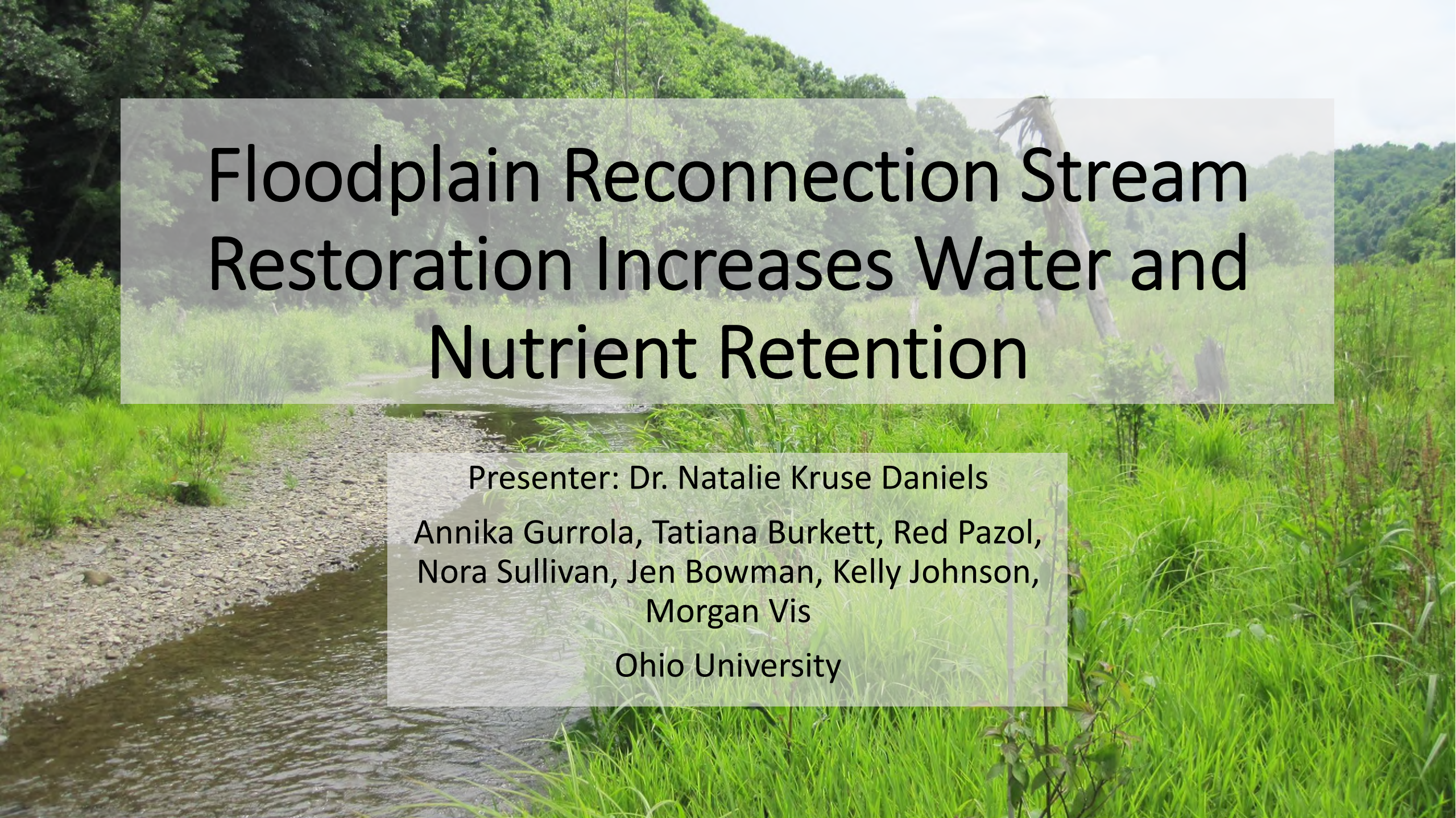


Floodplain Reconnection Stream Restoration Increases Water and Nutrient Retention

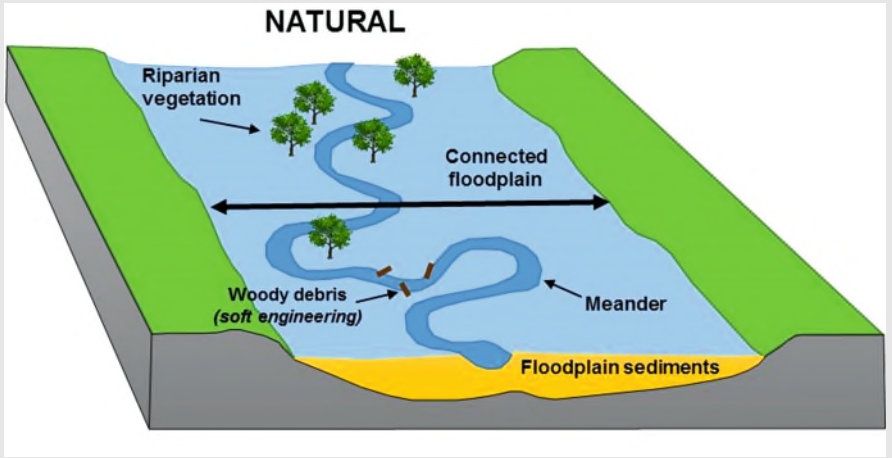
Presenter: Dr. Natalie Kruse Daniels

Annika Gurrola, Tatiana Burkett, Red Pazol, Nora Sullivan, Jen Bowman, Kelly Johnson, Morgan Vis

Ohio University

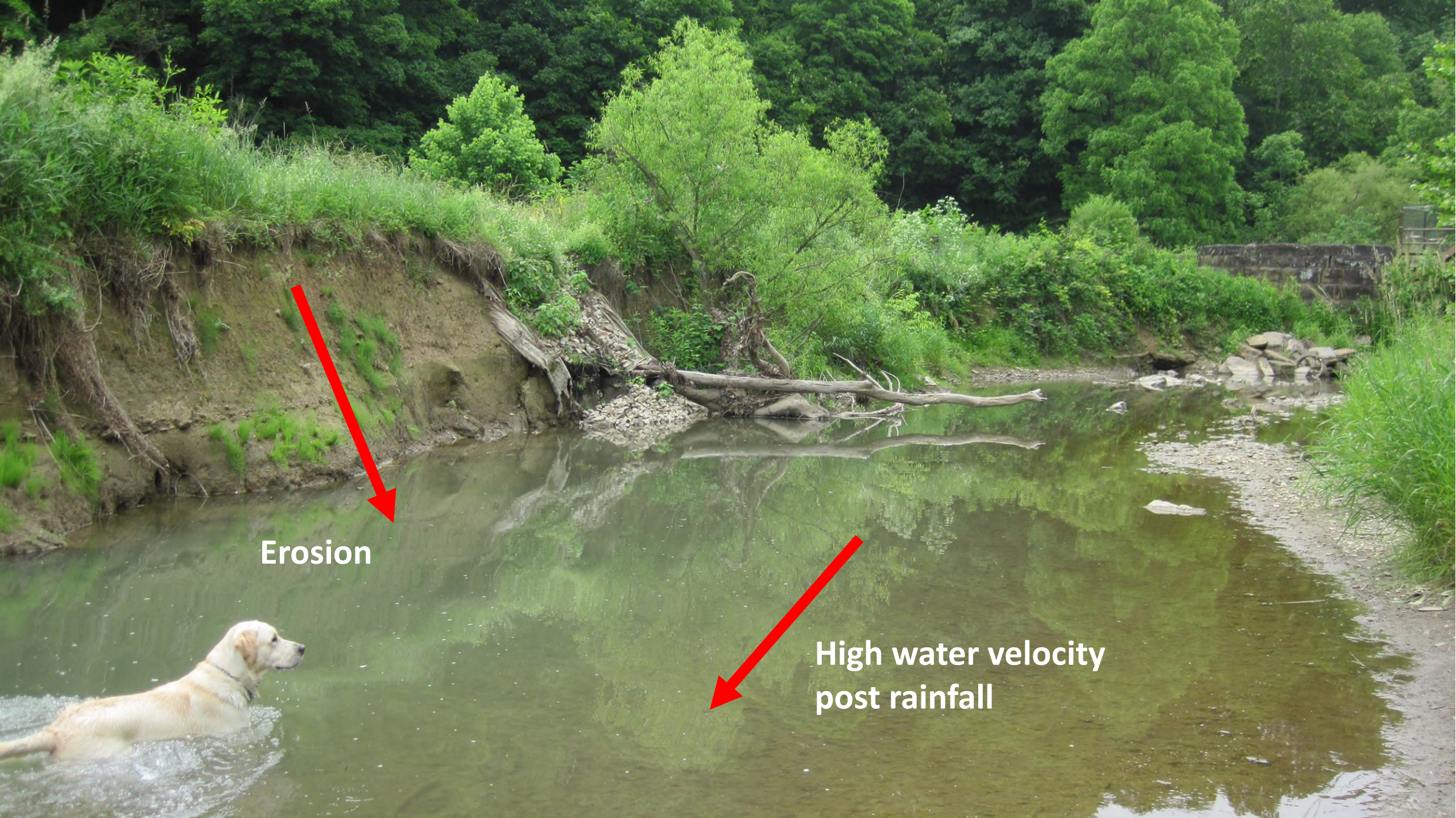
Floodplain Reconnection and Restoration

- Purpose
  - To establish a connection between stream channel and the surrounding terrestrial environment
- Why we're using it
  - Increased water storage
  - Increased nutrient storage
  - Increased resilience to flooding
  - Reduced erosion



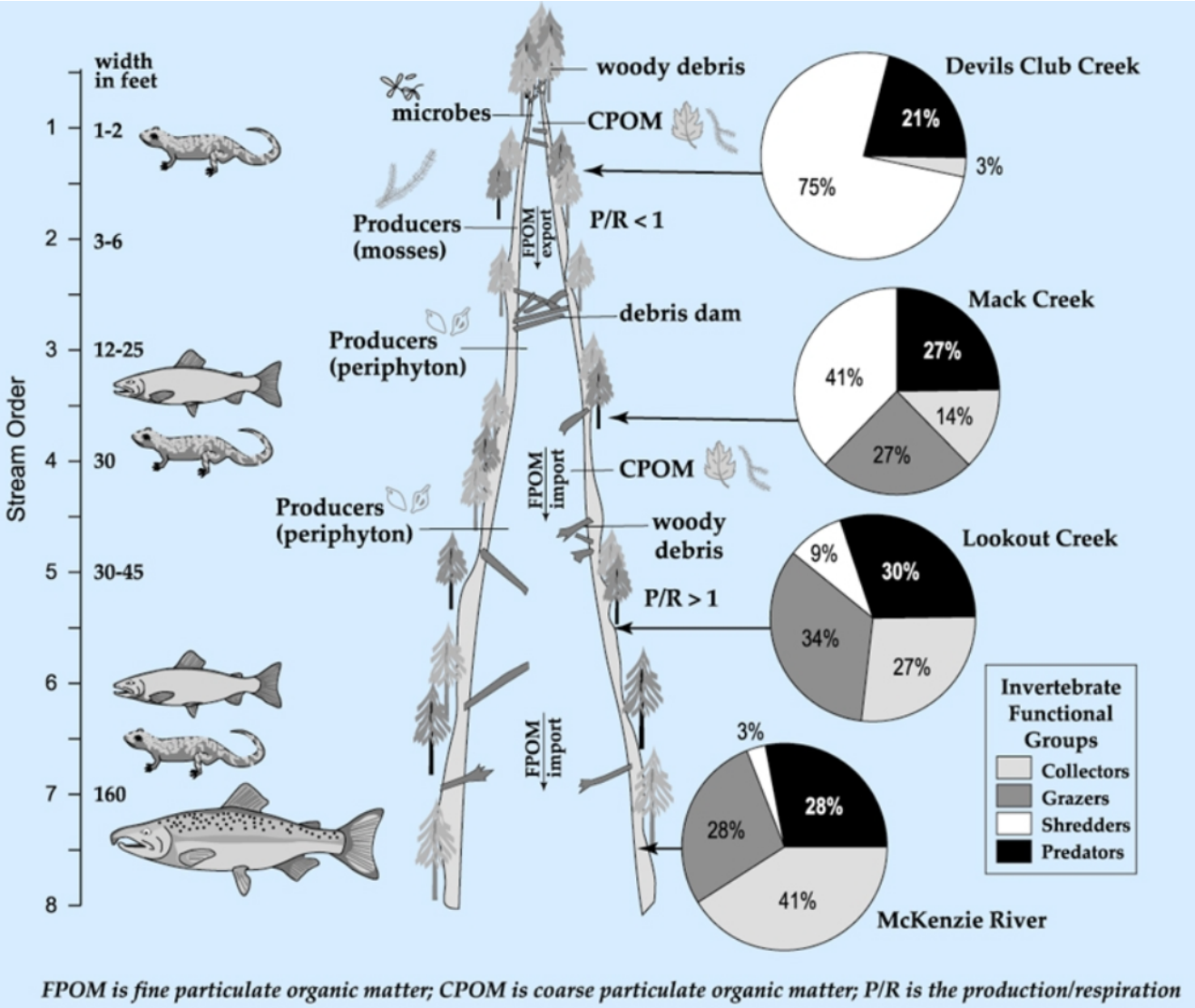
Cooper, Hiscock, & Lovett, 2019

Historically, streams in this area behaved this way.

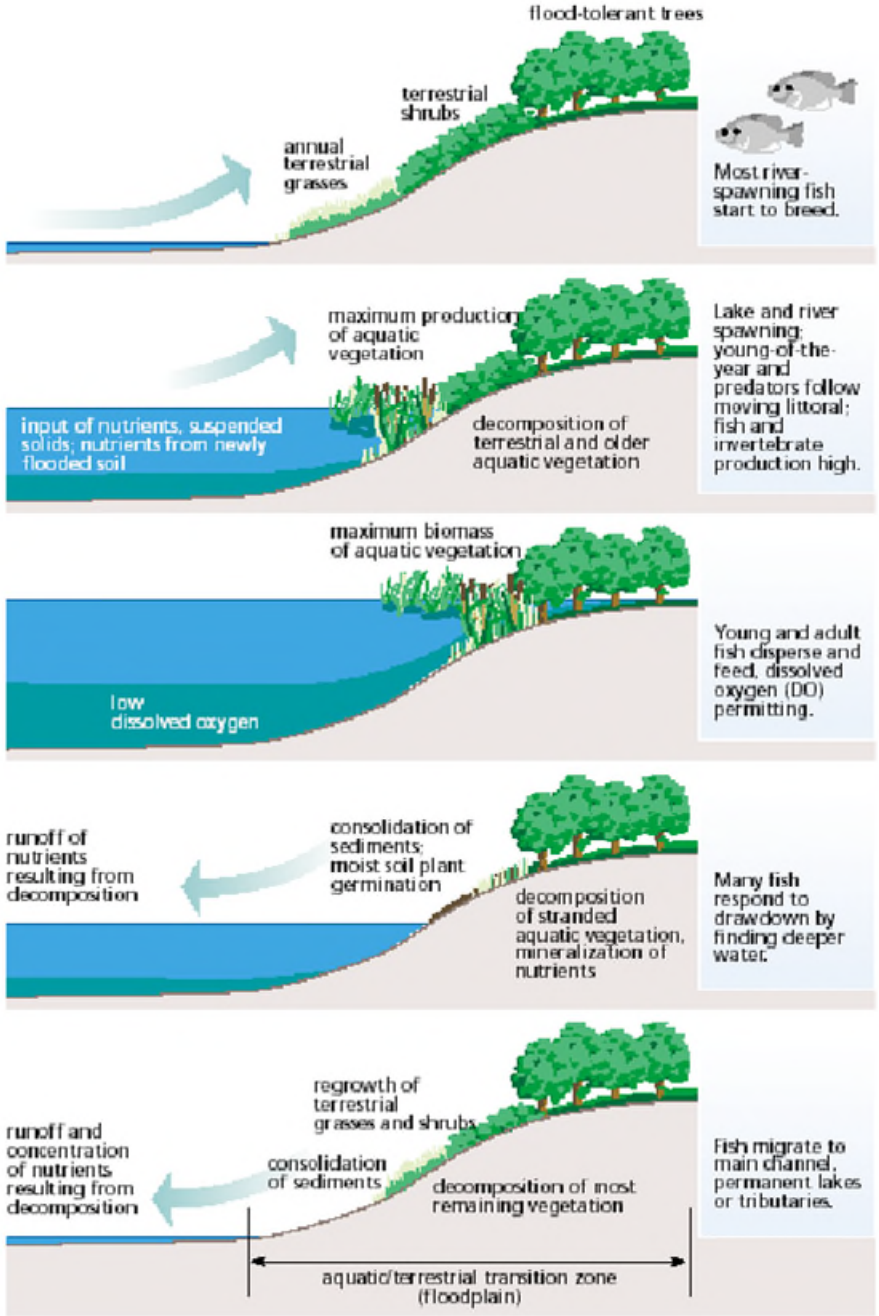

Erosion
High water velocity
post rainfall


Increased water storage
Reduced sediment flux into channel
Less SW nutrient export DS
Less sediment export DS

Ecosystem Concepts



FPOM is fine particulate organic matter; CPOM is coarse particulate organic matter; P/R is the production/respiration



Sediment Dynamics

Excess sediment can cause: turbid water, habitat destruction, lower biodiversity

Sediment can harbor excess nutrients

Velocity and volume of water moves sediment at different rates

Nutrient Cycling

Nutrients are vital for ecosystem health, but too much or too little can be harmful to biodiversity

Many different biotic and hydrologic factors control rates of nutrient retention, removal, and release

McMillan and Noe note that nutrient processing rates were primarily controlled by physical channel features

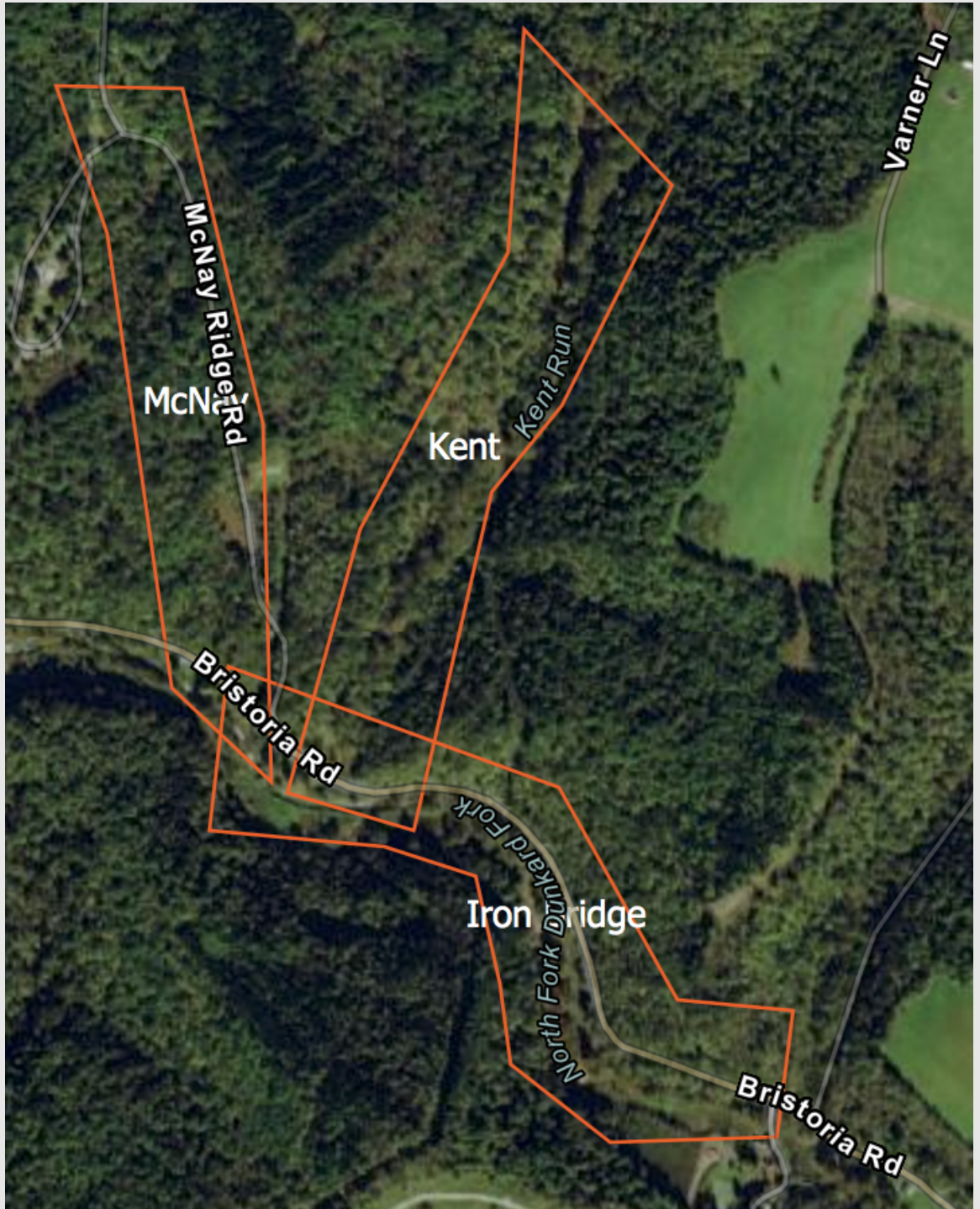
Simplified channel structure does not lead to a connected system like varied, natural streams do

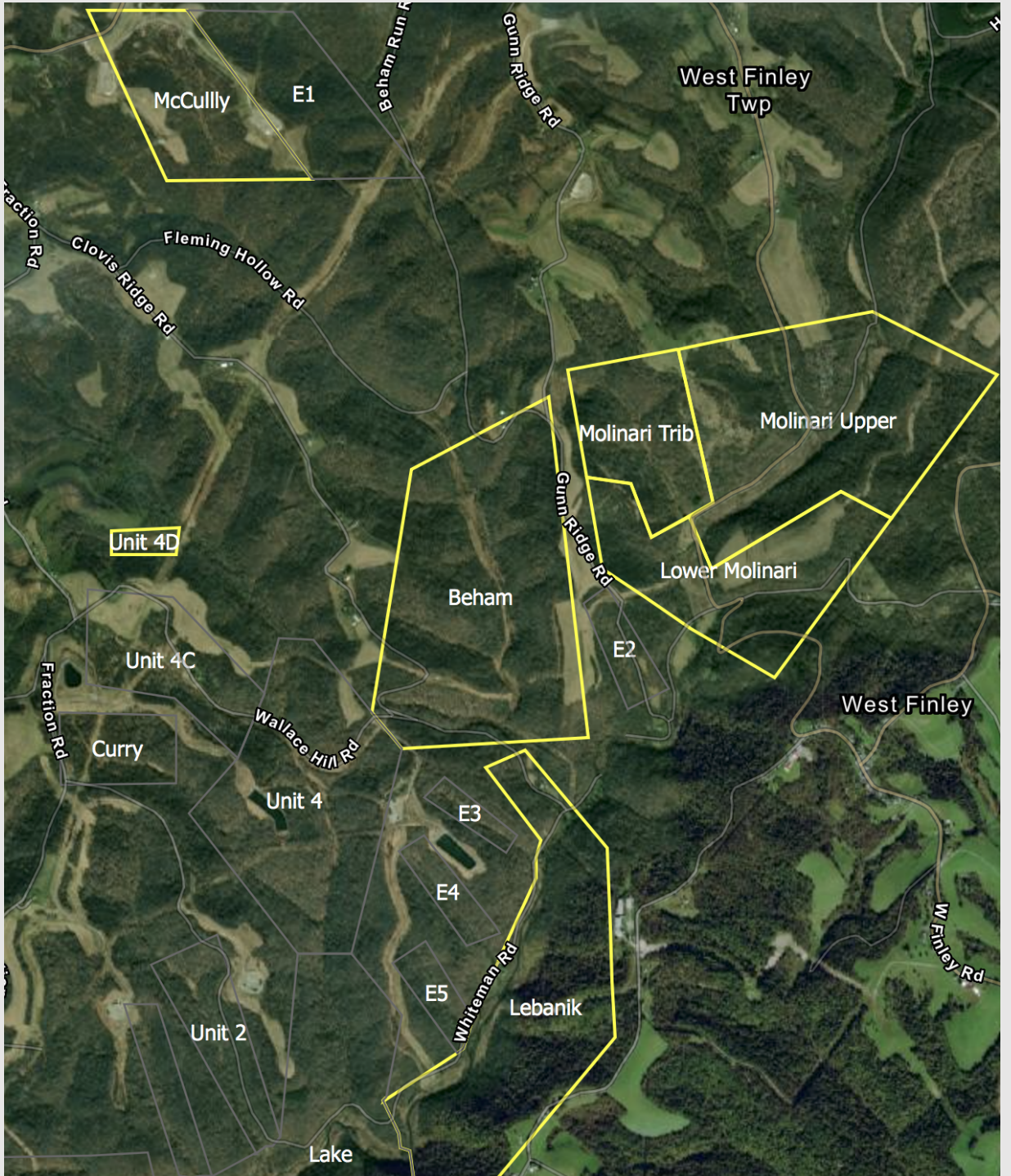
Objectives

- Characterize impact of the floodplain reconnection method by comparing the following characteristics of restored and unrestored sites
  - Water storage
  - Sediment retention and export
  - N and P retention and export in the sediment and surface water
  - Carbon accumulation and retention

Methods

- Flow and Water Level
- Water and Sediment Chemistry
  - Nutrients
  - Carbon
  - Pore Water
- Carbon Inputs


McNay Ridge Rd
McNay
Kent
Kent Run
Varner Ln
Bristoria Rd
Iron Bridge
North Fork Dunkard Fork
Bristoria Rd


McCullly
E1
Beham Run Rd
Gunn Ridge Rd
West Finley Twp
Fraction Rd
Clovis Ridge Rd
Fleming Hollow Rd
Molinari Trib
Molinari Upper
Unit 4D
Gunn Ridge Rd
Lower Molinari
Beham
E2
Unit 4C
Fraction Rd
Curry
Wallace Hill Rd
West Finley
Unit 4
E3
E4
W Finley Rd
Whiteman Rd
E5
Lebanik
Unit 2
Lake

Study Sites

Primary headwaters

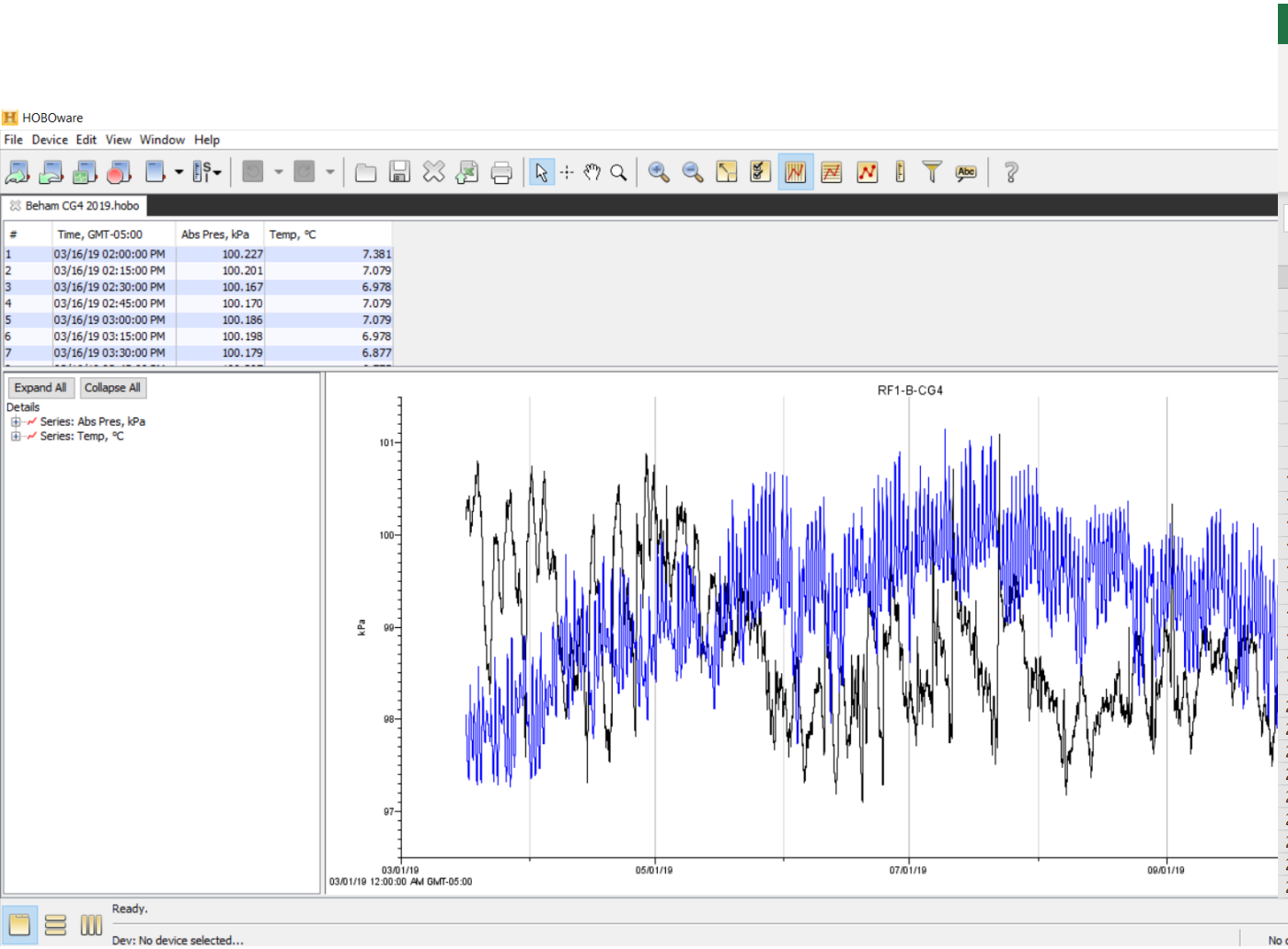
Headwaters

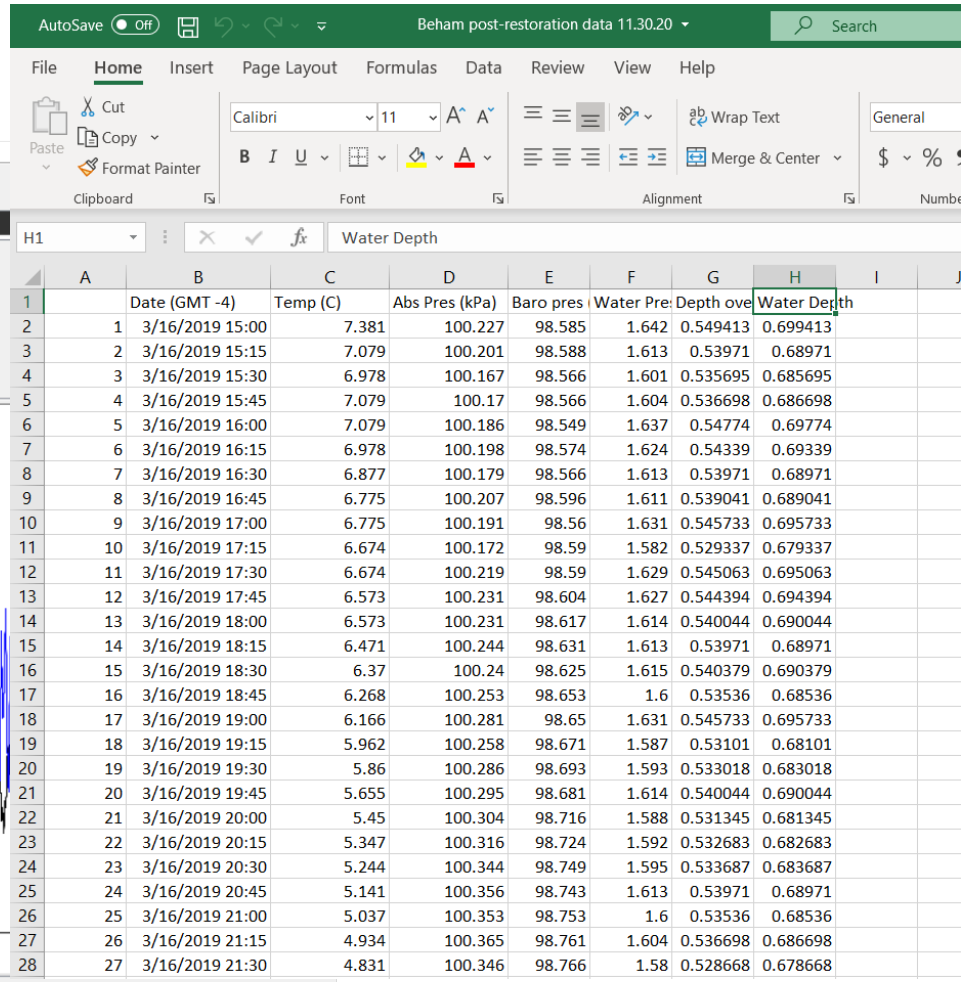
Wadeable

Flow and Water Storage

- Channel flow with flume, SonTek, or pygmy
- Salt tracing to measure transient flow with YSI meter
- Water storage is difference between salt tracing flow (includes vadose zone) and channel flow

Water Level Monitoring





	A	B	C	D	E	F	G	H
1		Date (GMT -4)	Temp (C)	Abs Pres (kPa)	Baro pres	Water Pre	Depth ove	Water Depth
2	1	3/16/2019 15:00	7.381	100.227	98.585	1.642	0.549413	0.699413
3	2	3/16/2019 15:15	7.079	100.201	98.588	1.613	0.53971	0.68971
4	3	3/16/2019 15:30	6.978	100.167	98.566	1.601	0.535695	0.685695
5	4	3/16/2019 15:45	7.079	100.17	98.566	1.604	0.536698	0.686698
6	5	3/16/2019 16:00	7.079	100.186	98.549	1.637	0.54774	0.69774
7	6	3/16/2019 16:15	6.978	100.198	98.574	1.624	0.54339	0.69339
8	7	3/16/2019 16:30	6.877	100.179	98.566	1.613	0.53971	0.68971
9	8	3/16/2019 16:45	6.775	100.207	98.596	1.611	0.539041	0.689041
10	9	3/16/2019 17:00	6.775	100.191	98.56	1.631	0.545733	0.695733
11	10	3/16/2019 17:15	6.674	100.172	98.59	1.582	0.529337	0.679337
12	11	3/16/2019 17:30	6.674	100.219	98.59	1.629	0.545063	0.695063
13	12	3/16/2019 17:45	6.573	100.231	98.604	1.627	0.544394	0.694394
14	13	3/16/2019 18:00	6.573	100.231	98.617	1.614	0.540044	0.690044
15	14	3/16/2019 18:15	6.471	100.244	98.631	1.613	0.53971	0.68971
16	15	3/16/2019 18:30	6.37	100.24	98.625	1.615	0.540379	0.690379
17	16	3/16/2019 18:45	6.268	100.253	98.653	1.6	0.53536	0.68536
18	17	3/16/2019 19:00	6.166	100.281	98.65	1.631	0.545733	0.695733
19	18	3/16/2019 19:15	5.962	100.258	98.671	1.587	0.53101	0.68101
20	19	3/16/2019 19:30	5.86	100.286	98.693	1.593	0.533018	0.683018
21	20	3/16/2019 19:45	5.655	100.295	98.681	1.614	0.540044	0.690044
22	21	3/16/2019 20:00	5.45	100.304	98.716	1.588	0.531345	0.681345
23	22	3/16/2019 20:15	5.347	100.316	98.724	1.592	0.532683	0.682683
24	23	3/16/2019 20:30	5.244	100.344	98.749	1.595	0.533687	0.683687
25	24	3/16/2019 20:45	5.141	100.356	98.743	1.613	0.53971	0.68971
26	25	3/16/2019 21:00	5.037	100.353	98.753	1.6	0.53536	0.68536
27	26	3/16/2019 21:15	4.934	100.365	98.761	1.604	0.536698	0.686698
28	27	3/16/2019 21:30	4.831	100.346	98.766	1.58	0.528668	0.678668

Water Chemistry

- Samples analyzed for TSS, N, and P
- Myron Ultrameter used for field parameters

Total Organic Carbon
Summer & Fall 2022

- Collection: glass 40 mL vials
- Hach Test 'n Tube method
  - Analytical triplicate
  - 10 mL of sample combined with 0.4 mL of buffer solution and spun for 10 minutes
  - Sample digested for 2 hours using a block digester
- TOC measured using DR2800 spectrophotometer

Sediment Dynamics

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

https://www.soilmoisture.com/MICRO-RHIZON-SAMPLER-10-CM-LONG-2.5-MM-DIAM-Set-of-1/

Pore Water

- Measured dissolved N and P concentrations in upper layer
- Micro-rhizon samplers collected water from upper soil layer
- Soil temp, pH, DO, ORP, conductivity, moisture content determined by Orion meter

Large Woody Debris Index

- 100 m stretch
- Dead piece of wood that is at least 10 cm in diameter and at least one-meter long (more than 3 pieces together is considered a debris dam)

Data collected for index for individuals:

Length/bankfull width

Diameter (cm)

Location

Type (bridge, ramp, buried, and submerged)

Structure (amount of branches/roots attached)

Stability (potential mobility)

Orientation (degrees)

Leaf Litter Input

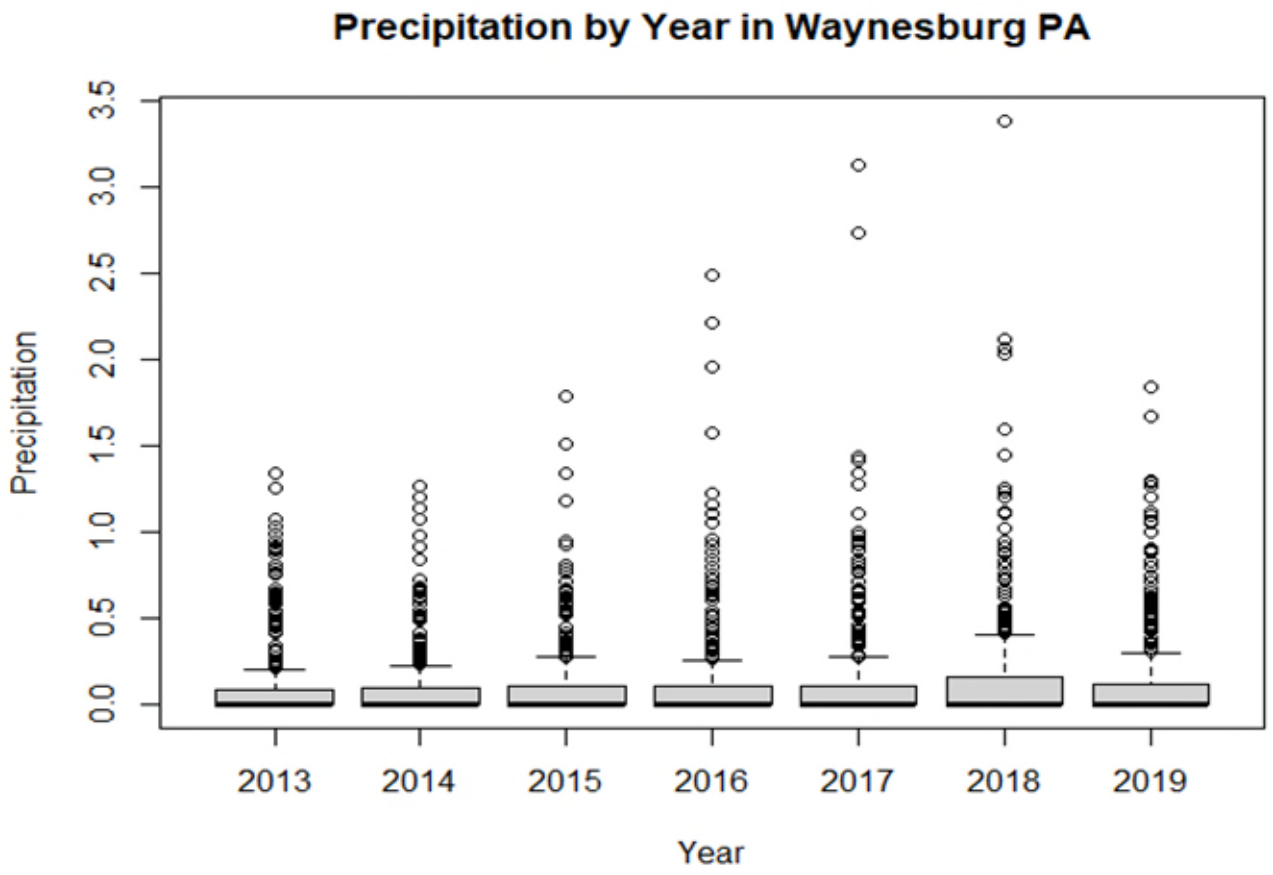
- 5 baskets per site
- Random placement with in the 100m stretch of stream with a 3m buffer on each side of the stream
- Collected every 2 weeks starting 10/10
- Contents dried and weighed after a minimum of 10 days
- Pictures taken after drying on 10/24, 11/6, 11/19 and 12/3

Soil Organic Matter

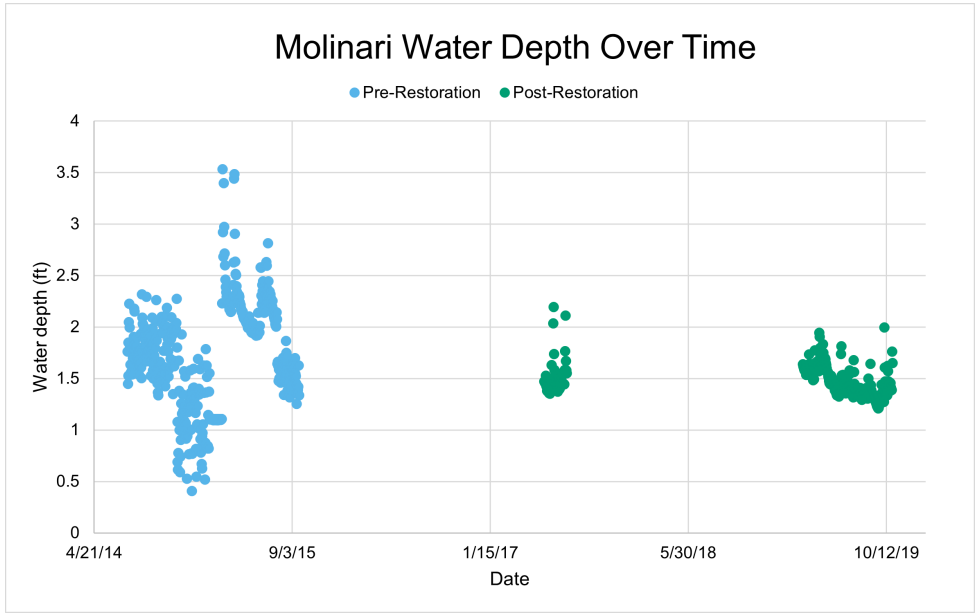
- Soil dried at 95 Celsius
- Ground and sieved until each site had 500g of fine soil
- 3 crucibles with 50g of soil were used per site
- Burned at 400 Celsius for 3 hours
- The Loss on Ignition weight was then taken

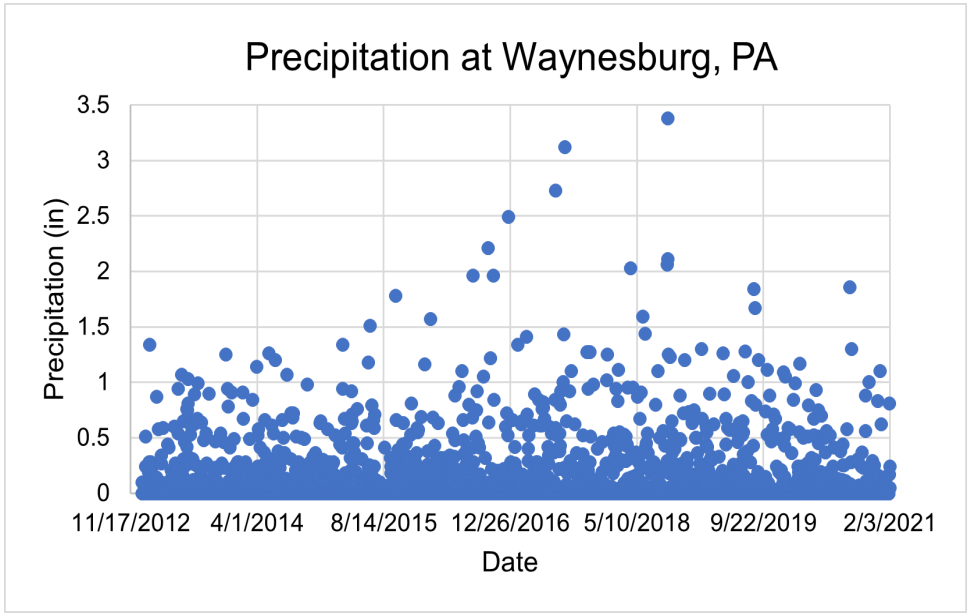
Results

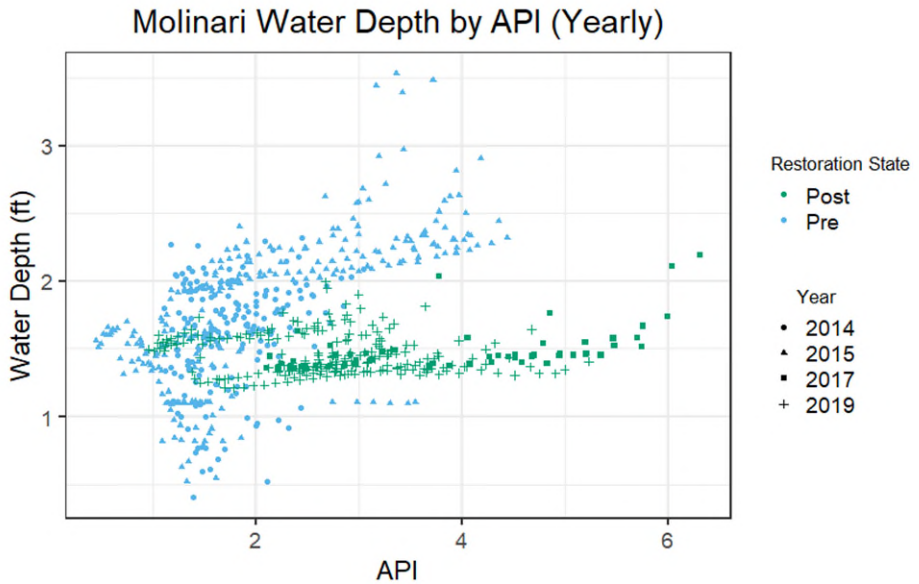
- Rainfall, Flow, Water Storage
- Nutrients in Water, Pore Water, and Sediment
- Carbon Input and Storage

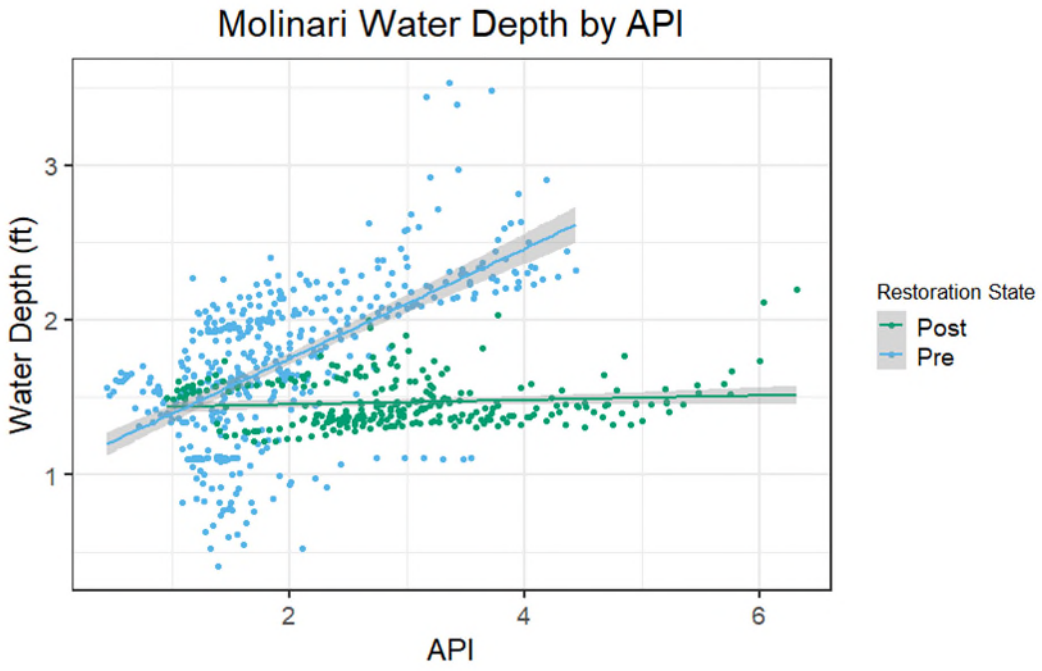


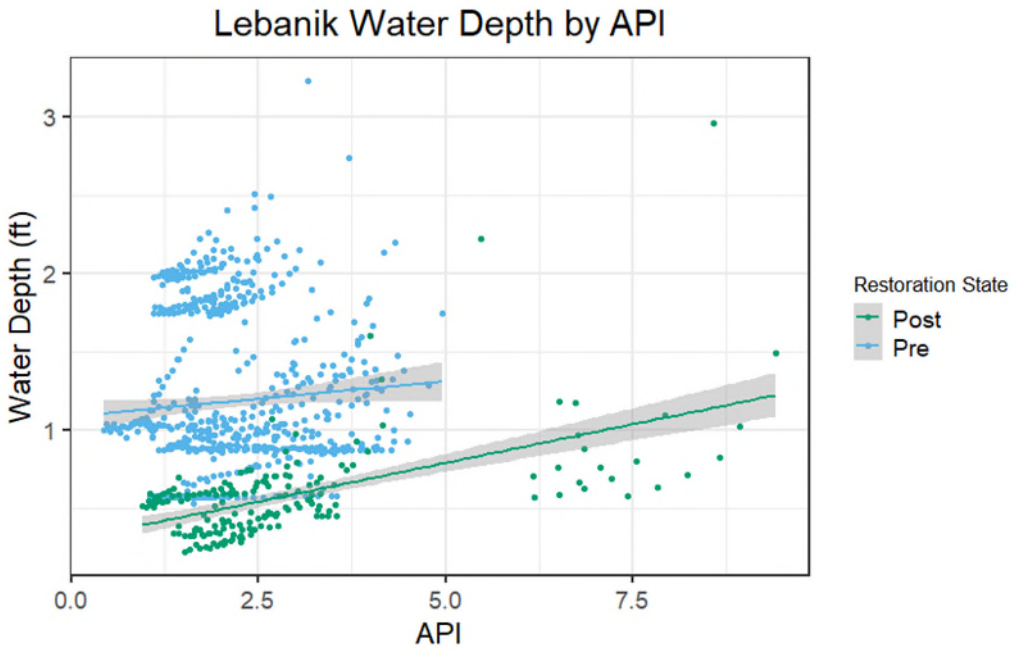
Only significant difference between precipitation in 2014 and 2018


Molinari Water Depth Over Time
Pre-Restoration
Post-Restoration
Water depth (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
4/21/14
9/3/15
1/15/17
5/30/18
10/12/19
Date


Precipitation at Waynesburg, PA
Precipitation (in)
0
0.5
1
1.5
2
2.5
3
3.5
11/17/2012
4/1/2014
8/14/2015
12/26/2016
5/10/2018
9/22/2019
2/3/2021
Date


Molinari Water Depth by API (Yearly)
Water Depth (ft)
1
2
3
2
4
6
API
Restoration State
Post
Pre
Year
2014
2015
2017
2019

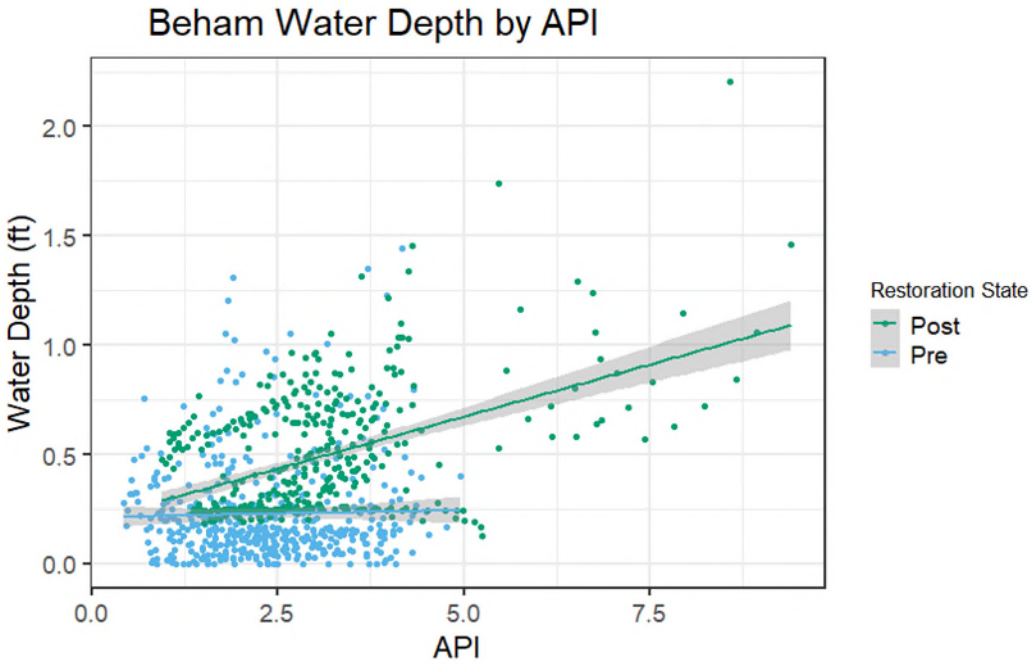


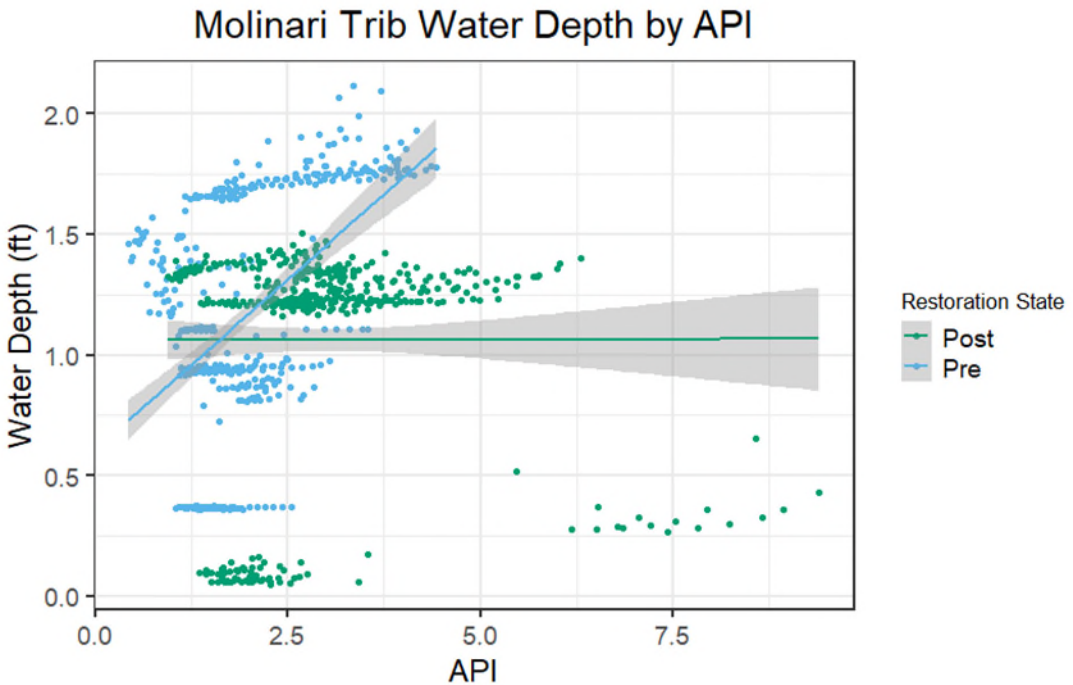


Wadeable streams

Molinari – Slope decreased post-restoration. This means that water level stays fairly consistent over a wide range of wetness and is not influenced by periods of high precipitation nearly as much as it was pre-restoration.

Lebanik – Water level was lower post-restoration. Contrary to my hypothesis, behaves oppositely Molinari and the slope increases post-restoration, meaning that the water level was more influences by periods of high precipitation.

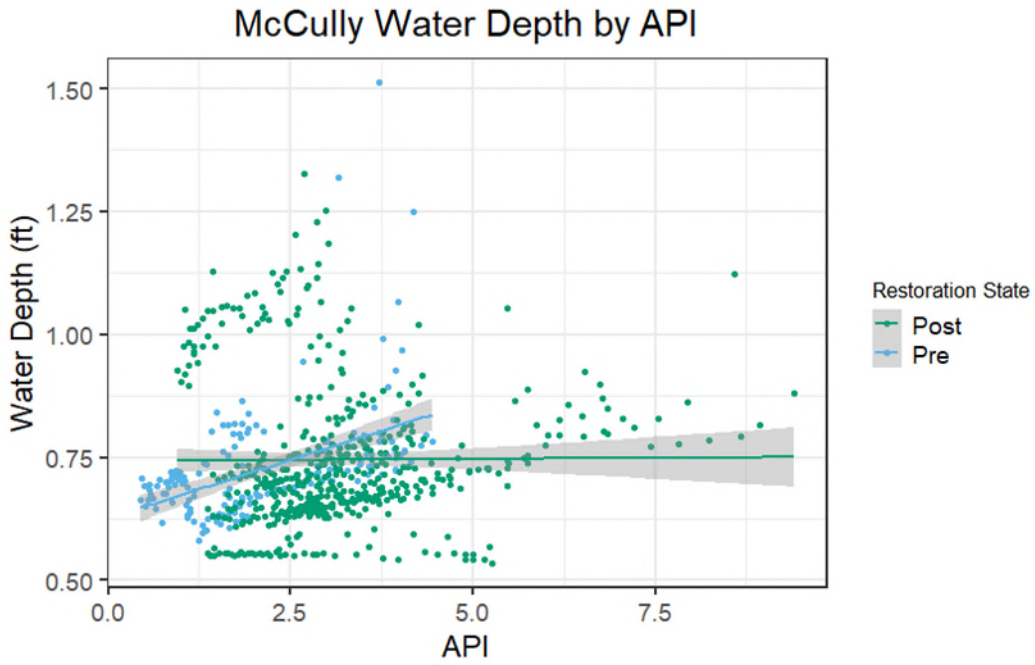


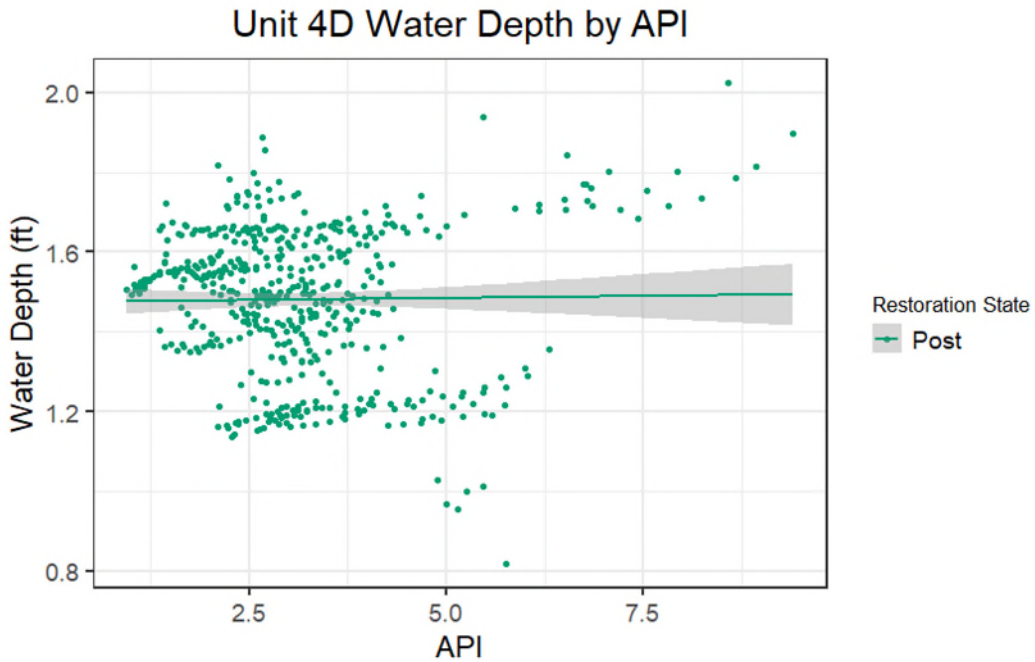


Headwater streams

Beham – Water level was higher post-restoration. Slope increased post-restoration.

Molinari Trib - Slope decreased post-restoration





Primary headwaters

McCulley – Slope decreased post-restoration

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

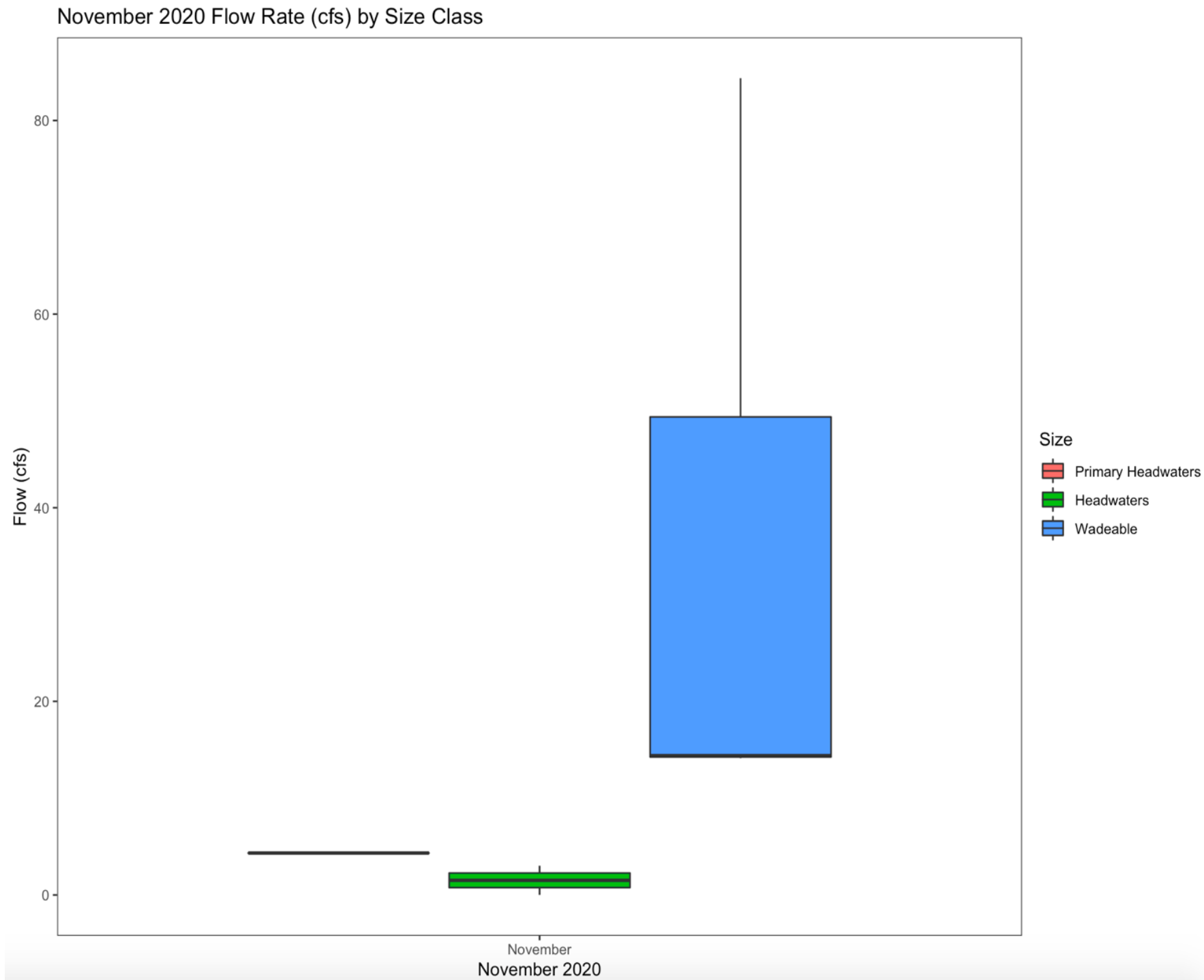
Flow

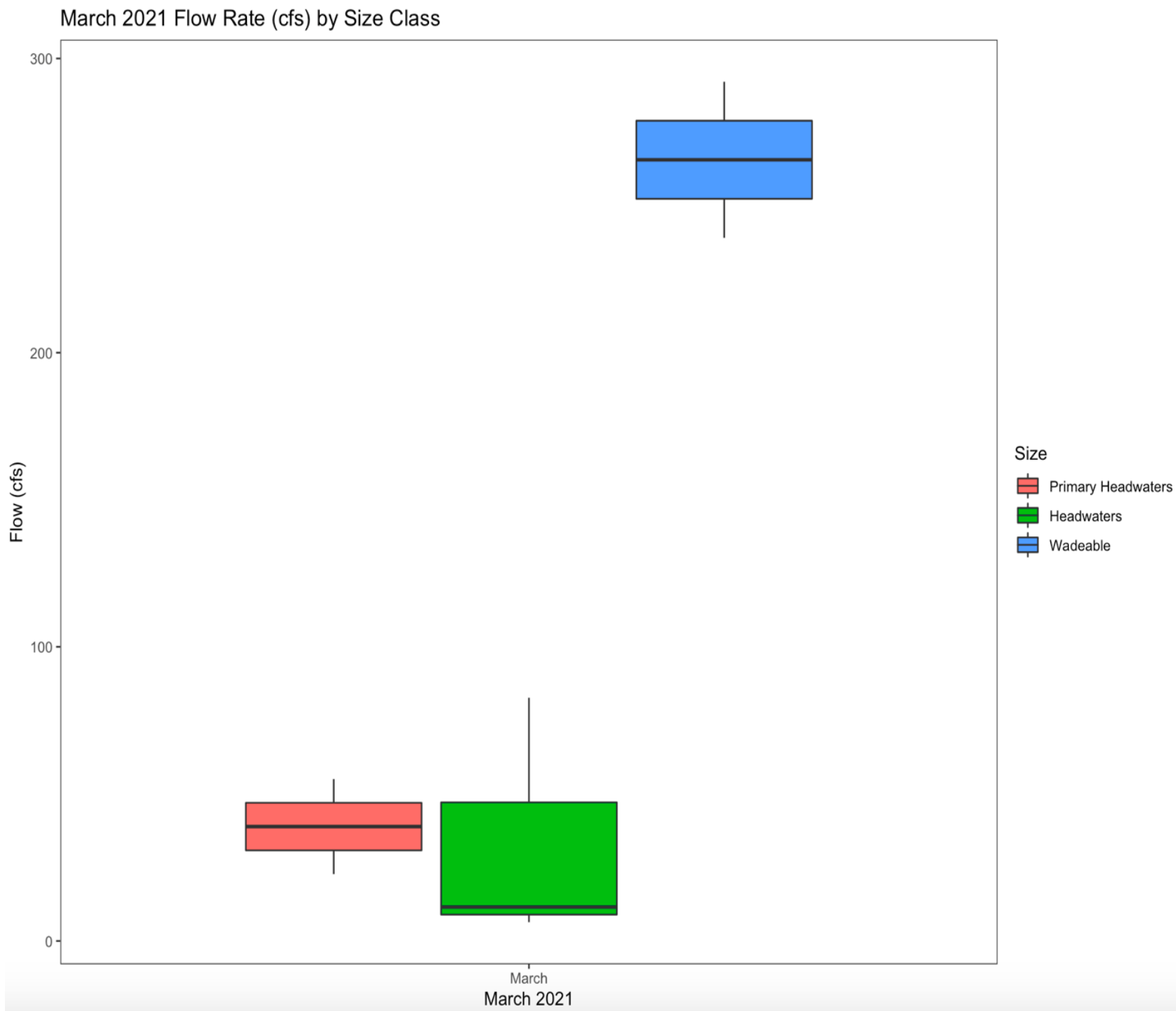
- Low flow: July 2020
- Base flow: November 2020
- High flow: March 2021

Antecedent Rainfall
0”
0.75”
1.2”

Not different by restoration status, different by size class

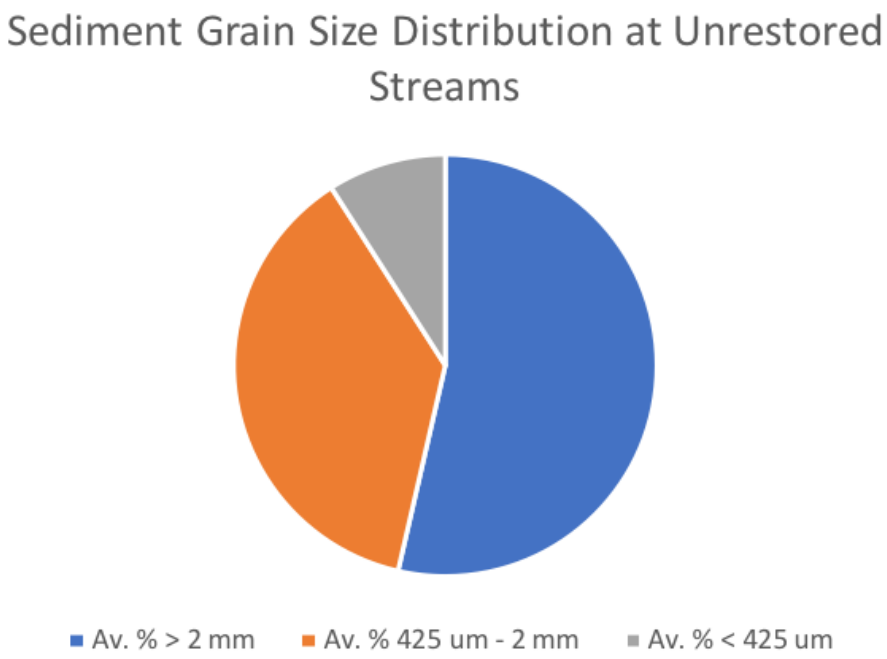

July 2020 Flow Rate (cfs) by Size Class
Flow (cfs)
0.2
0.1
0.0
July
July 2020
Size
Primary Headwaters
Headwaters
Wadeable

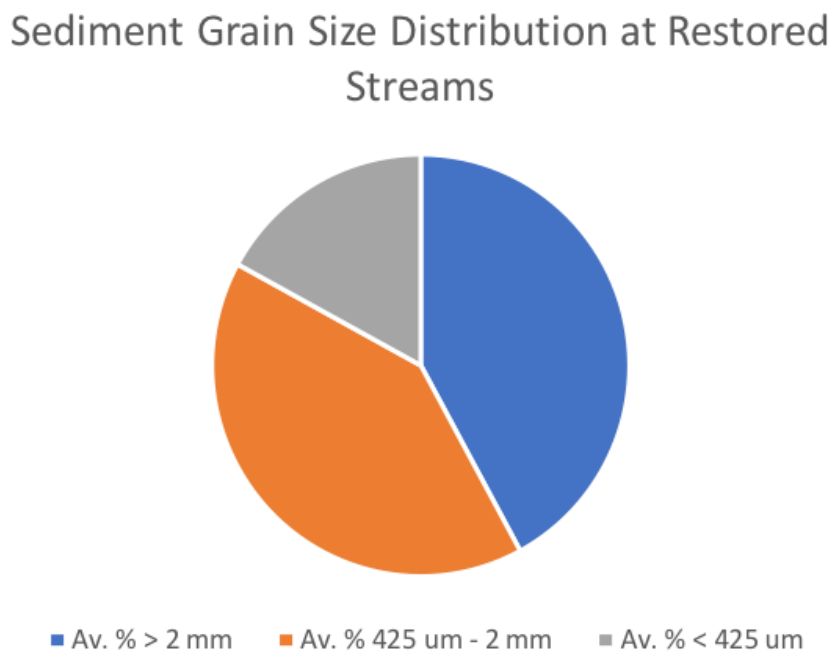

November 2020 Flow Rate (cfs) by Size Class
Flow (cfs)
80
60
40
20
0
November
November 2020
Size
Primary Headwaters
Headwaters
Wadeable


March 2021 Flow Rate (cfs) by Size Class
300
200
100
0
Flow (cfs)
March
March 2021
Size
Primary Headwaters
Headwaters
Wadeable

Sediment Dynamics

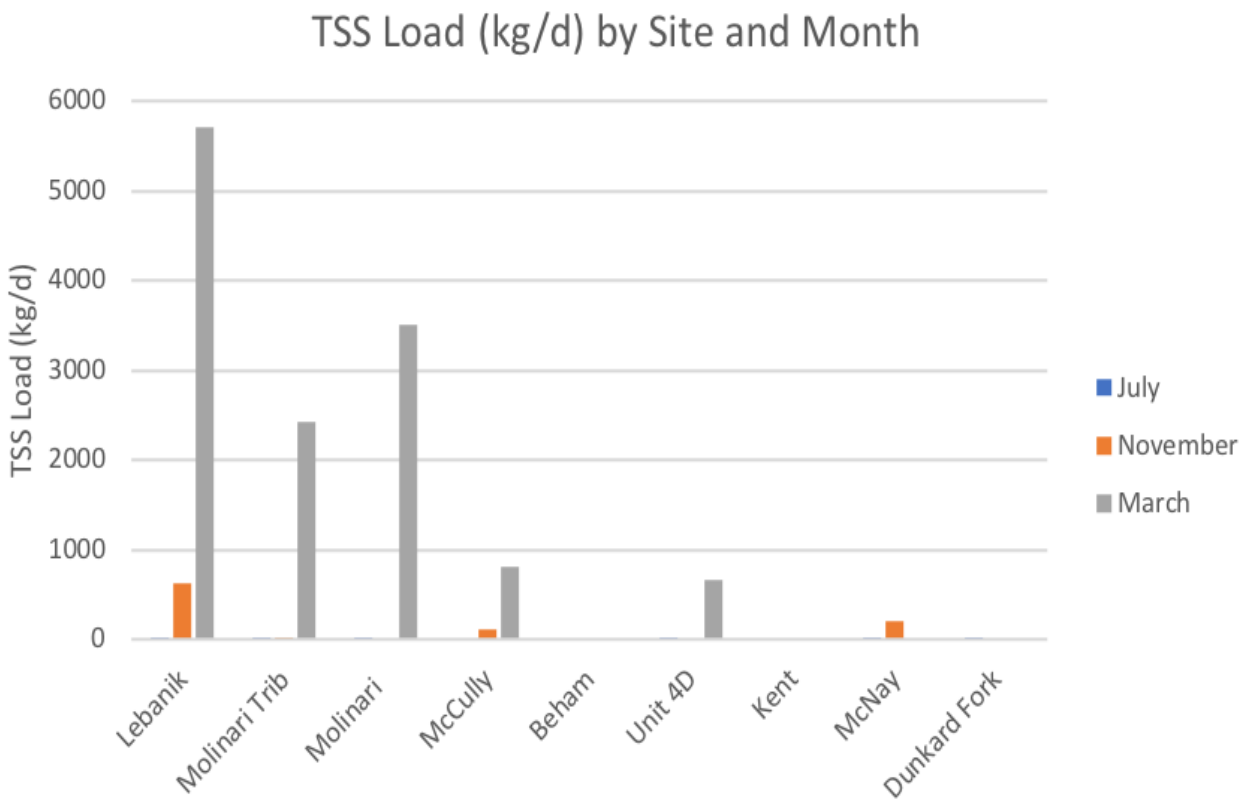
- More fine-grained sediment in restored sites

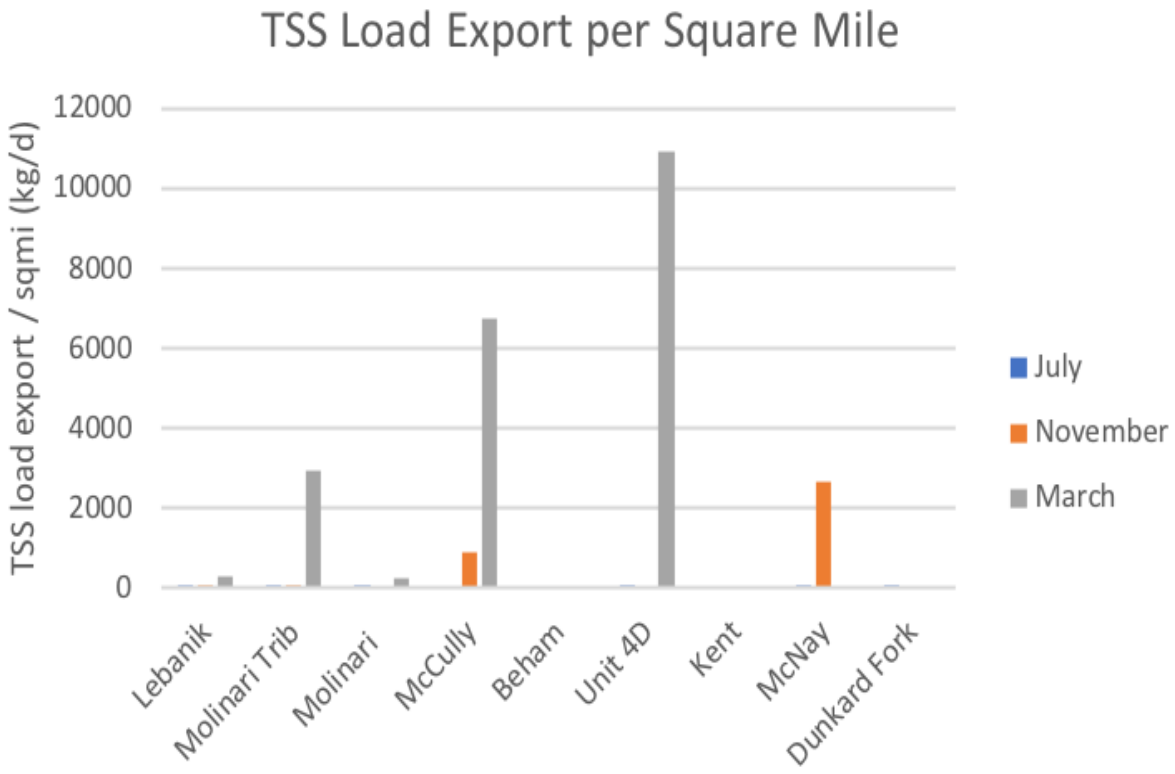




Sediment Dynamics

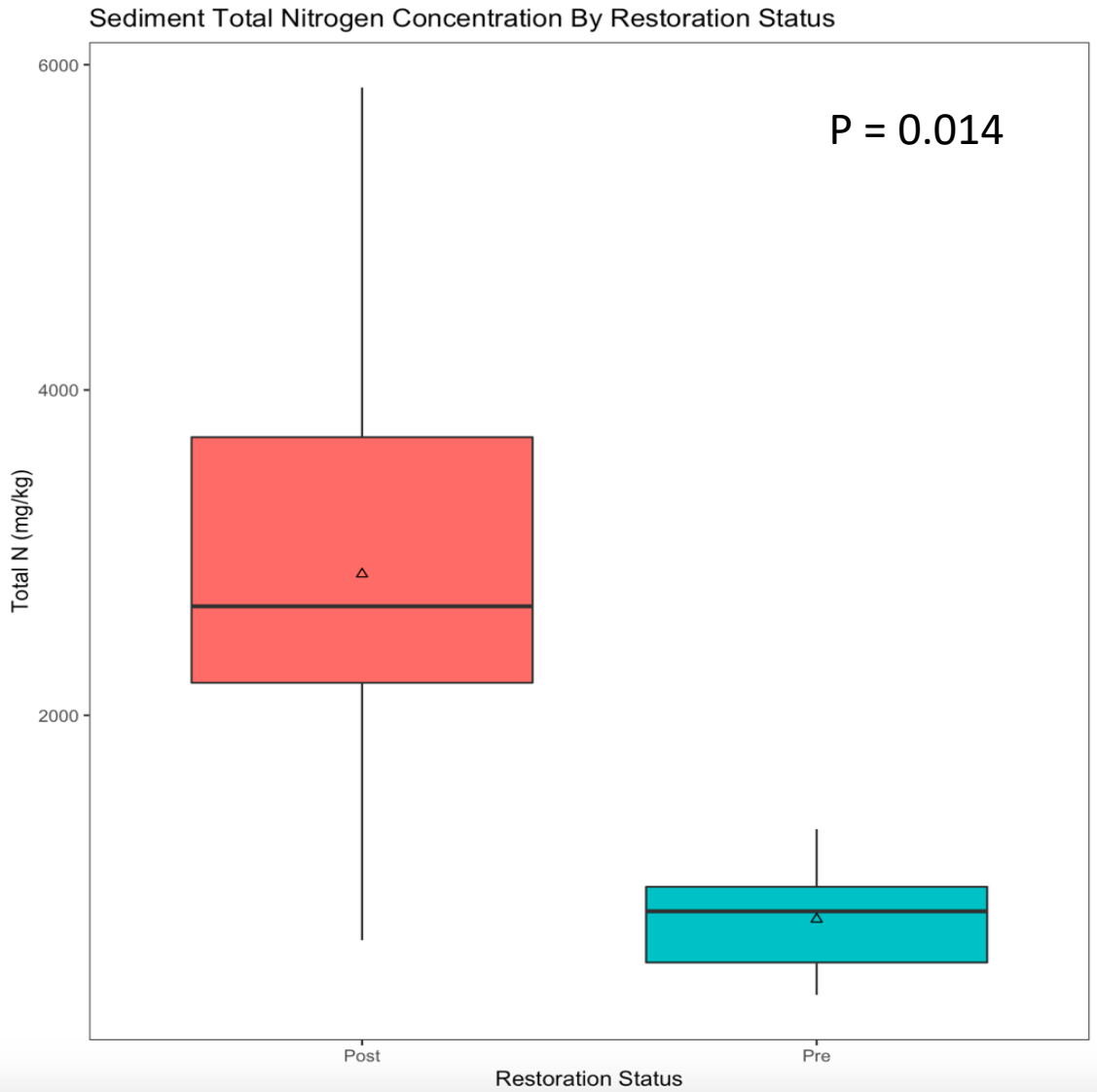
- TSS load export/sq mi was highest in high flow, lowest during low flow

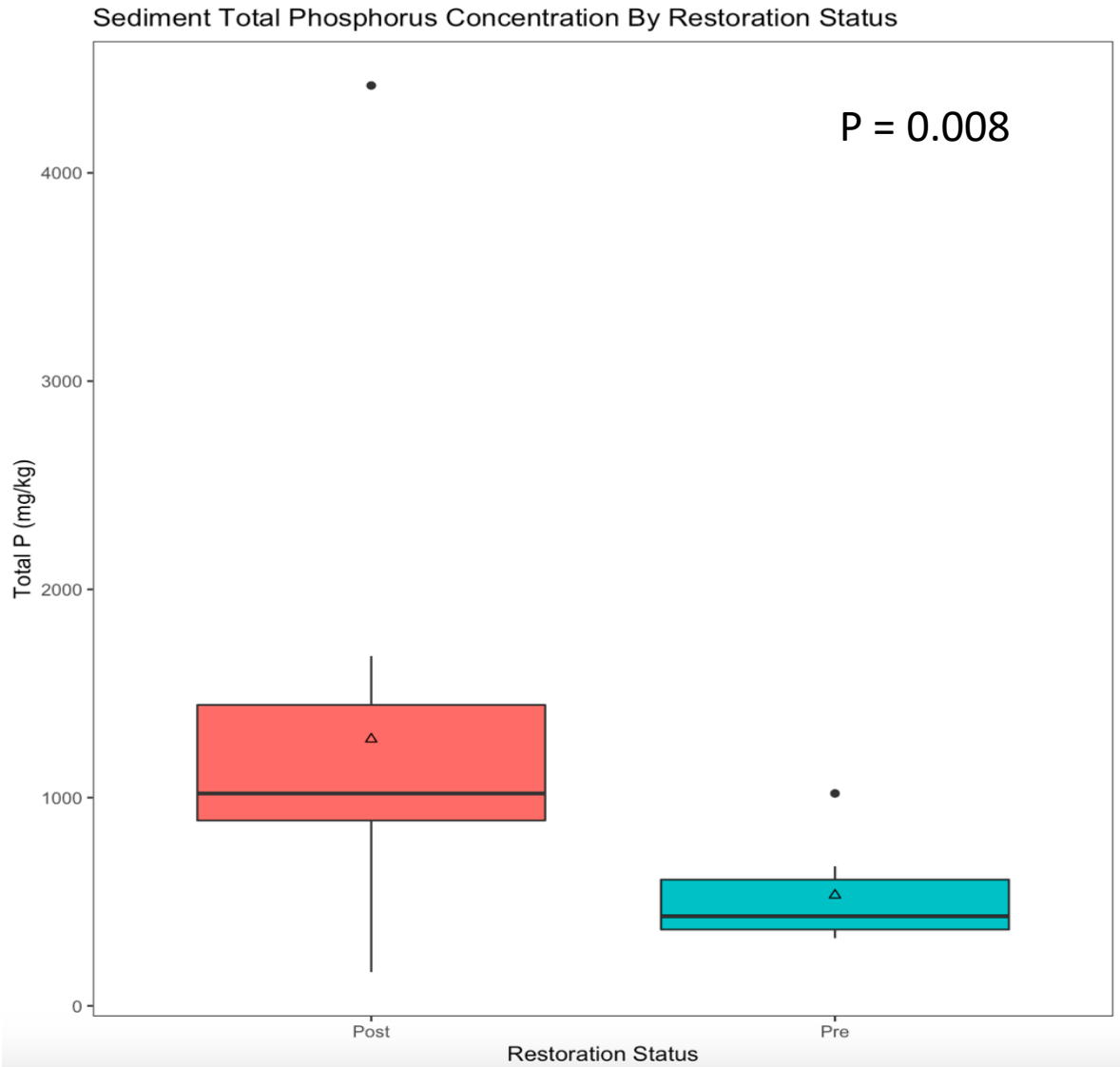


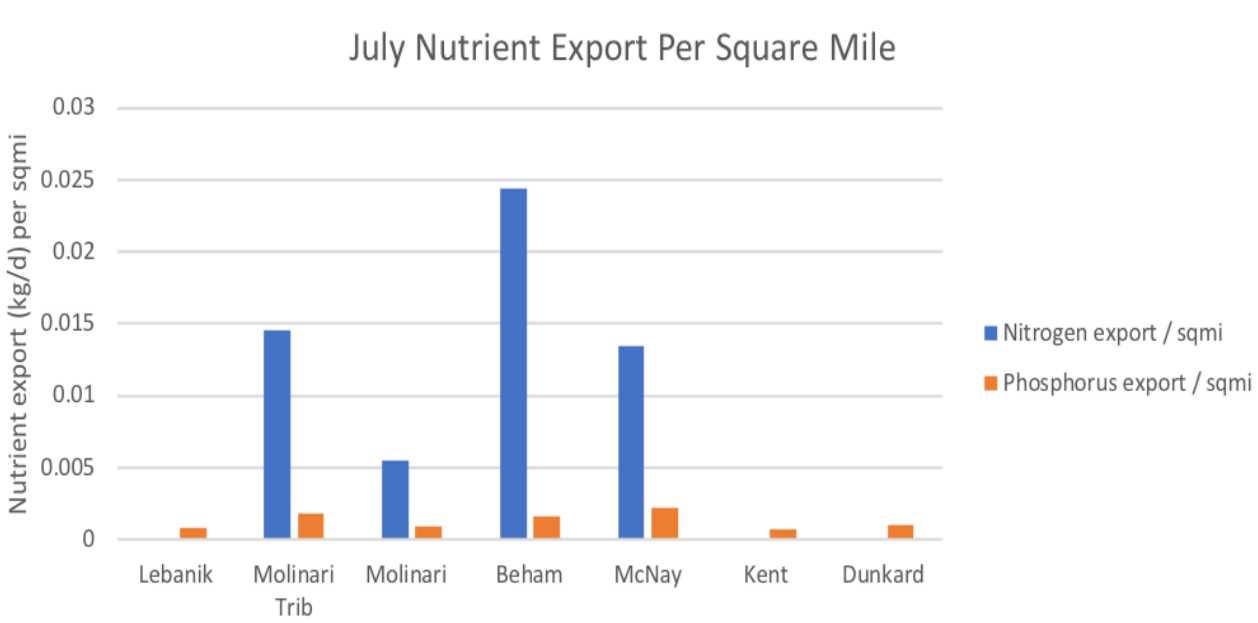


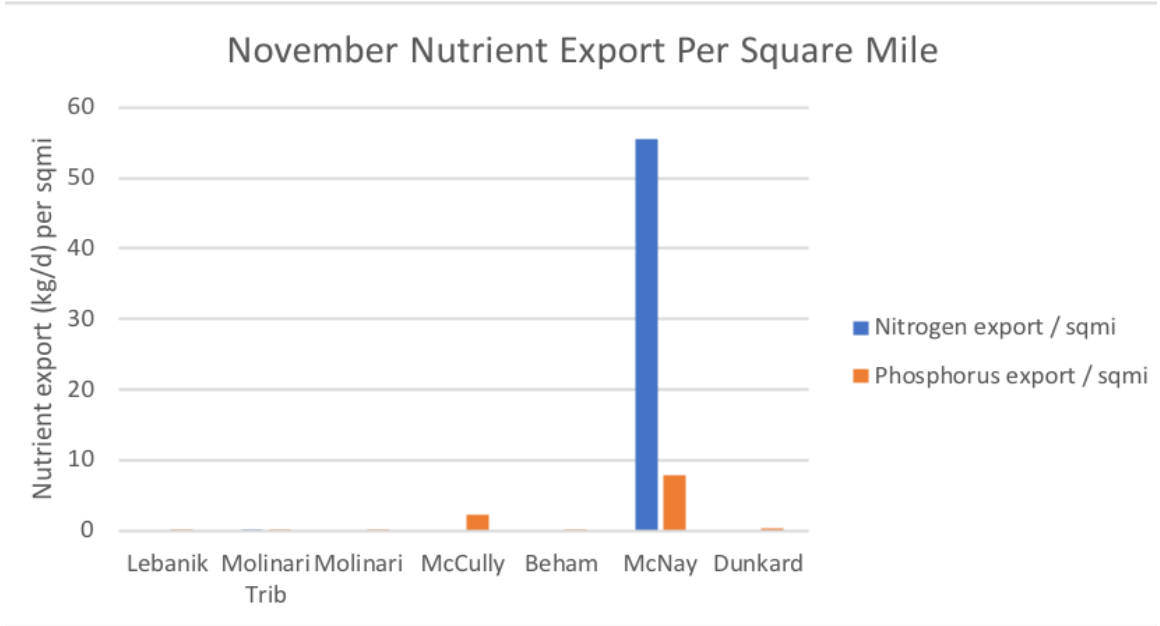
Nutrients

- Sediment
  - More N and P in restored sites

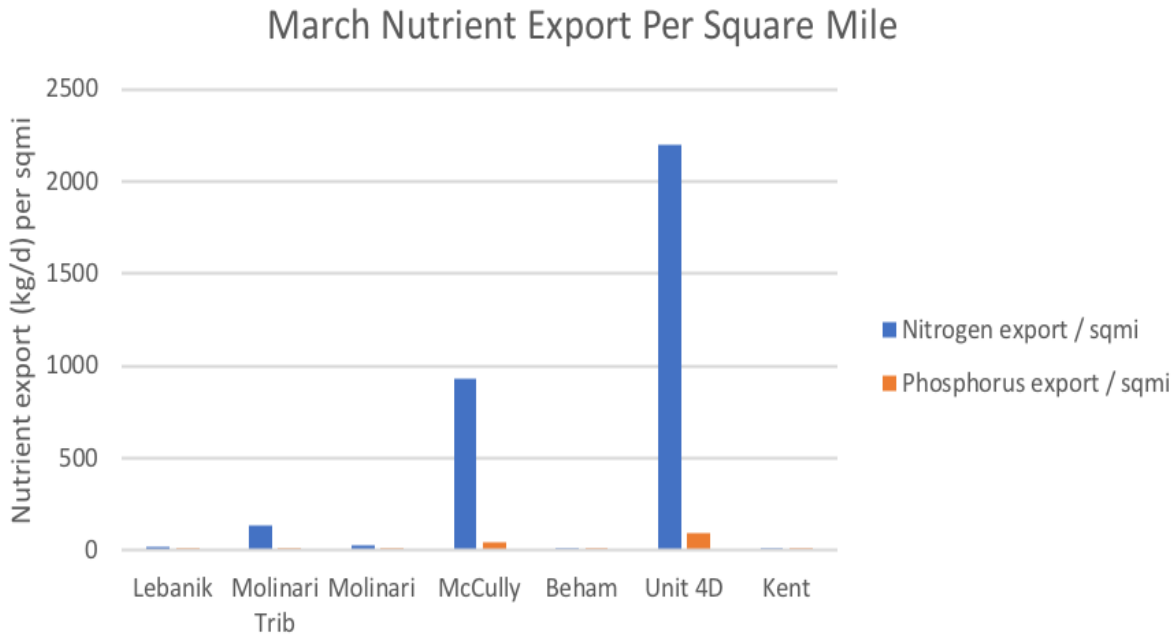




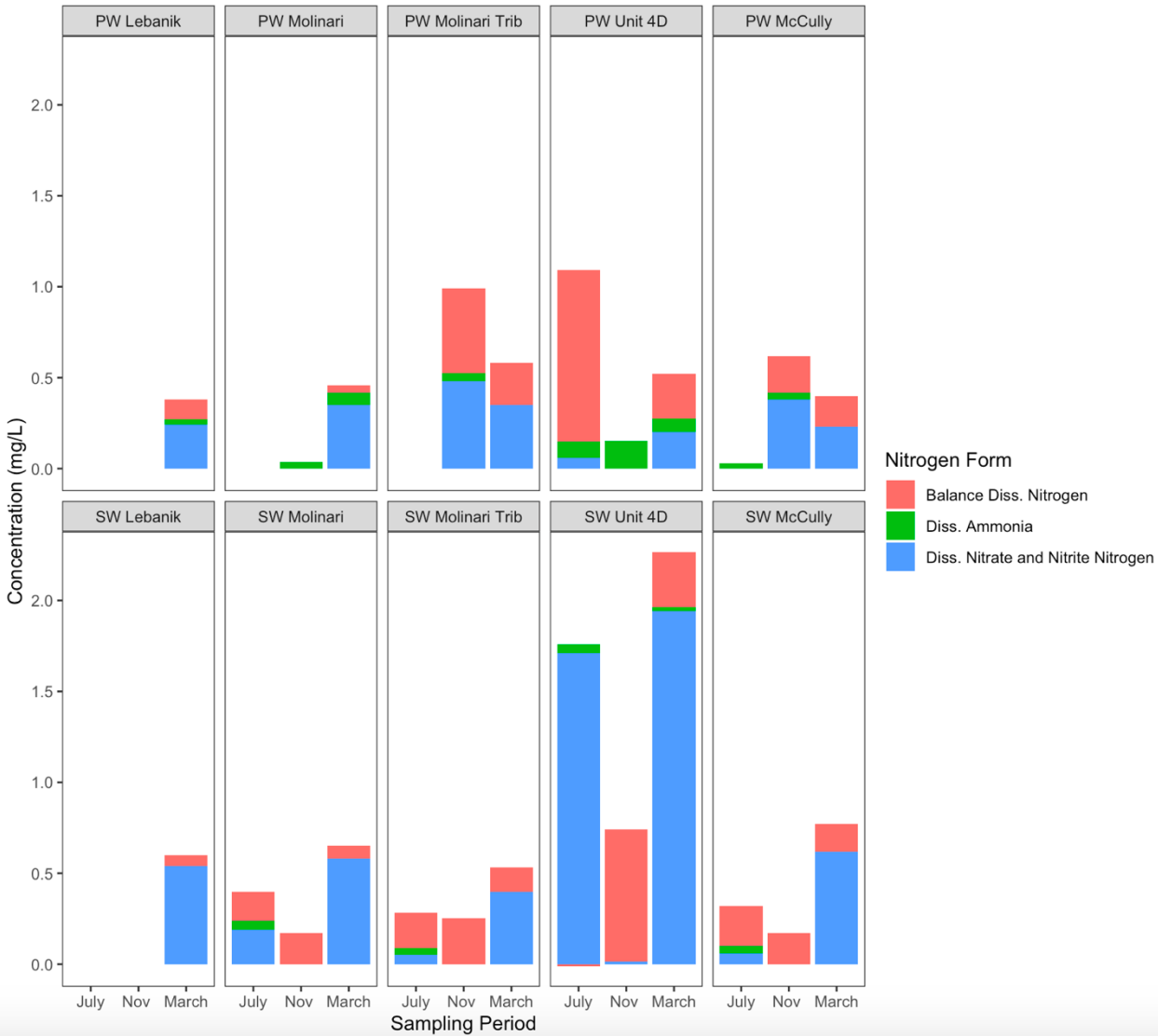


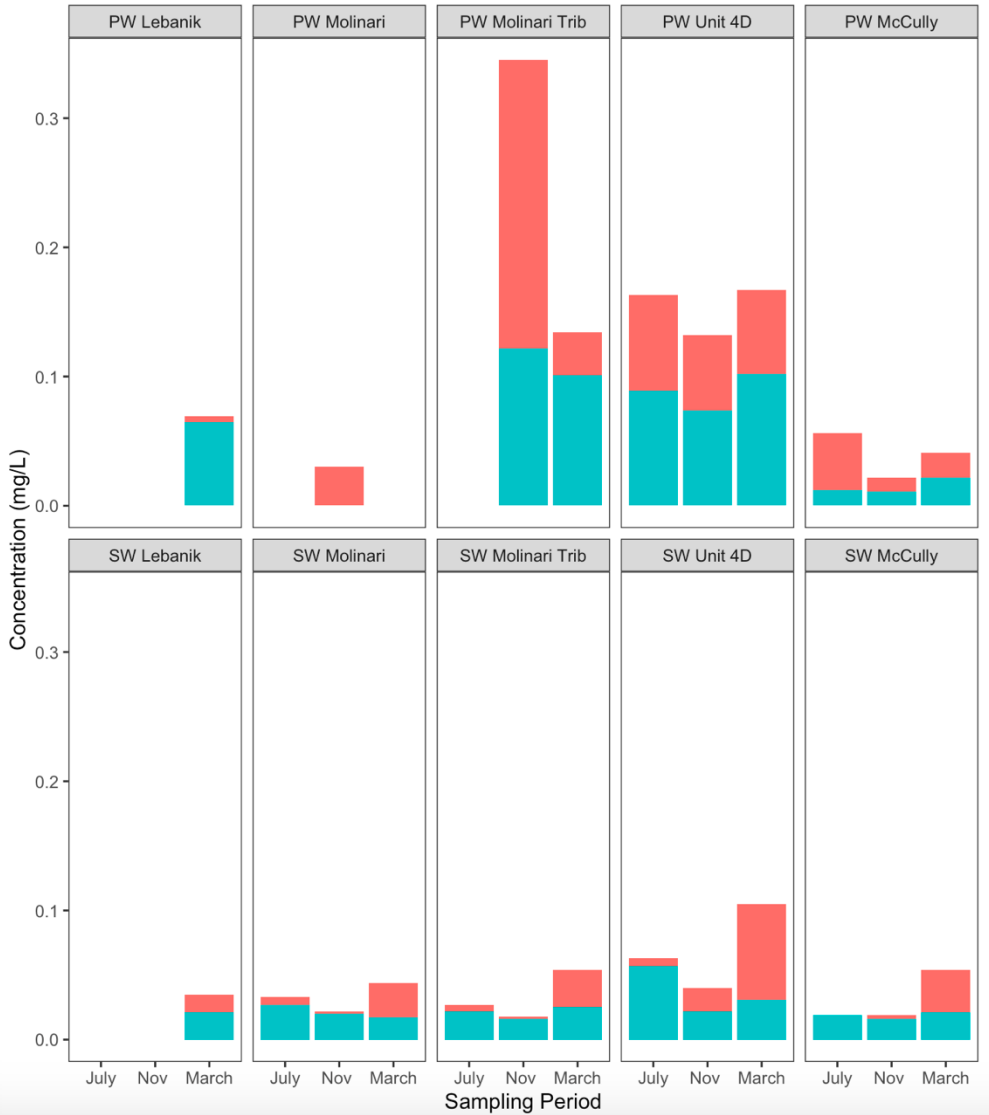


- Nutrient Flux
  - Variable with flow, not restoration status



Floodplain Nutrient Interactions: PW and SW

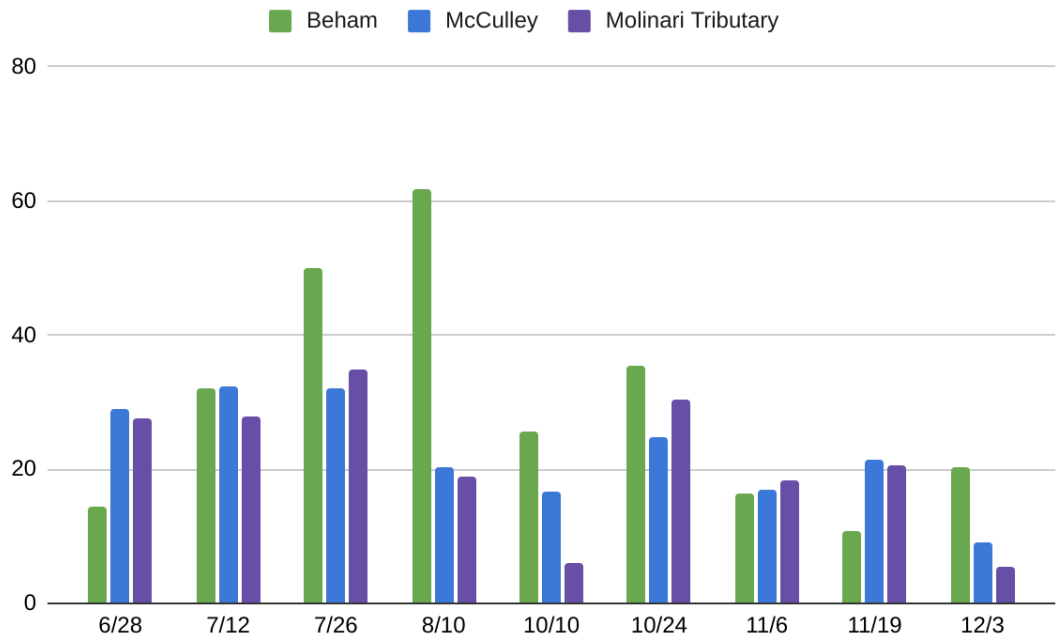


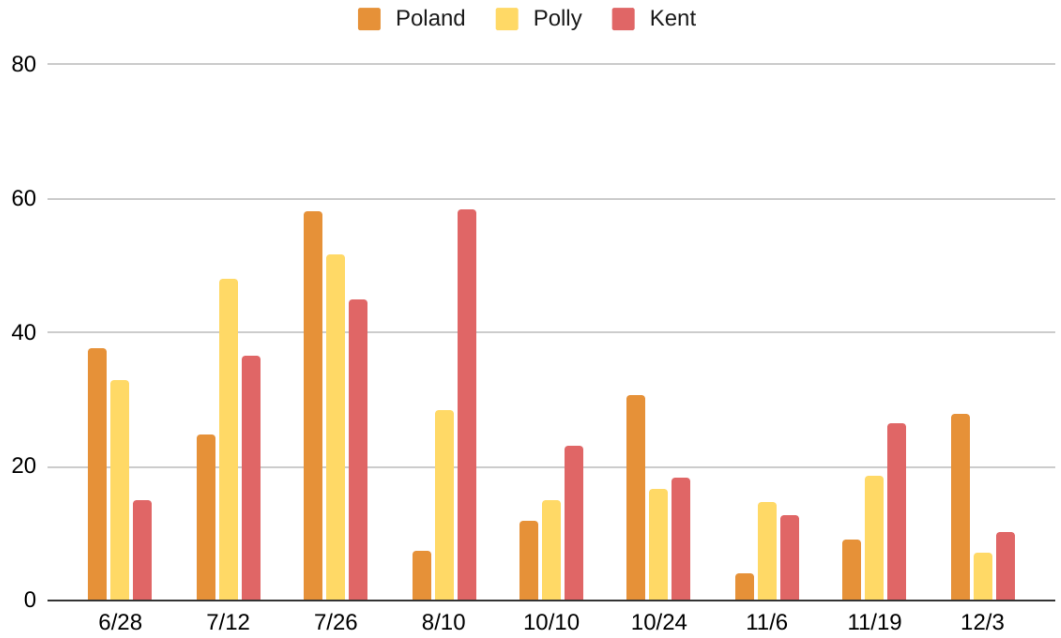


p = 0.017

Total Organic Carbon
Summer and Fall 2022

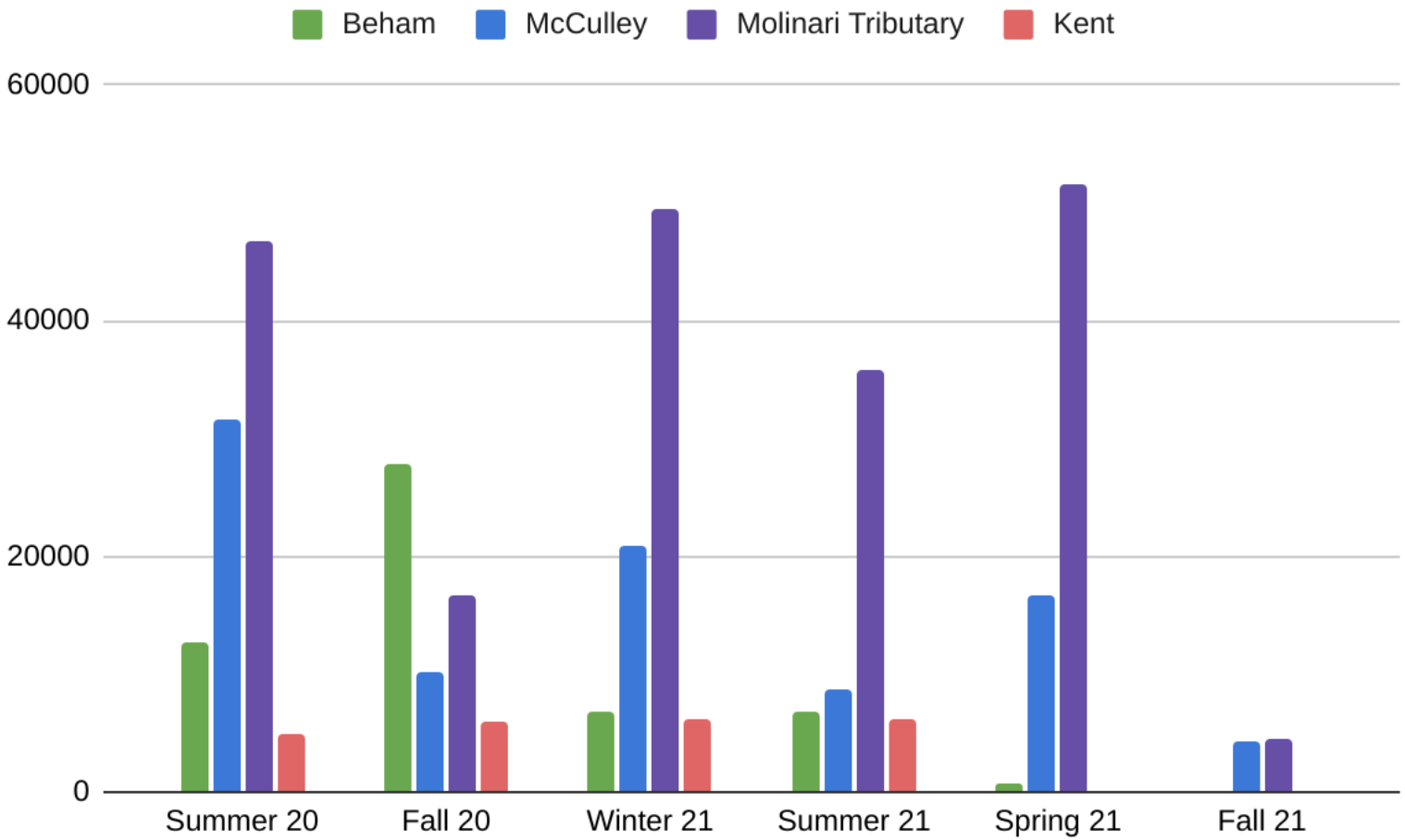
TOC and Season $p < 0.05$





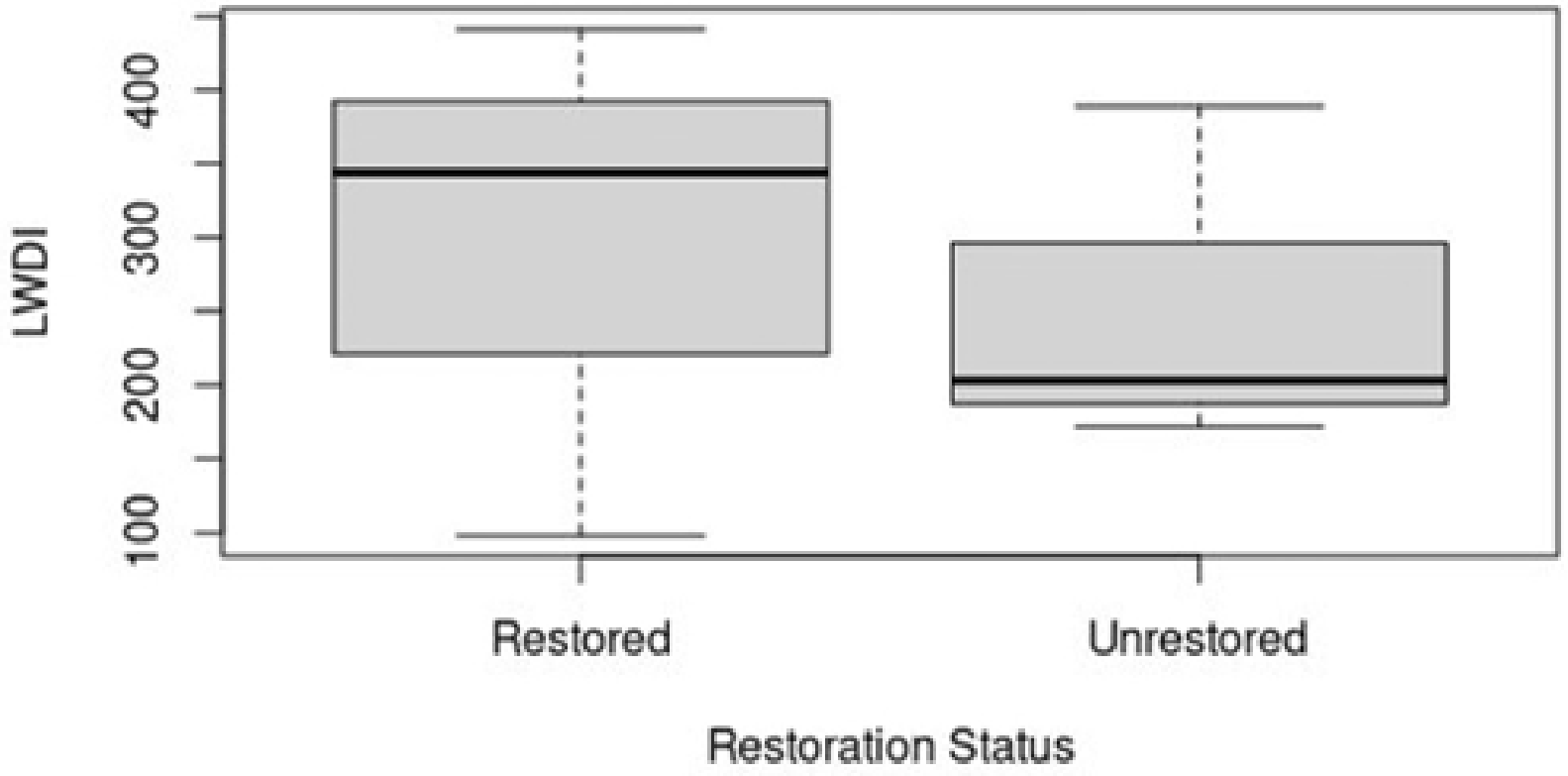
Sediment Carbon Content

- One way Anova of quarterly sediment data for Kent, Beham, McCulley, and Molinari Tributary
- Carbon compared to restoration status p=0.09
- Extremely small sample size



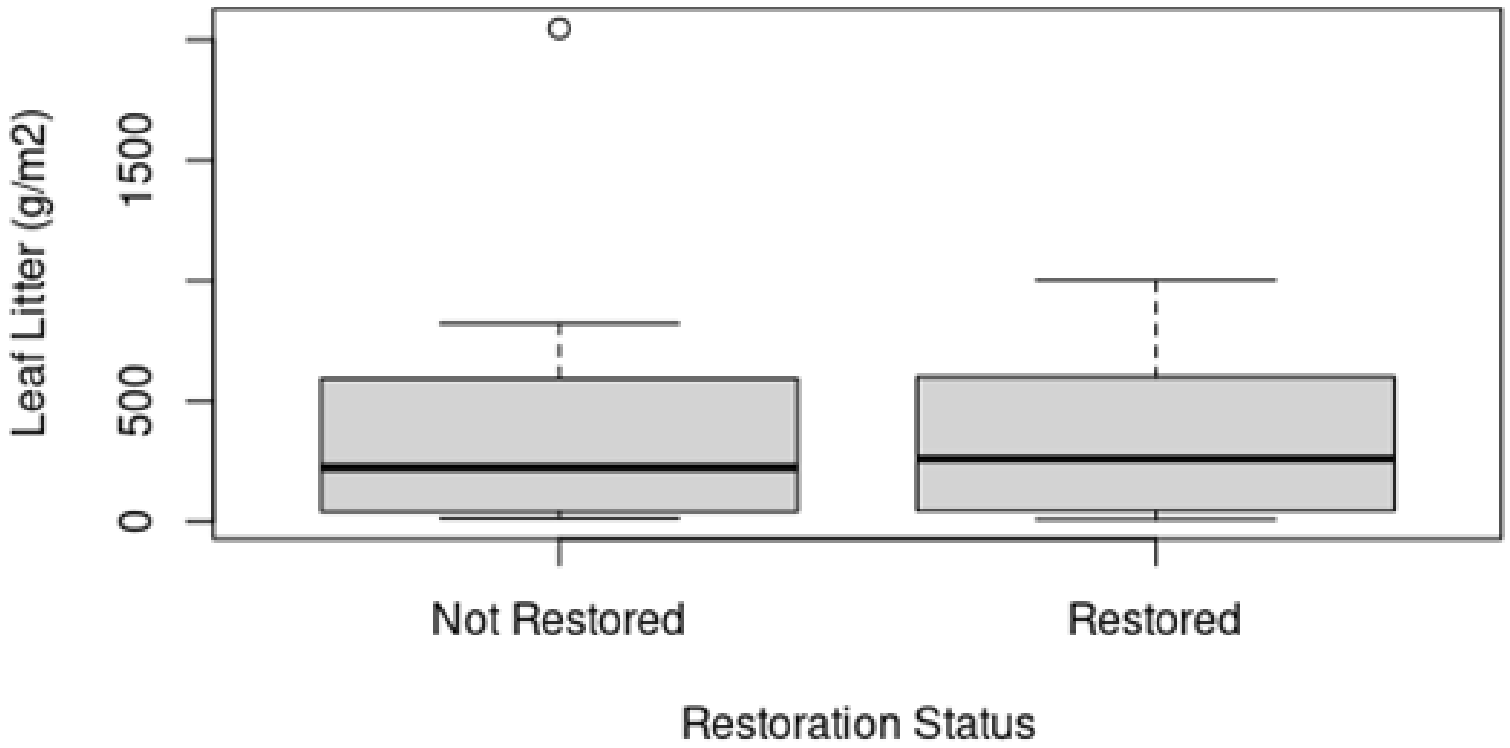
Large Woody Debris Index

No statistical relationship between large woody debris and TOC or Restoration Status



Leaf Litter Input

No statistical relationship between leaf litter input and TOC or Restoration Status



Soil Organic Matter

No statistical relationship between soil organic matter and TOC.

Soil organic matter vs. Restoration status $p<0.05$.

Conclusions

- Water storage
  - Slightly increased in restored sites
- Sediment
  - Higher proportion of fine-grained sediment at restored sites
  - DS TSS load was driven by flow
  - TSS export/sq mi was lowest at pre-restoration sites
  - Sediment retention was occurring during high flow at restored sites
- Nutrients
  - Sediment: Richer in N and P in restored sites
  - Surface water: Retention was variable, seemingly seasonal or flow dependent
  - Interactions: May be a positive relationship between sediment and surface water N concentrations at restored sites, more organic P in PW than SW

Conclusions

- Total organic carbon
  - Dependent upon season (greater in the growing season), not restoration status
- Carbon Input
  - Not significantly different between restoration status
- Soil organic matter
  - Greater in restored sites than unrestored

Acknowledgements

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Thank you! Questions?
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