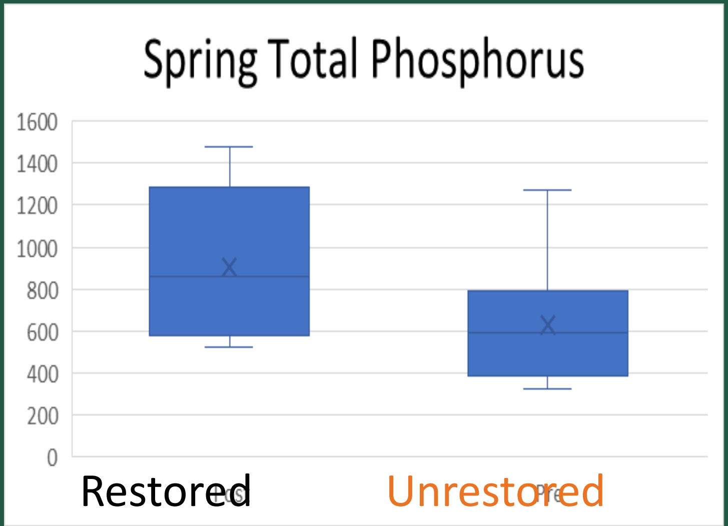


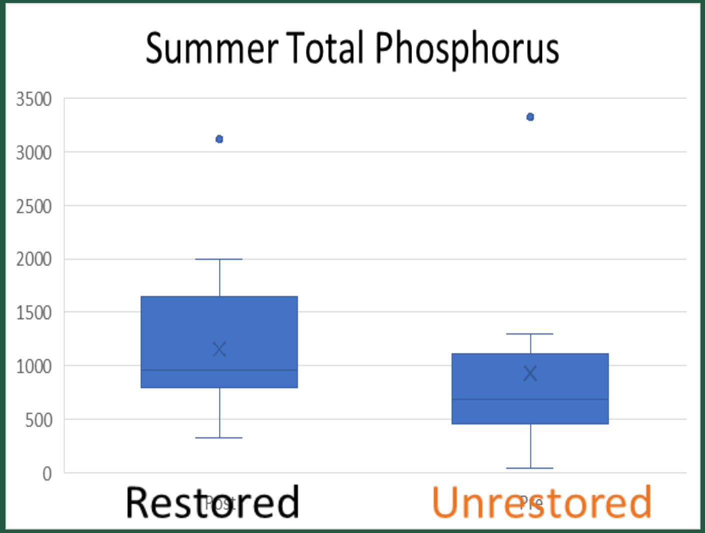


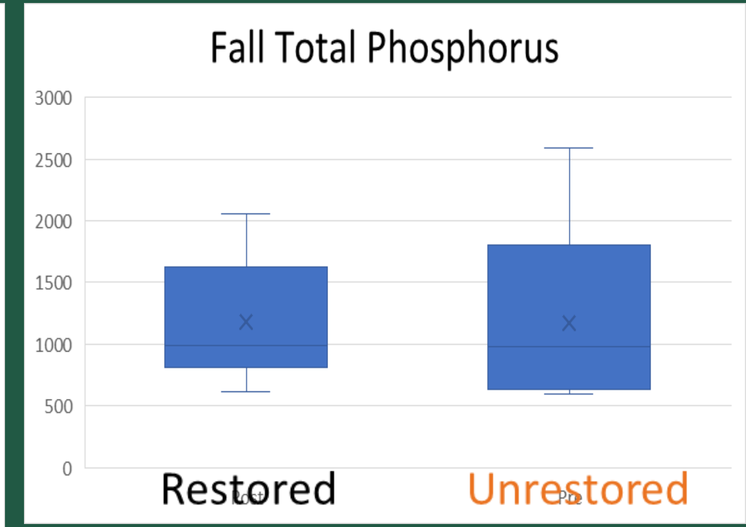
Sediment Phosphorus

3 years of data (July 2020-Aug 2023)

- Trend for higher P in restored sites
- But no differences in large wadeable sites
- Seasonal trends, slightly more P in sediments in spr and su but not fall







Ohio University Monitoring

- Restored sites tended to be less flashy
- Initially more fines retained at restored sites
- Trends for higher sediment N at restored sites, and slightly higher P) – working on statistics

- Water chemistry, In-stream primary production (periphyton)and macroinvertebrates

- Carbon accumulation and retention (terrestrial litter inputs, decomposition rates, soil organic matter)

- Wet/dry cycles (frequency & duration)

Did disturbance of legacy sediments release nutrients?

How strong are links between nutrients –> periphyton –> macroinvertebrate biomass?

- July 2019 (2 yrs post restoration)
- 10 rock scrubs per riffle
- Three riffles per stream reach
  - AFDM (ash free dry mass)
  - Chlorophyll *a*





Macroinvertebrates

Ashlee Widener, MS 2021

3 HABITATS SAMPLED

Riffle – kick-net 1 meter

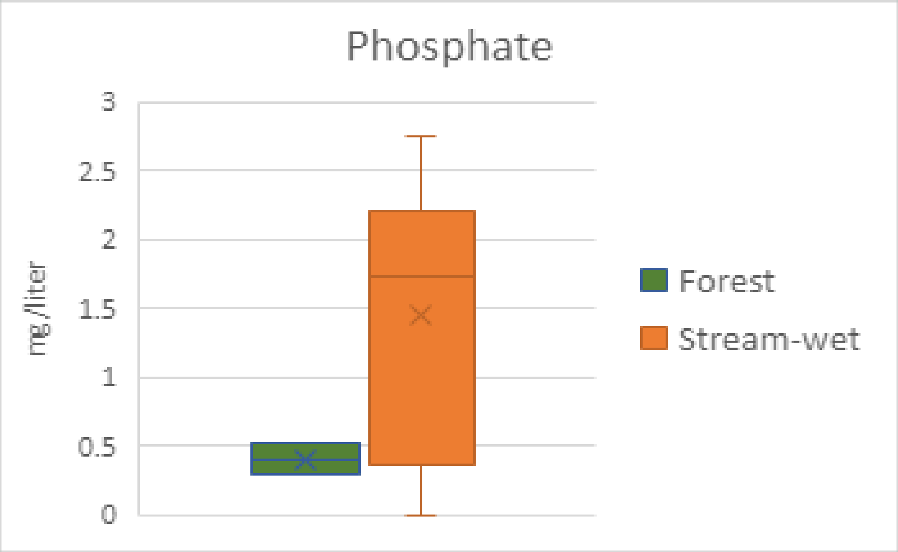
Edges, woody debris, pools – D-ring dipnet

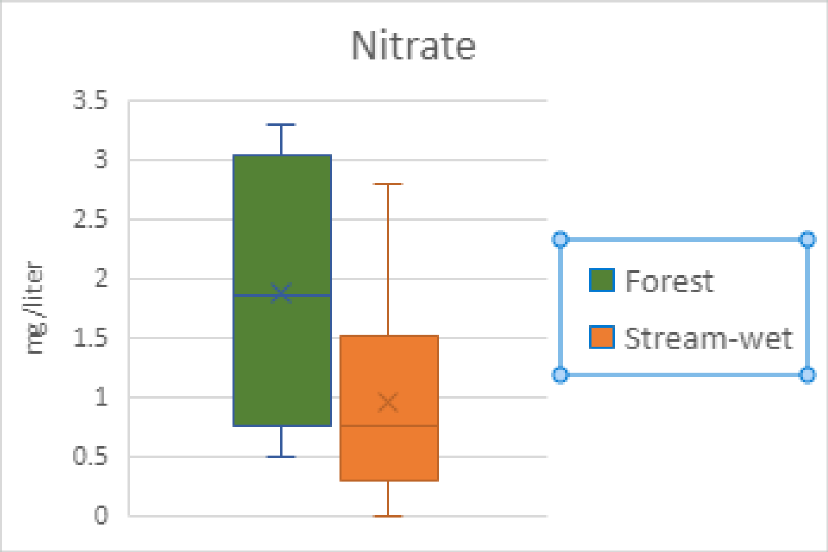
Depositional habitats – ‘bucket’

METRICS

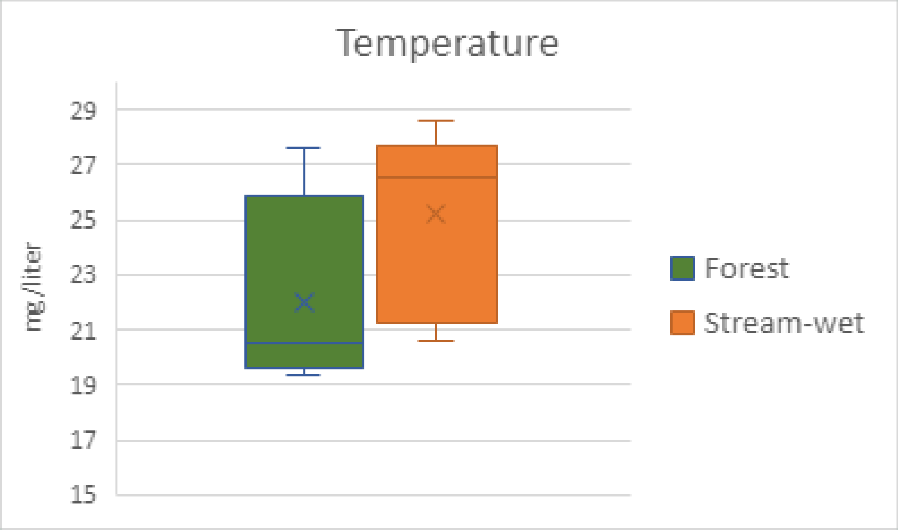
- Total biomass, abundance, richness, diversity, %EPT
- Biomass of Elmidae, Heptageniidae, Hydropsychidae and Chironomidae

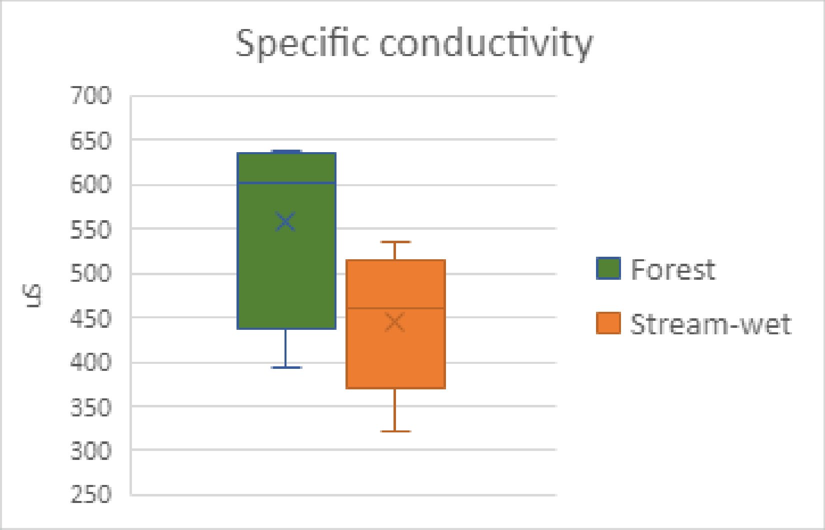
Water quality in unrestored vs restored streams
(one sampling date, July 2019)





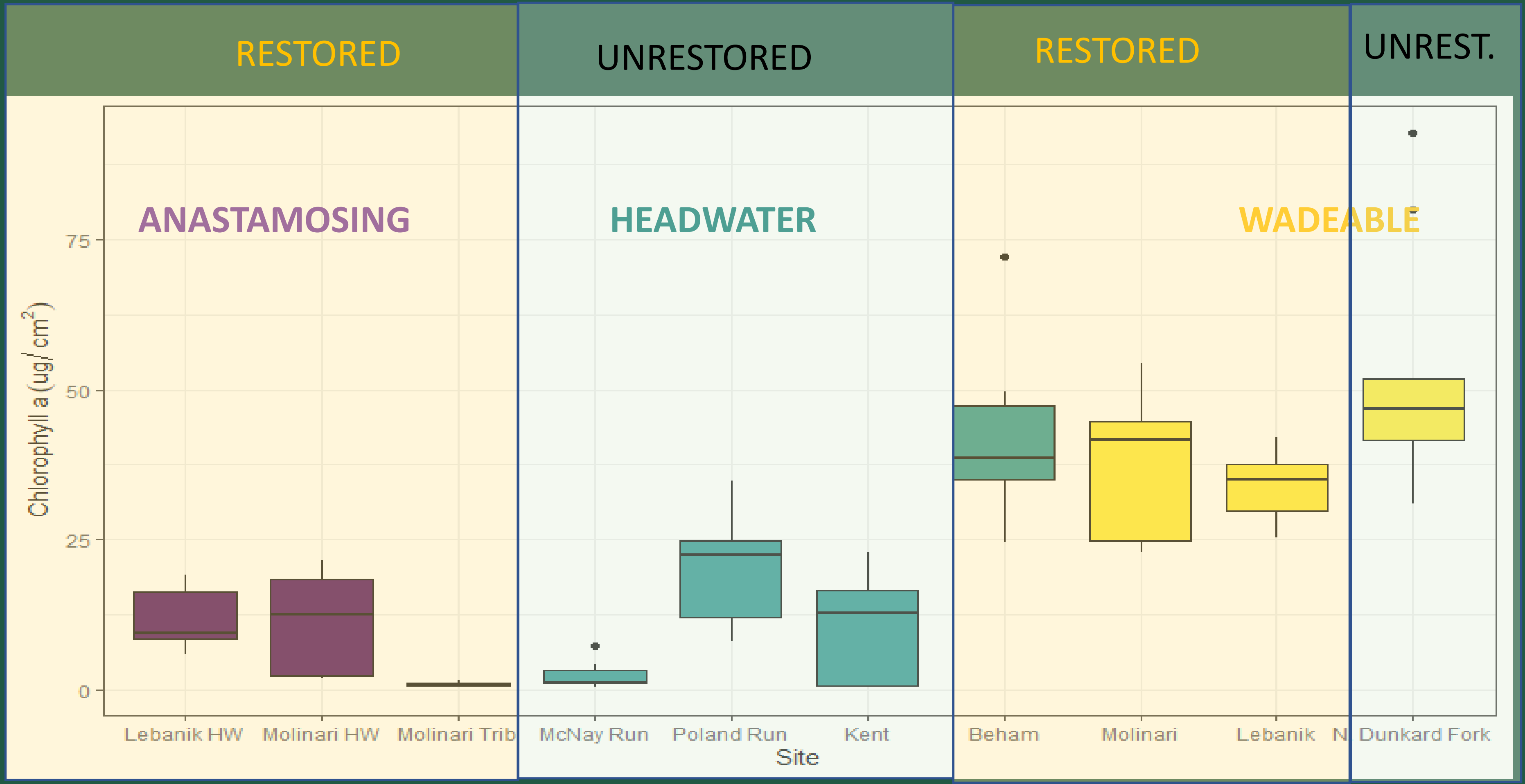
Nitrate levels did not differ between restored sites and forested ($F_{1,8}$ = 1.7971, p = 0.22)

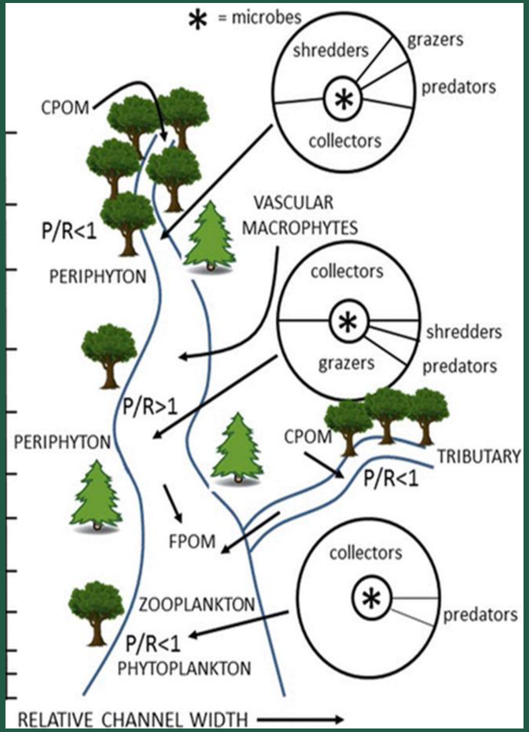




Phosphate levels did not differ ($F_{1,8}$ = 3.892, p = 0.084)

Periphyton influenced by stream size, not restoration status





Mean chlorophyll a differed between sites ($F_{9,79}$ = 28.74, p < 0.0001) and stream size ($F_{2,86}$ = 37.02, p < 0.0001) but not between forested and restored sites ($F_{1,87}$ = 0.1642, p = 0.6863).

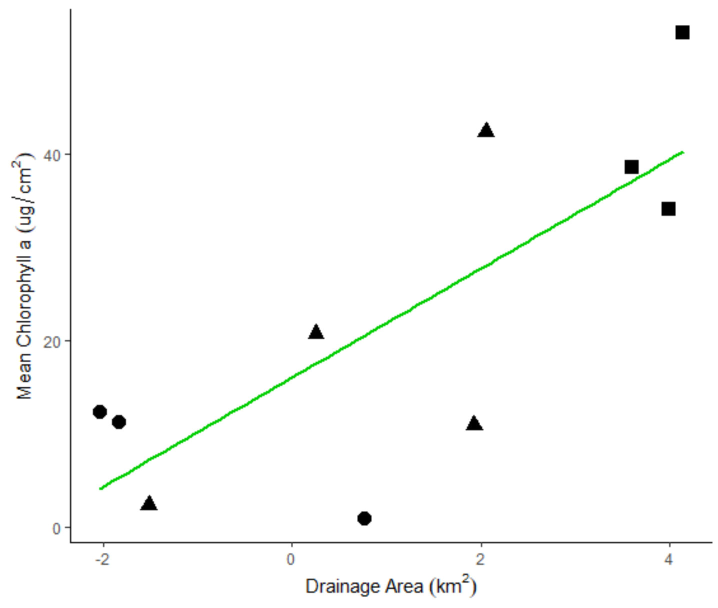
Mean AFDM (g) did not differ among stream size ($F_{2,27}$ = 0.4608, p = 0.6356), or between forested and restored sites ($F_{1,28}$ = 0.0257, p = 0.8738)

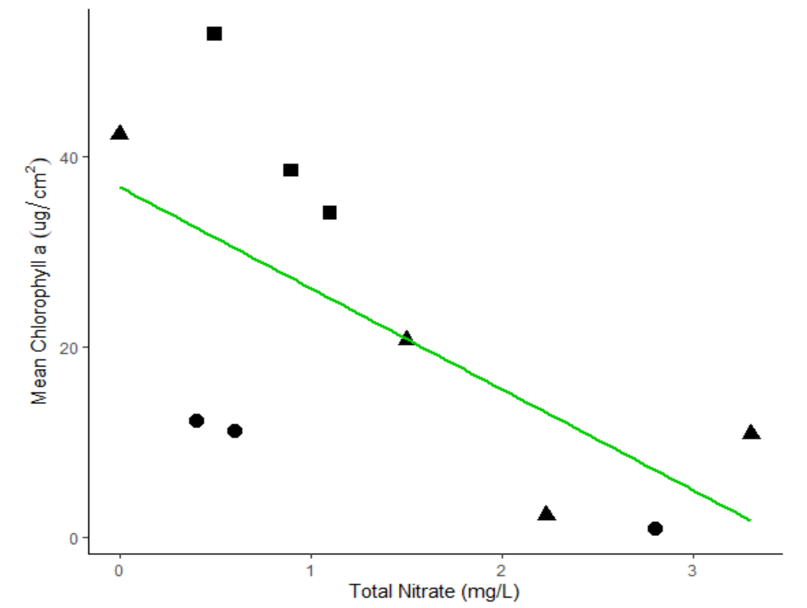
Periphyton correlated with macroinvertebrate abundance and biomass

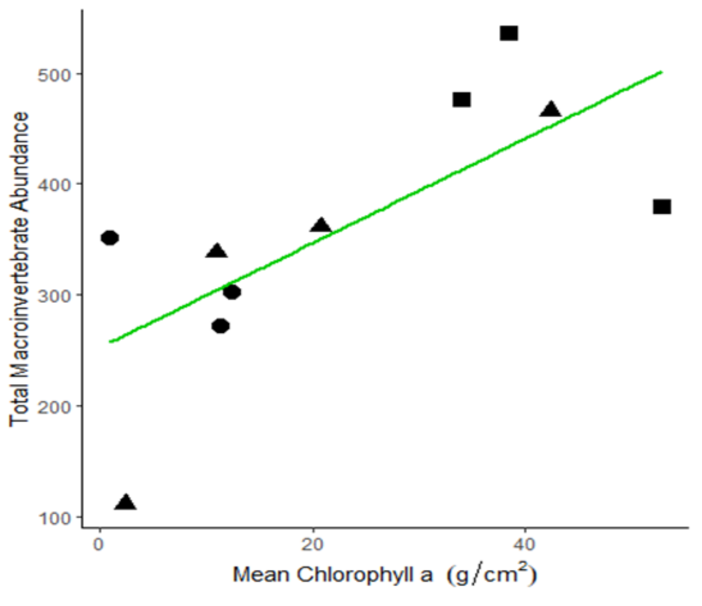
Chl a increased with drainage area

Negative correlation with nitrate

Positive correlation with macro abundance







CF

Drainage Area and Mean Chlorophyll a
Linear: R^2=0.60, $F_{1,8}$ = 11.9, p = 0.0087

Total Nitrate and Mean Chlorophyll a
Linear: R^2 = 0.42, $F_{1,8}$ = 5.79, p = 0.043

SG

Biomass of scraper grazers and filter Feeders correlated with Chla

Predators and shredders less so

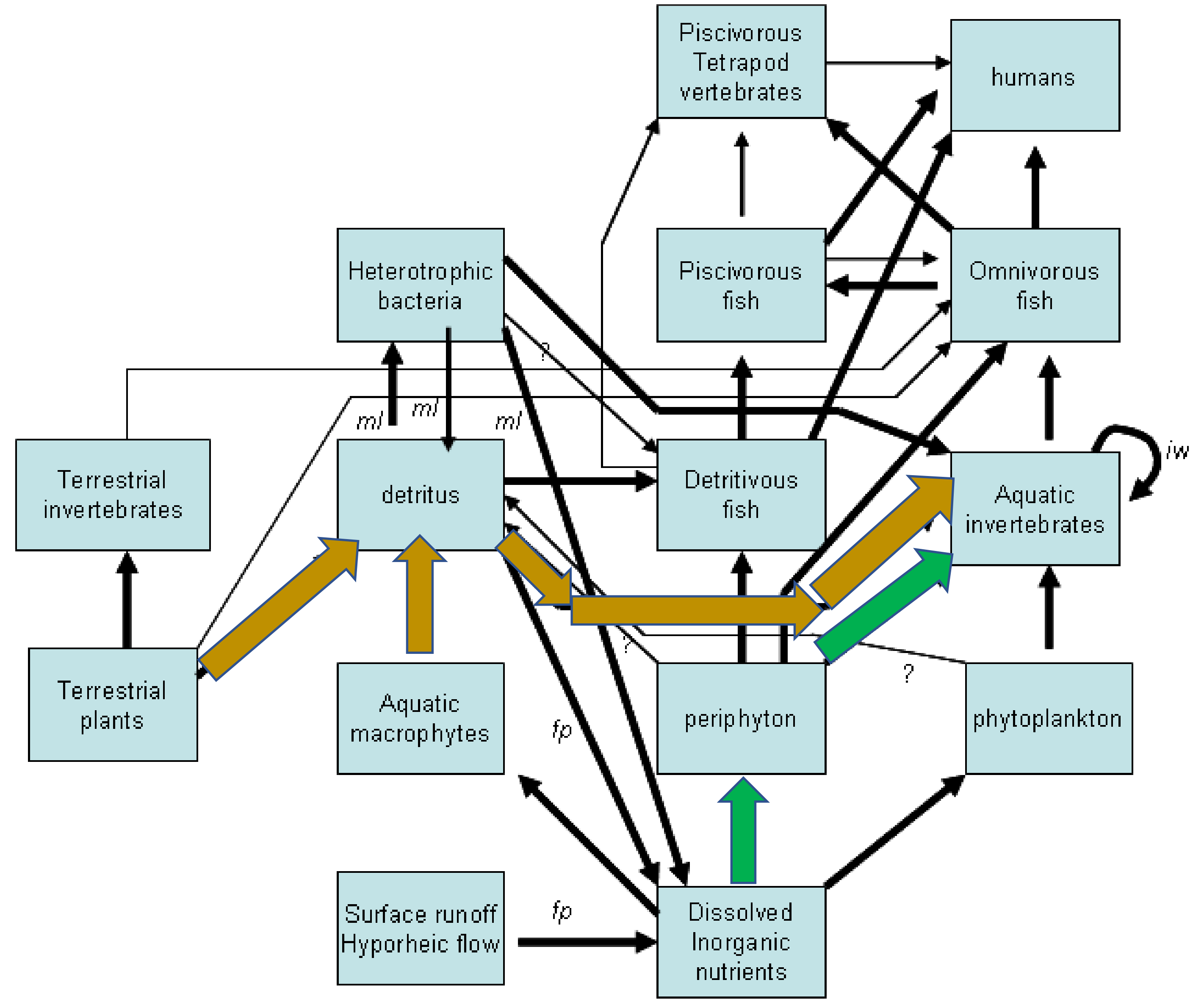


Figure 1: Generalised food web for floodplain-river ecosystems (adapted from Winemiller 2003)
Boxes are aggregate material pools and vectors represent consumer resource interactions with thick arrows representing dominant pathways (ml= microbial loop path, fp = nutrient pathways enhanced by flood pulses, iw = invertebrate web having complex trophic structure involving invertebrates and ? = poorly quantified pathways).

Ohio University Monitoring

- Water storage/discharge during precipitation events
- Sediment retention
- Sediment and water chemistry (nutrients N and P)

- No evidence of excess N, P during restoration
- Periphyton responded more to stream size/light than restoration
- Macroinvertebrate biomass linked to periphyton

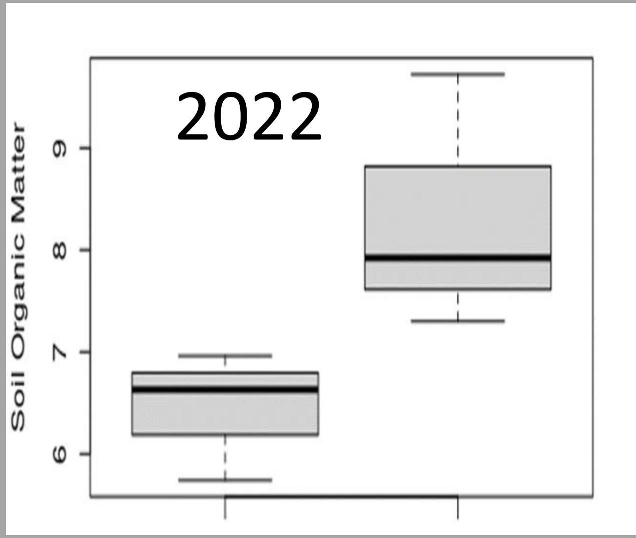
- Carbon accumulation and retention (terrestrial litter inputs, decomposition rates, soil organic matter)

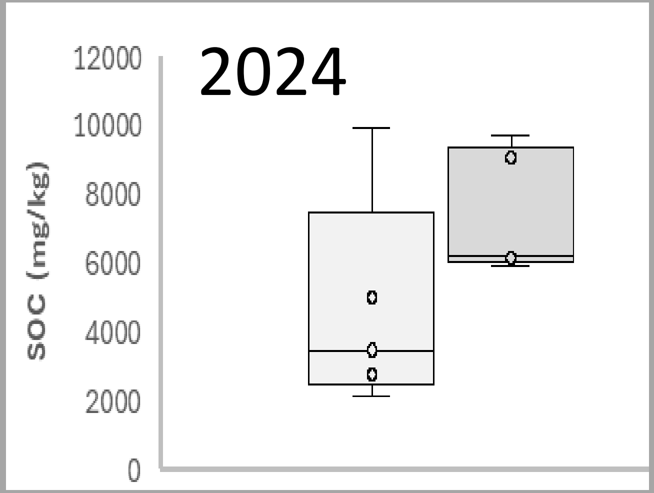
- Wet/dry cycles (frequency & duration)

Soil Organic Carbon

- Twenty cores per sample reach
- Within 3 m of stream channel
- Pooled and oven dried (95° C)
- Ground and sieved (500g of fine soil)
- 3 crucibles with 50g of soil per site
- Ashed at 400° C for 5 hours (Loss upon ignition)
- Mass Loss on Ignition = Soil Organic Carbon

Soil organic carbon higher at restored sites $p<0.05$





Unrestored Restored

Tatiana Burkett
MS 2022

Allochthonous (Leaf Litter) Inputs in smaller headwater catchments

- 5 baskets per site
- Random placement with in the 100m stretch of stream with a 3m buffer on each side of the stream
- Collected every 2 weeks (10/10, 10/24, 11/6, 11/19 and 12/3)
- Leaf litter dried

  and weighed

P<0.01

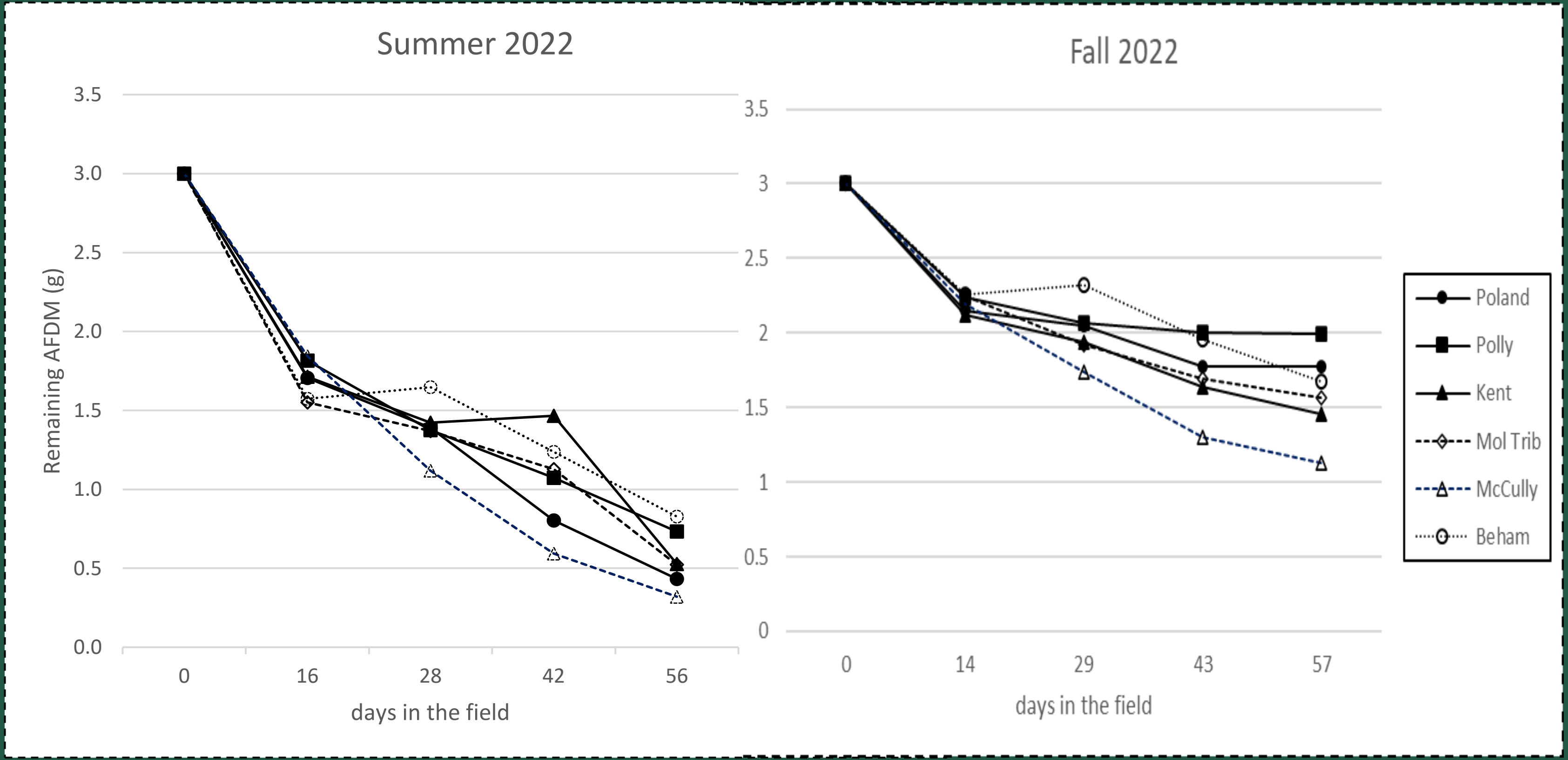
Samantha Holdaway,
Honors Thesis 2025

Nick Chilson, MS 2026

Leaf litter decomposition: a key functional process

Faster in summer than fall

No difference between restored/unrestored sites



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- Carbon accumulation and retention (terrestrial litter inputs, decomposition rates, soil organic matter)

- Wet/dry cycles (frequency & duration)

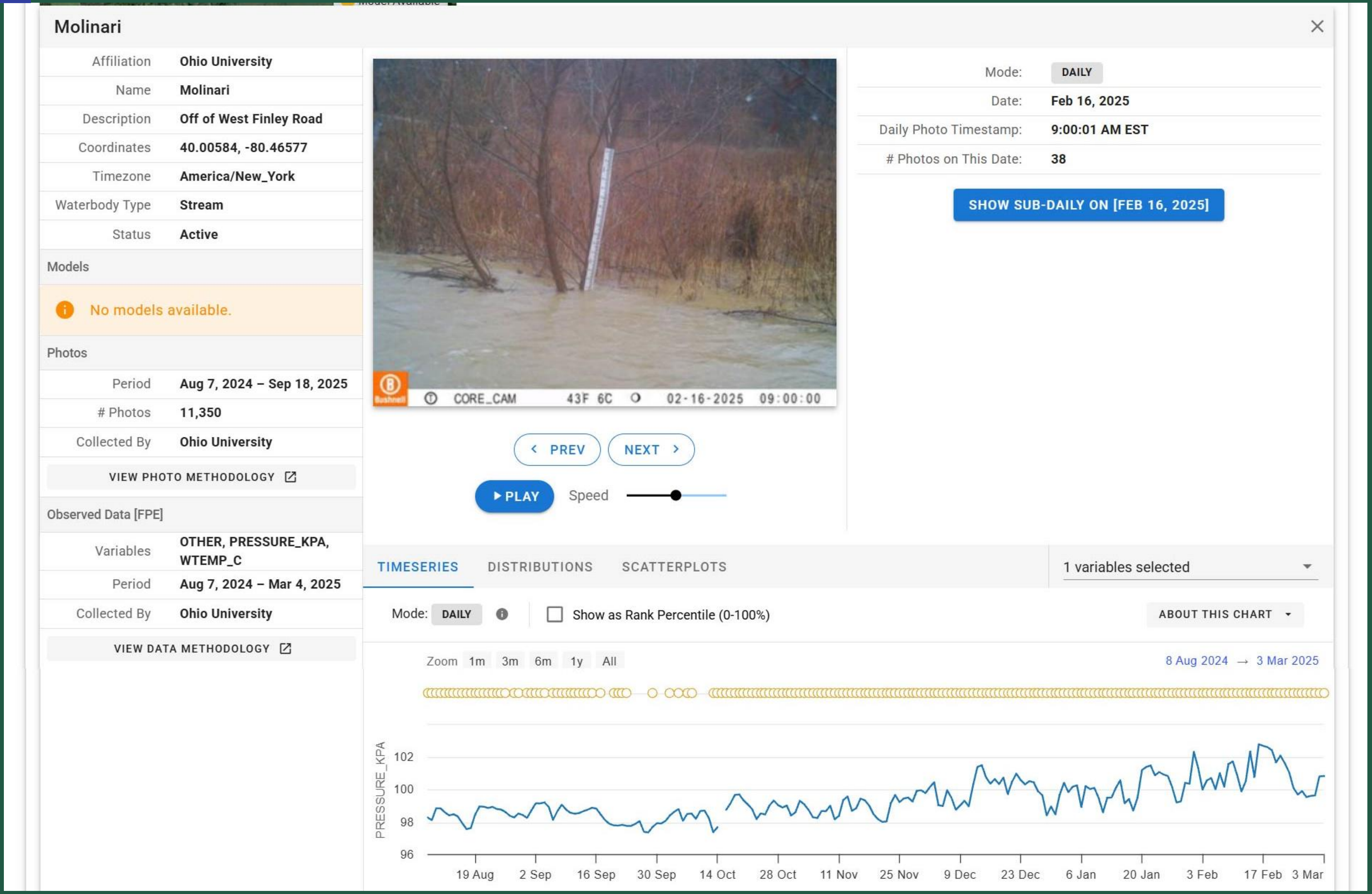
Can we better characterize spatial and temporal extent of inundation patterns ?

- Water depth and discharge – HOBO loggers
- Trail cam images of gages/water depth/ and wetted area
- STIC (wet/dry sensors)
- Soil moisture

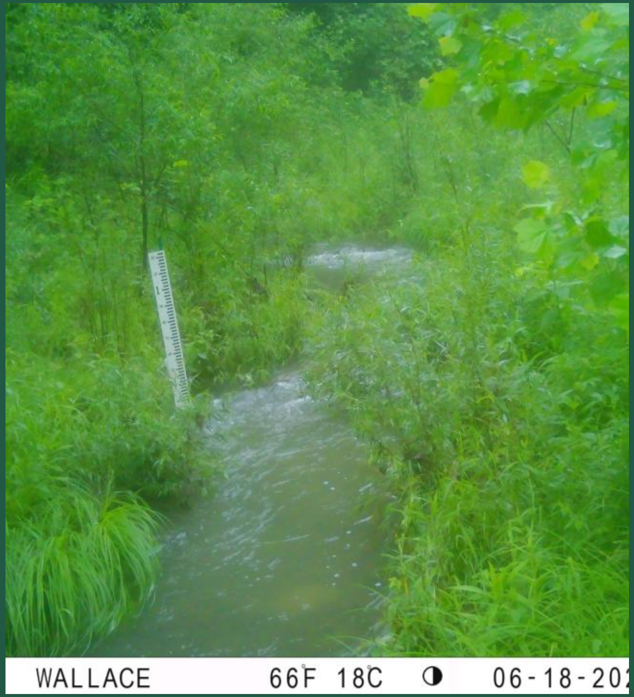
USGS
science for a changing world

Flow Photo Explorer v2.2.20

Synchronizes
Time-lapse photos
From trail cams
to water depth
loggers



But vegetation is a challenge at smaller streams



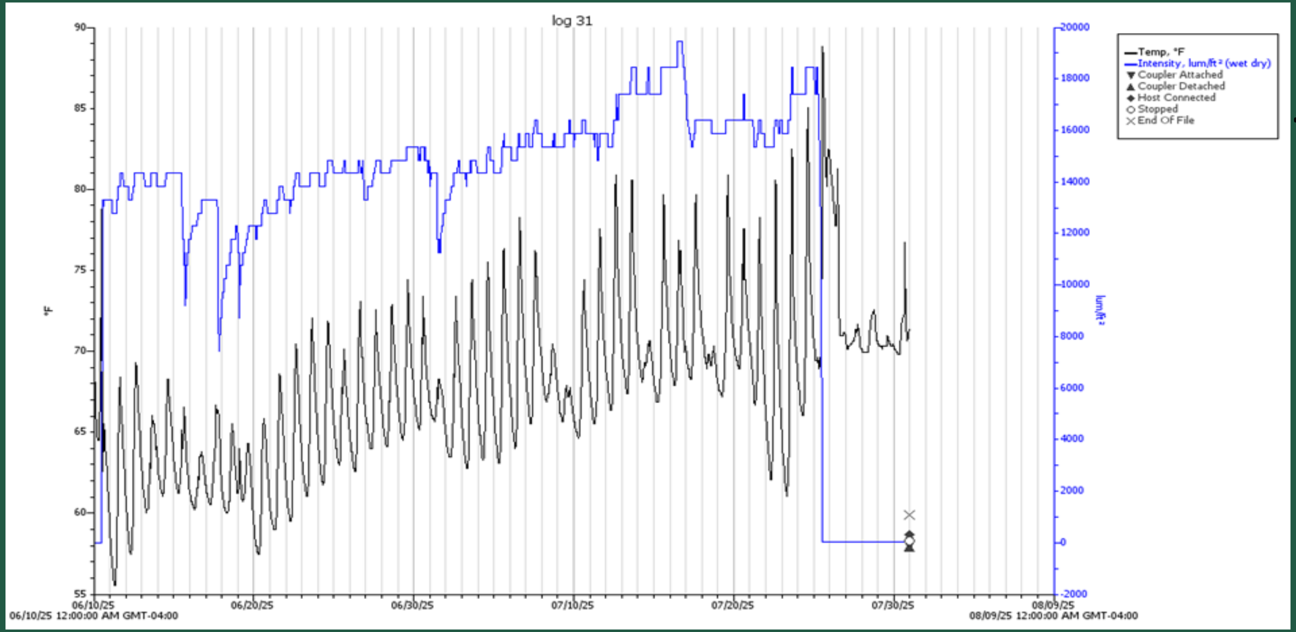
Wallace 6/10/2025 average flow
Gage: 16

Amphibian pools are full

Riparian (anastomosing) zone very wet
STIC sensor 'Wallace 12'

STIC (wet/dry) sensors

- Modified HOBO light/temperature pendants
- Light sensor replaced with conductivity leads
- Registers current when leads are submerged



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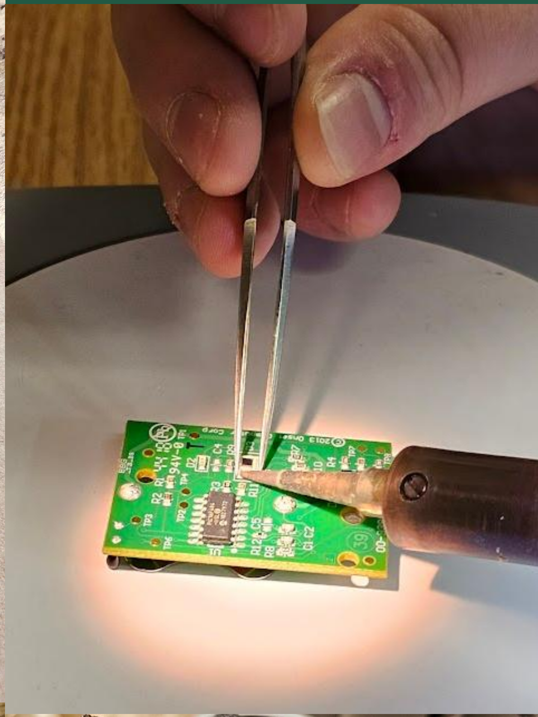
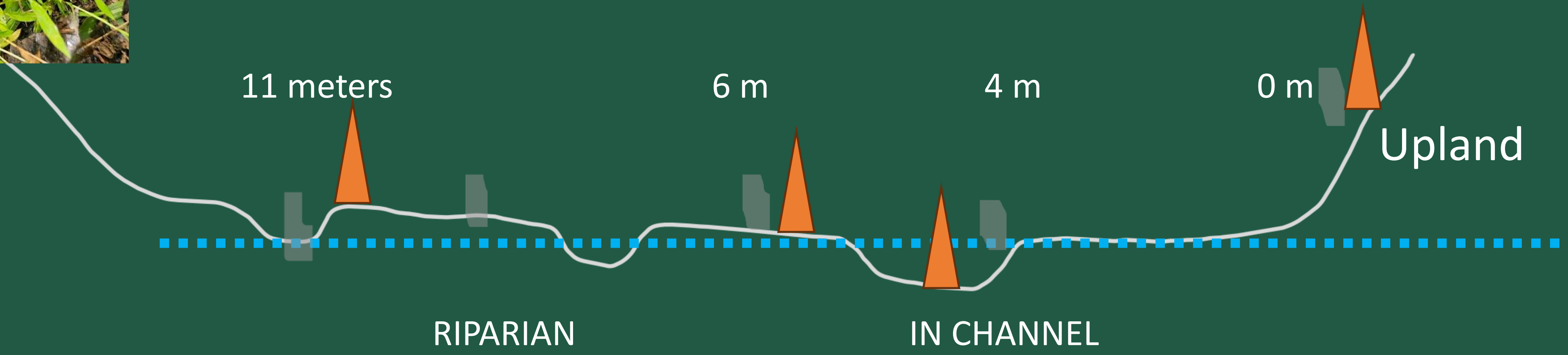


Undergraduates Ben Merkle, and Ranlyn Chowdury

STIC sensors arranged along transect perpendicular to flow

- UPLAND - always dry
- RIPARIAN - intermittent wet/dry
- IN CHANNEL - frequently wet



Has the quality of Robinson Fork improved?

North Dunkard Fork, Ryerson

Lebanik , Robinson Fork

2025 Aquatic Life Use Assessment Report (DRAFT)

WATER QUALITY MONITORING SECTION WATER QUALITY DIVISION BUREAU OF CLEAN WATER DEPARTMENT OF ENVIRONMENTAL PROTECTION

(Prepared by Megan Monteleone)

Based in part on:

Macroinvertebrates by DEP in 2021 at 12 stations

Water chemistry by Ohio University from 2020-2024 at thirteen stations

Previously assessed in 2000

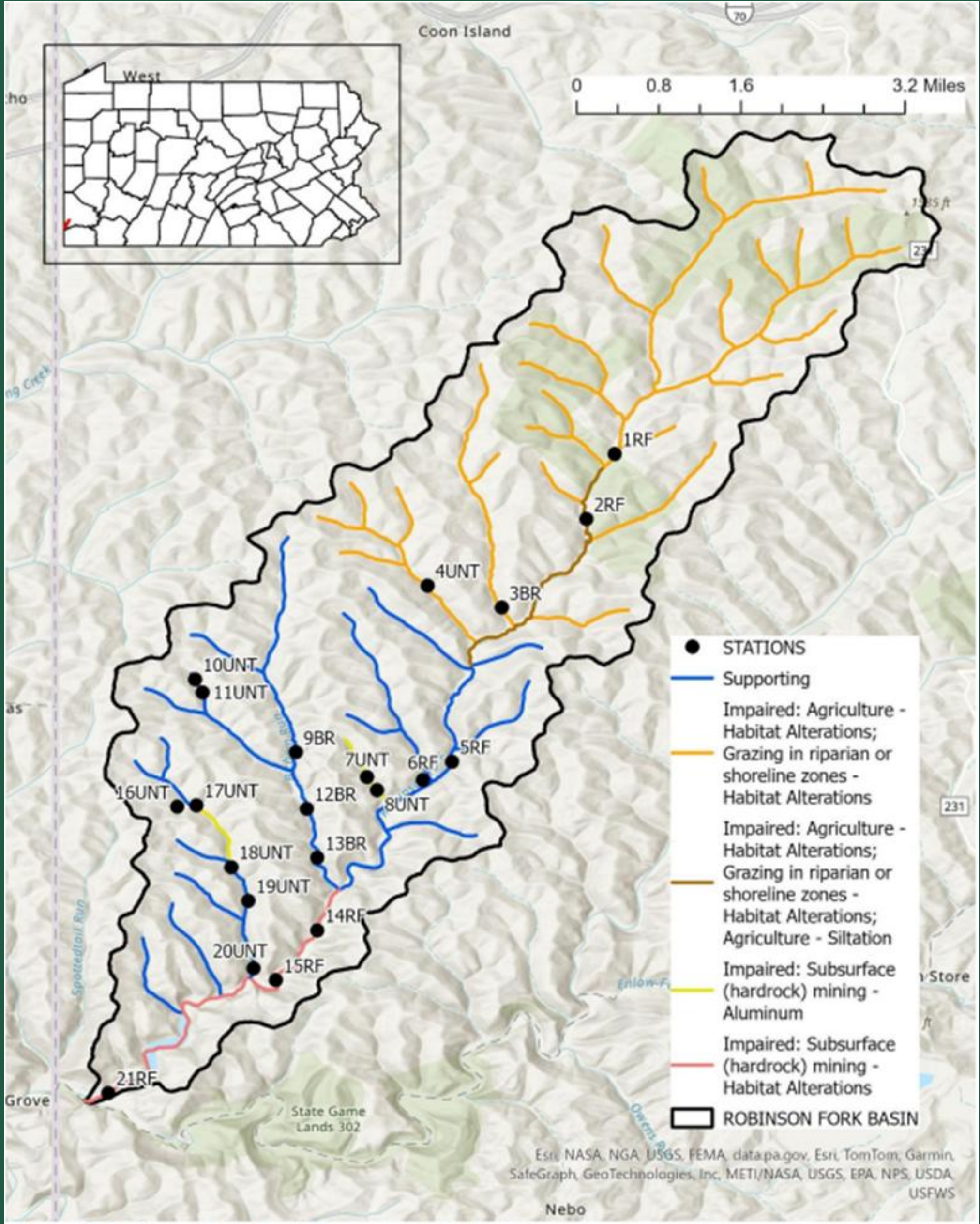


Figure 2. Robinson Fork Basin Assessment Delineations.

2025 Aquatic Life Use Assessment Report (DRAFT)

WATER QUALITY MONITORING SECTION WATER QUALITY DIVISION BUREAU OF CLEAN WATER DEPARTMENT OF ENVIRONMENTAL PROTECTION

(Prepared by Megan Monteleone)

2000 Impairments:

Robinson Fork basin from source to UNT 32674 – Grazing in riparian or shoreline zones, Habitat Alterations Organic Enrichment

Robinson Fork mainstem from UNT 32674 to mouth Organic Enrichment, Habitat Alterations from Subsurface (hardrock) mining, Siltation

Acknowledgements

- Special thanks to…
  - Pennsylvania Department of Environmental Protection
  - LandStudies and RES
  - Ephriam Zimmerman and Western Pennsylvania Conservancy
  - Voinovich School faculty/staff Nichole Kirchner, Nora Sullivan, Amy Mackey, Nicole Mazzone, Sebastian Teas, Jen Bowman

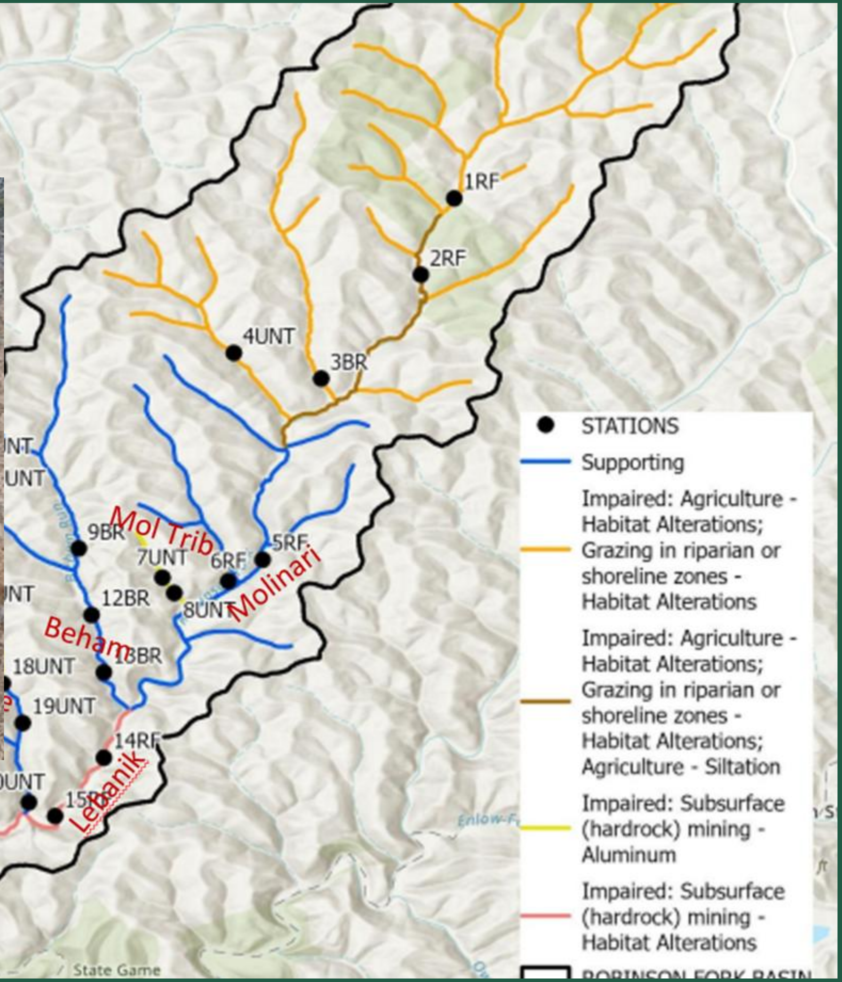
Graduate students:
Ashlee Widener MS
Annika Gurola MS
Tatiana Burkett MS
Kelly Love MS
Mohsin Khan PhD
Nick Chilson MS

Undergraduates:
Red Pazol
Samantha Holdaway
Brittney Seargent
Ben Merkle
Ranlyn Chowdury

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Western Pennsylvania Conservancy

OHIO UNIVERSITY
VOINOVICH SCHOOL OF LEADERSHIP AND PUBLIC AFFAIRS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4UNT
3BR
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Molinari
12BR
8UNT
Beham
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20UNT
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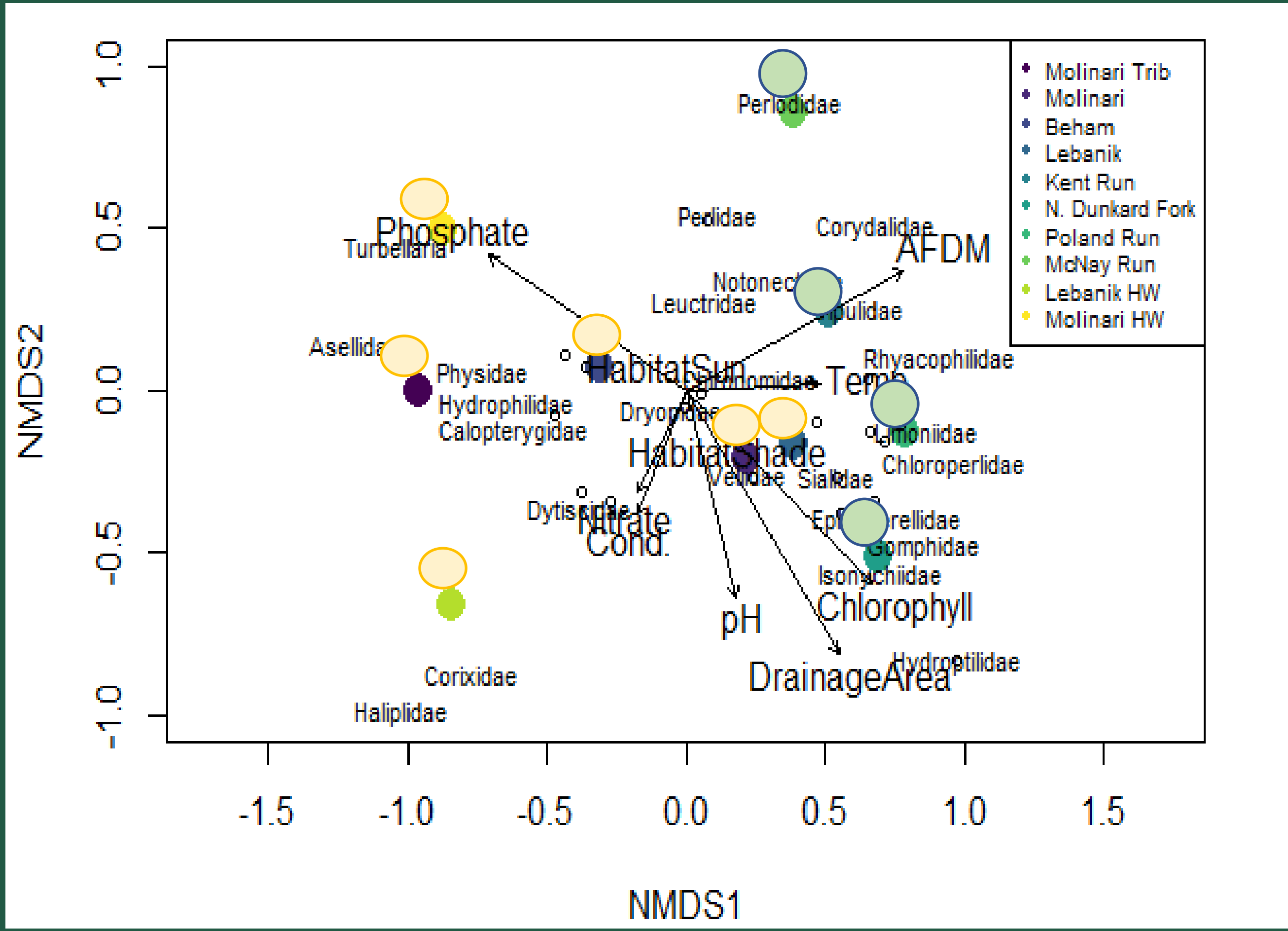
State Game
STATIONS
Supporting
Impaired: Agriculture - Habitat Alterations; Grazing in riparian or shoreline zones - Habitat Alterations
Impaired: Agriculture - Habitat Alterations; Grazing in riparian or shoreline zones - Habitat Alterations; Agriculture - Siltation
Impaired: Subsurface (hardrock) mining - Aluminum
Impaired: Subsurface (hardrock) mining - Habitat Alterations

Macroinvertebrate community in smaller channels differed between restored and unrestored sites





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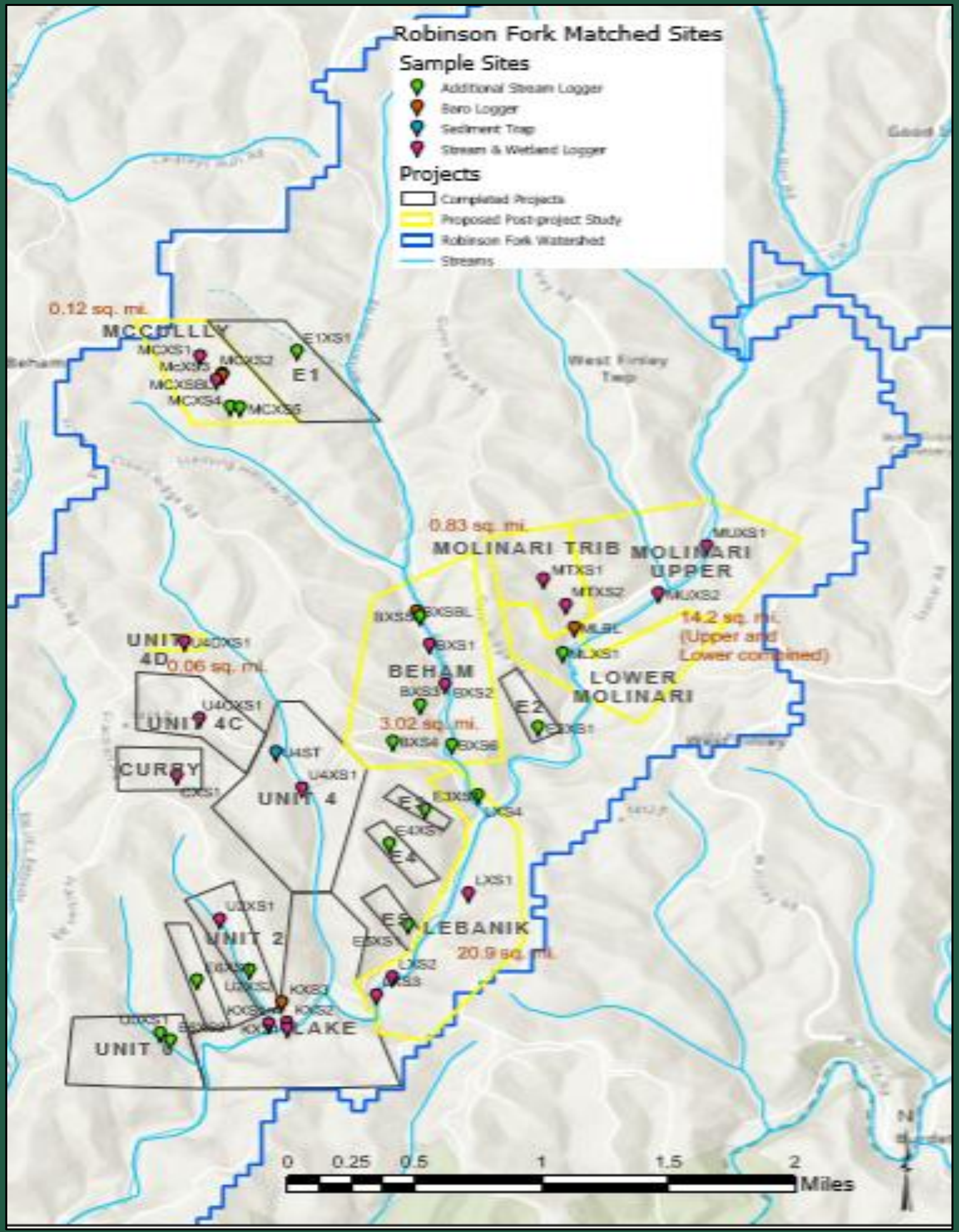
Family composition differed between restored stream-complexes (yellow) and unrestored forested (green) sites ($F_{1,8} = 2.7969$, $p = 0.033$) and stream size ($F_{2,7} = 3.0251$, $p = 0.012$)

6 restored sites (Robinson Fork)



4 forested, single channel (Ryerson)