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BUREAU OF CLEAN WATER

Didymo in the mid-Atlantic US

Matt Shank
PA Dept. of Environmental Protection

GLP information session: Didymo
6/15/2021

Tom Wolf, Governor

Patrick McDonnell, Secretary

Outline

- Didymo in the mid-Atlantic
  - Mid-Atlantic distribution
  - Statewide (general) habitat suitability
  - Response to first observation in Pine Creek
    - eDNA and microscopy to understand distribution
  - Genetic diversity insights
  - CIM and water chemistry insights into mat formation
  - Paleolimnological study
    - Historic cell presence relationship with changing water chemistry

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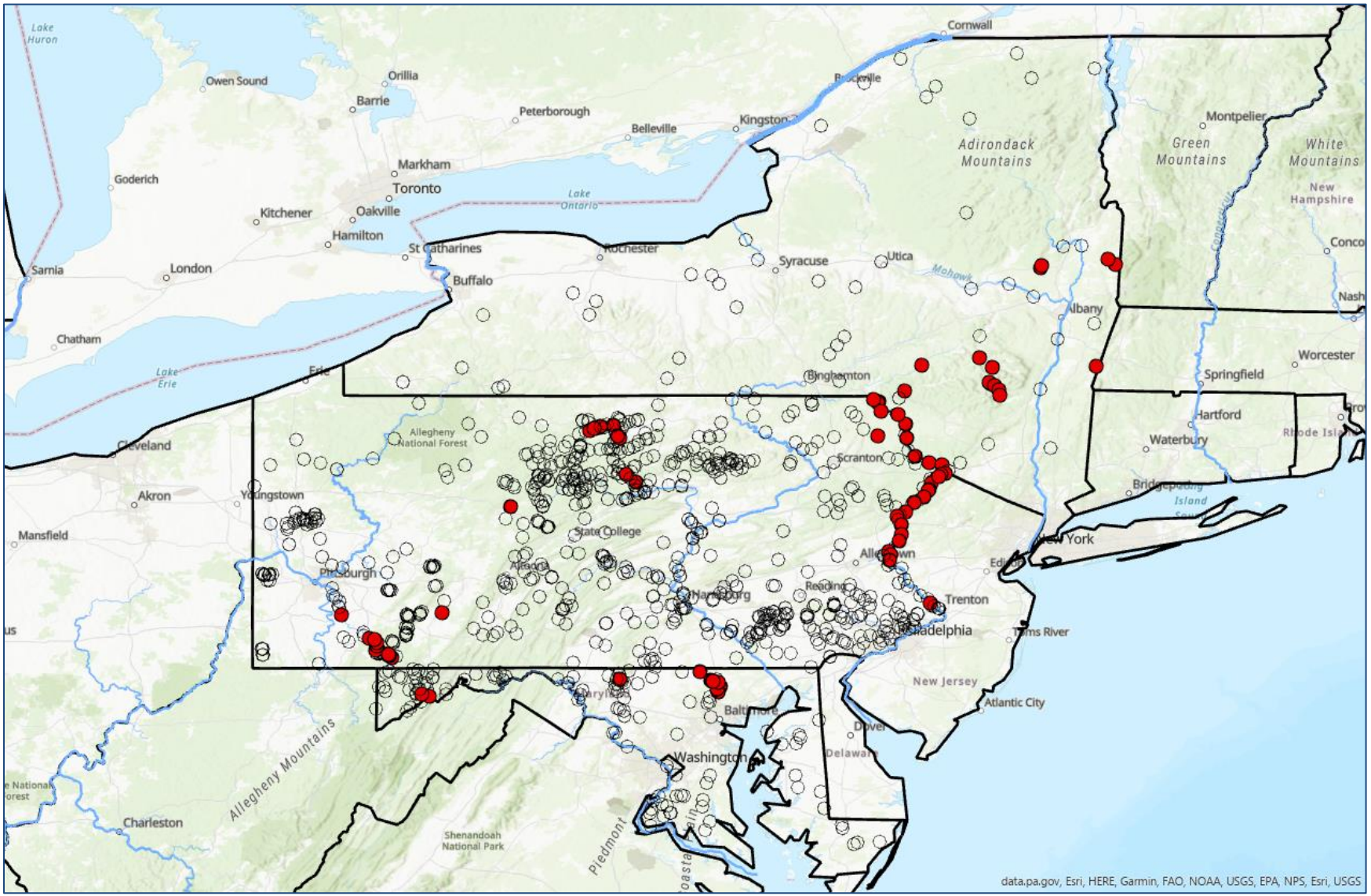
Mid-Atlantic distribution



- 2452 observations
- 398 didymo detections

Statewide (general) habitat suitability

***Didymosphenia geminata* in Pennsylvania: an investigation of current and historic distribution, habitat suitability, and nutritional content**

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Daniel E. Spooner, Ph.D.
Contract Research Ecologist
U.S. Geological Survey
Leetown Science Center Northern Appalachian Research Laboratory

November 17, 2014 – January 1, 2016

- http://seagrant.psu.edu/topics/invasive-species/research/didymosphenia-geminata-pennsylvania-investigation-current-and
- Grant funded project to investigate statewide distribution and habitat suitability after first few observations in 2013
- At this point we knew very little, relied on literature and began making connections with other researchers

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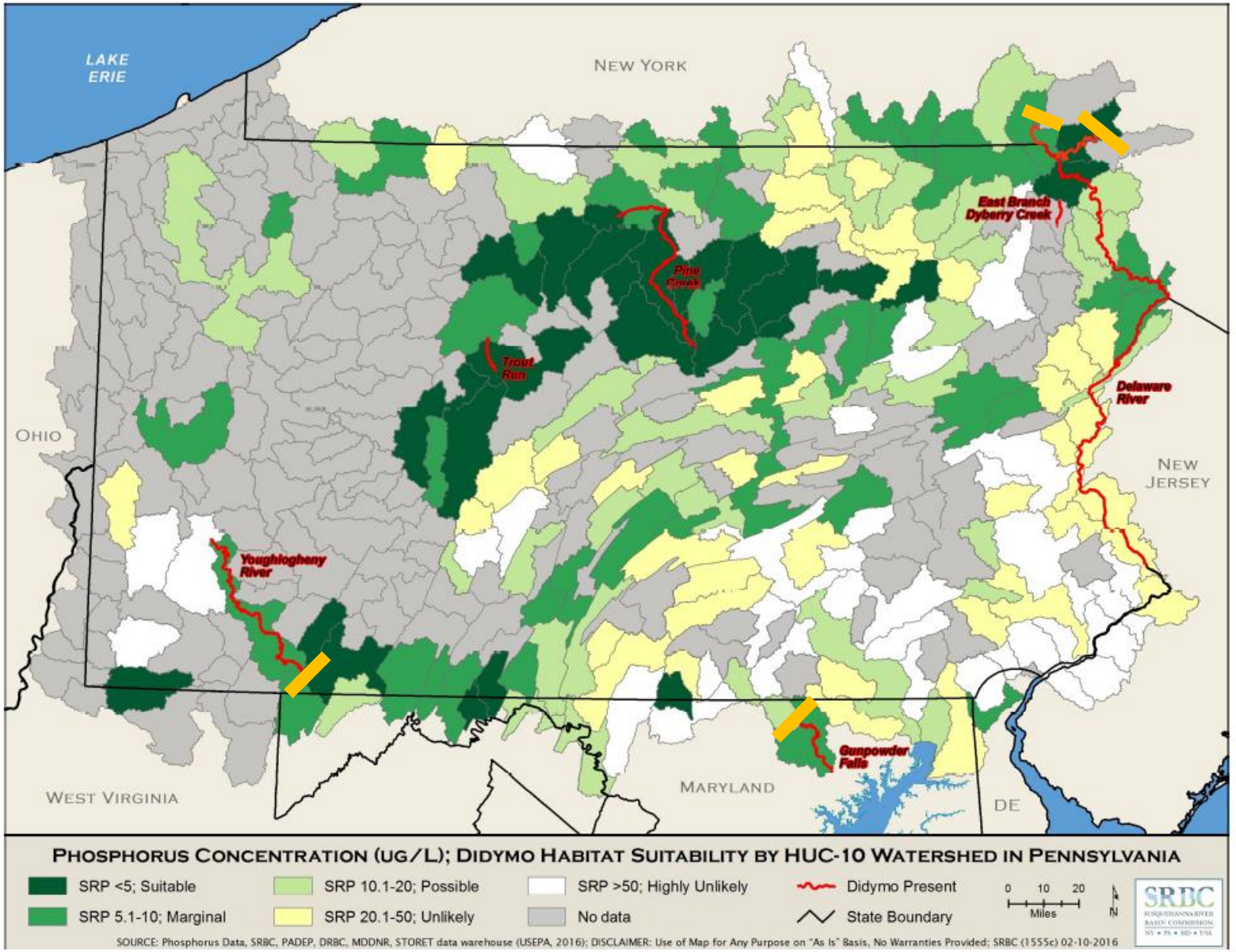
Statewide (general) habitat suitability



Statewide (general) habitat suitability

Table 1. Physicochemical Variables Influencing Didymo Habitat Suitability, Criteria Promoting Didymo Presence, Relative Weights, and Associated Literature Sources

	Variable	Criteria	Weight	Source
Physical	Flow regulation	Lakes/impoundments upstream	5	Whitton et al., 2009; Kirkwood et al., 2009; Bray et al., 2016
	Temperature	<10% days >18ºC	2	Lindstrøm and Skulberg, 2008; Whitton et al., 2009
	Light	> 10 m wide channel^	2	Bothwell and Kilroy, 2011; James et al., 2014; Bray et al., 2016
	Substrate	rocky/hard; large gravel to cobble	1	Whitton et al., 2009; Bergey et al., 2010
	Turbidity	<5 NTU*	1	Kirkwood et al., 2007; Bothwell et al., 2014
	Gradient	low gradients (<0.5%)+	1	James et al., 2014
Chemical	Soluble Reactive Phosphorus	<2 µg/L	5	Bothwell and Kilroy 2011; Kilroy and Bothwell 2012; Silldorff and Swann, 2013; Bothwell et al., 2014; Klauda et al., 2015
	Soluble Reactive Phosphorus	<5 µg/L	2	
	Soluble Reactive Phosphorus	<10 µg/L	1	
	pH	>6.7	2	Stoddard et al., 2005; Lindstrøm and Skulberg, 2008
	Sulfate	>2.5 mg/L	1	Lindstrøm and Skulberg, 2008
	Calcium	>1.8 mg/L	1	Lindstrøm and Skulberg, 2008
	Nitrate	<1 mg/L	1	Stoddard et al., 2005; Spaulding and Elwell, 2007
	Total organic carbon	<6.5 mg/L	1	Lindstrøm and Skulberg, 2008

^ Streams with mean width of >10m were preferred by didymo in a study in the Black Hills of SD (James et al., 2014).
* This threshold was based on Lloyd et al. (1987) that found a 3-13% decrease in primary productivity in clear Alaska streams in response to 5 NTU turbidity values.
+ Streams with gradients >0.5% were devoid of didymo in a study in the Black Hills of SD (James et al., 2014).

Statewide (general) habitat suitability

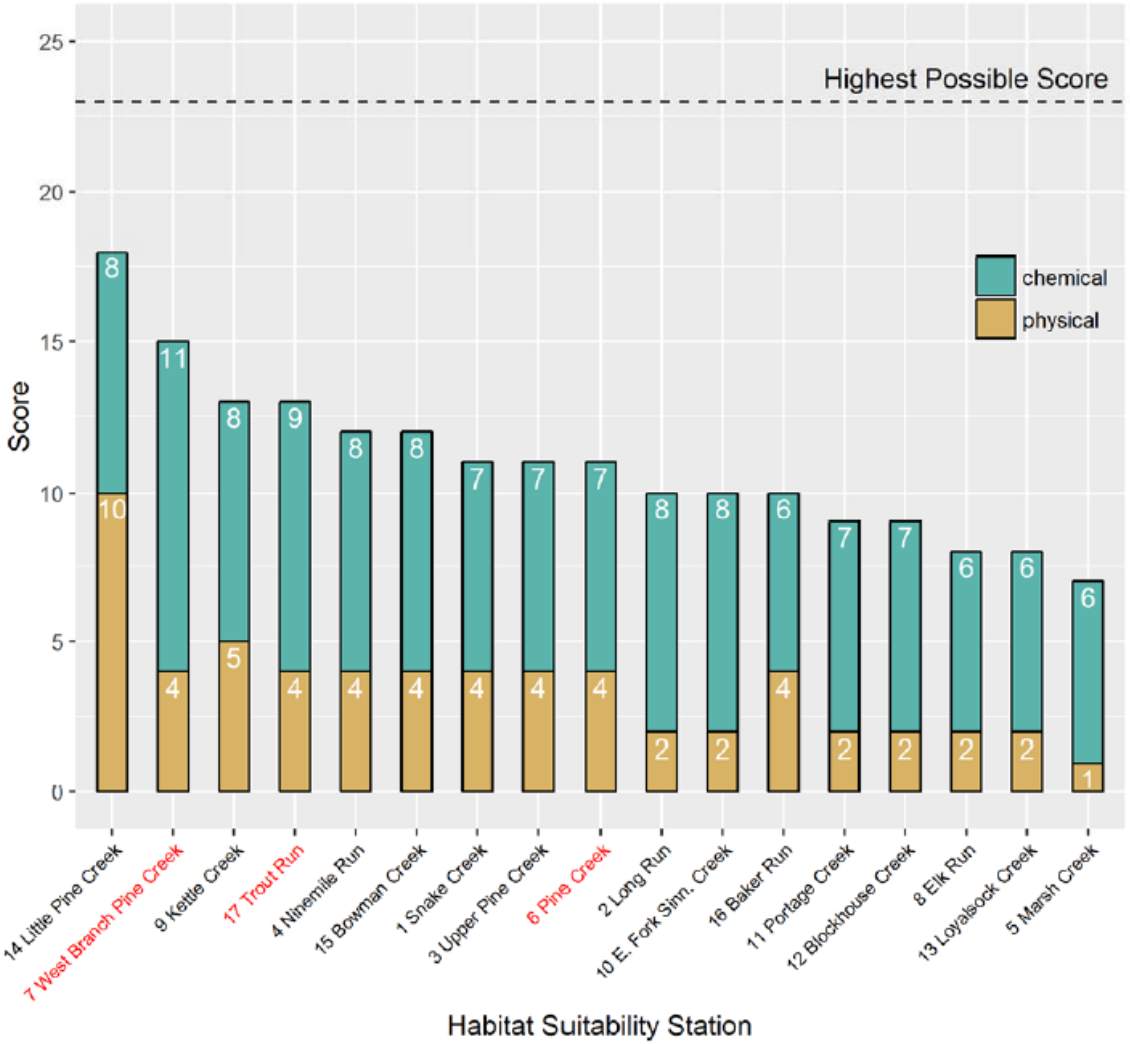


Figure 10. Results of Habitat Suitability Index Presented in Order of Most Suitable to Least Suitable (The number preceding the stream name on the x axis corresponds with the numbered watersheds in Figure 2. Red font on x axis indicates documented didymo presence in the watershed.)

- Red text indicates didymo presence
- Marginal habitat suitability throughout mountainous, forested watersheds.
  - Due to lack of hydrologic regulation (no dams)
  - And dams that are present are not bottom release

Response to first observation in Pine Creek

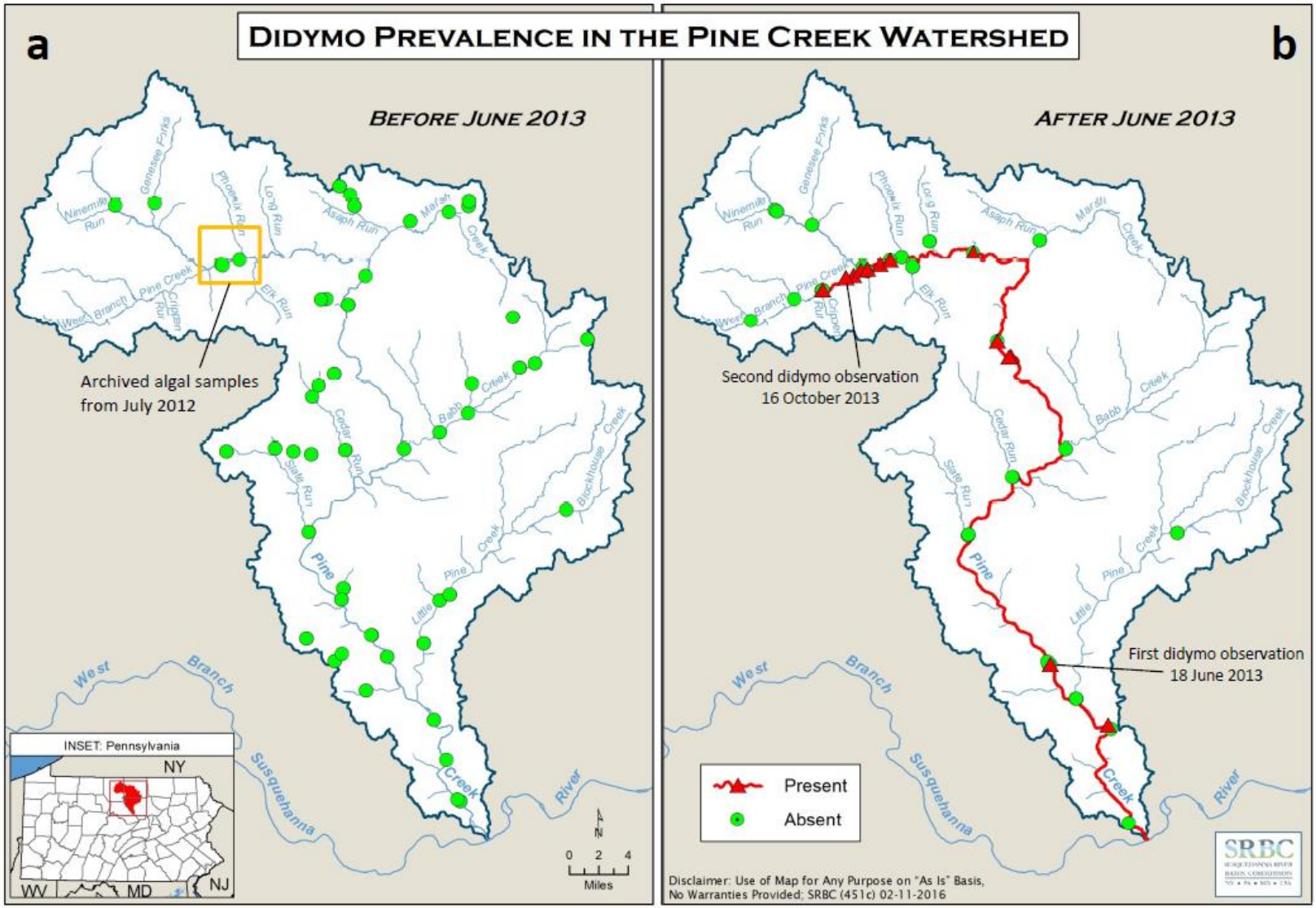


Figure 5. Presence of Didymo in Algal Samples in the Pine Creek Watershed Collected (a) Before and (b) After 18 June 2013

Genetic diversity insights

- Genetic project research questions:
  - Distribution:
    - Expected in cold and cool streams, but elsewhere?
    - Low level abundance everywhere?
  - Genetic insights:
    - Is it invasive?
    - Is it a single spreading lineage or a genetically diverse population?

Genetic diversity insights

Diversity and Distributions, (Diversity Distrib.) (2017) **23**, 381–393

BIODIVERSITY RESEARCH

Environmental DNA genetic monitoring of the nuisance freshwater diatom, *Didymosphenia geminata*, in eastern North American streams

Stephen R. Keller[1]* , Robert H. Hilderbrand[1], Matthew K. Shank[2] and Marina Potapova[3]

- https://onlinelibrary.wiley.com/doi/full/10.1111/ddi.12536
- Results
  - (1) D. geminata eDNA was detected at seven spatially unique sites, six of which were previously documented to contain recent D. geminata blooms.
  - (2) Sites where D. geminata eDNA was detected exhibited no difference in environmental conditions compared to sites with no-detected D. geminata eDNA.
  - (3) Sequencing of D. geminata eDNA showed that blooms were composed of multiple genetic lineages, closely related to those sampled elsewhere across the globe (i.e. not a single “invasive” lineage)
- Main conclusions
  - We interpret these results as most consistent with the hypothesis that D. geminata is an exotic invader in the Mid-Atlantic region, still in its early stages of invasion; thus, genetic monitoring and management efforts may still be effective at controlling its spread.

CIM and water chemistry insights

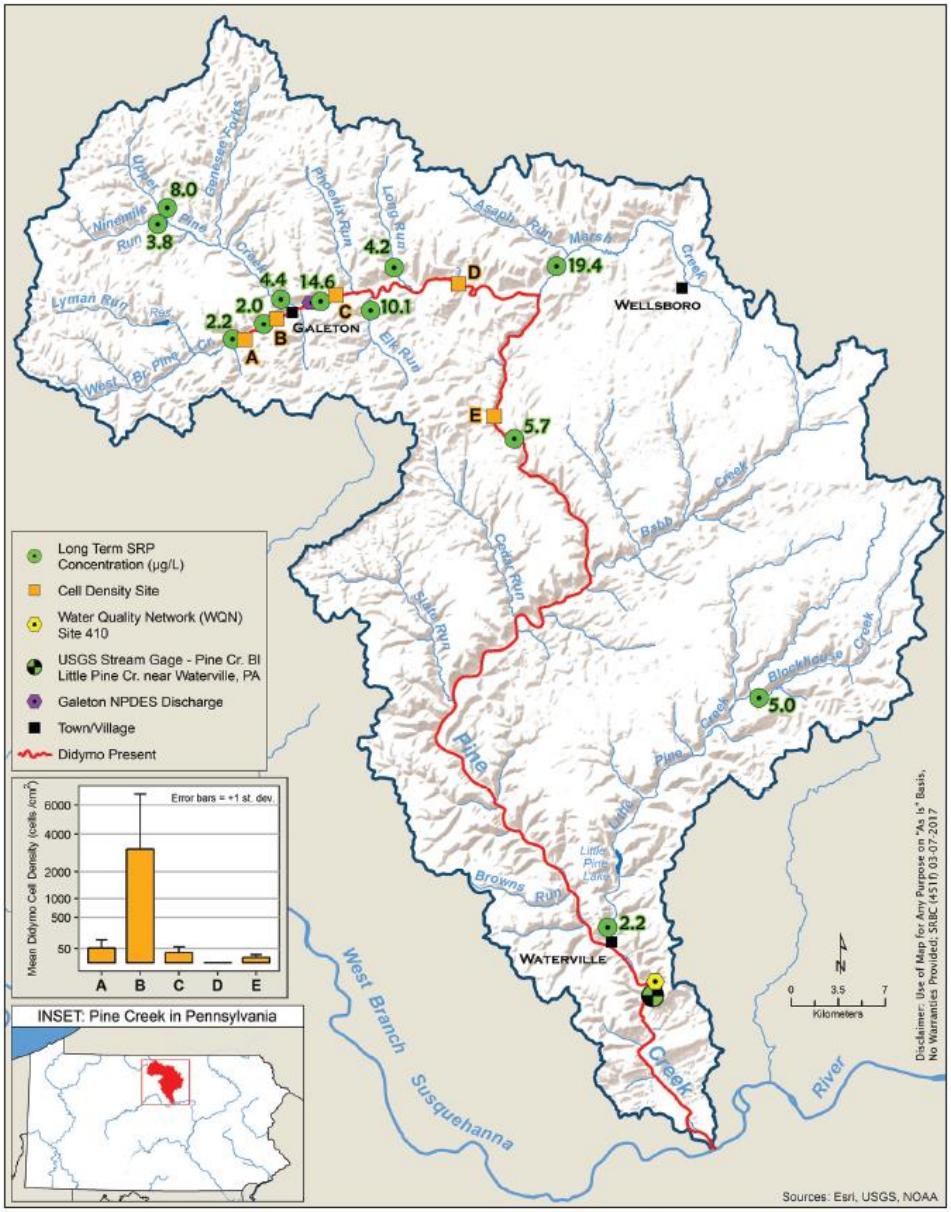
2019 NORTHEASTERN NATURALIST 26(2):420–445

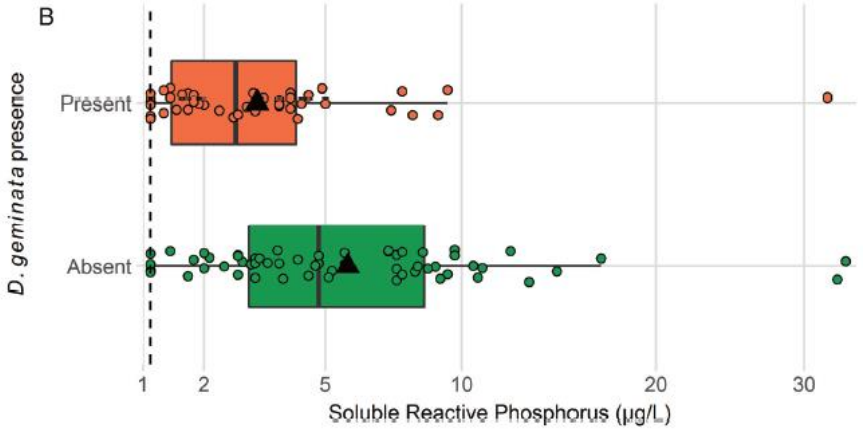
Physicochemical Controls on Spatiotemporal Distribution and Benthic Mat Severity of *Didymosphenia geminata* in Pine Creek, an Unregulated Watershed in Northern Pennsylvania

Matthew K. Shank*

- An intensive monitoring effort was made in the Pine Creek watershed to understand the variables associated with mat formation
- https://bioone.org/journals/Northeastern-Naturalist/volume-26/issue-2/045.026.0217/Physicochemical-Controls-on-Spatiotemporal-Distribution-and-Benthic-Mat-Severity-of/10.1656/045.026.0217.short

CIM and water chemistry insights

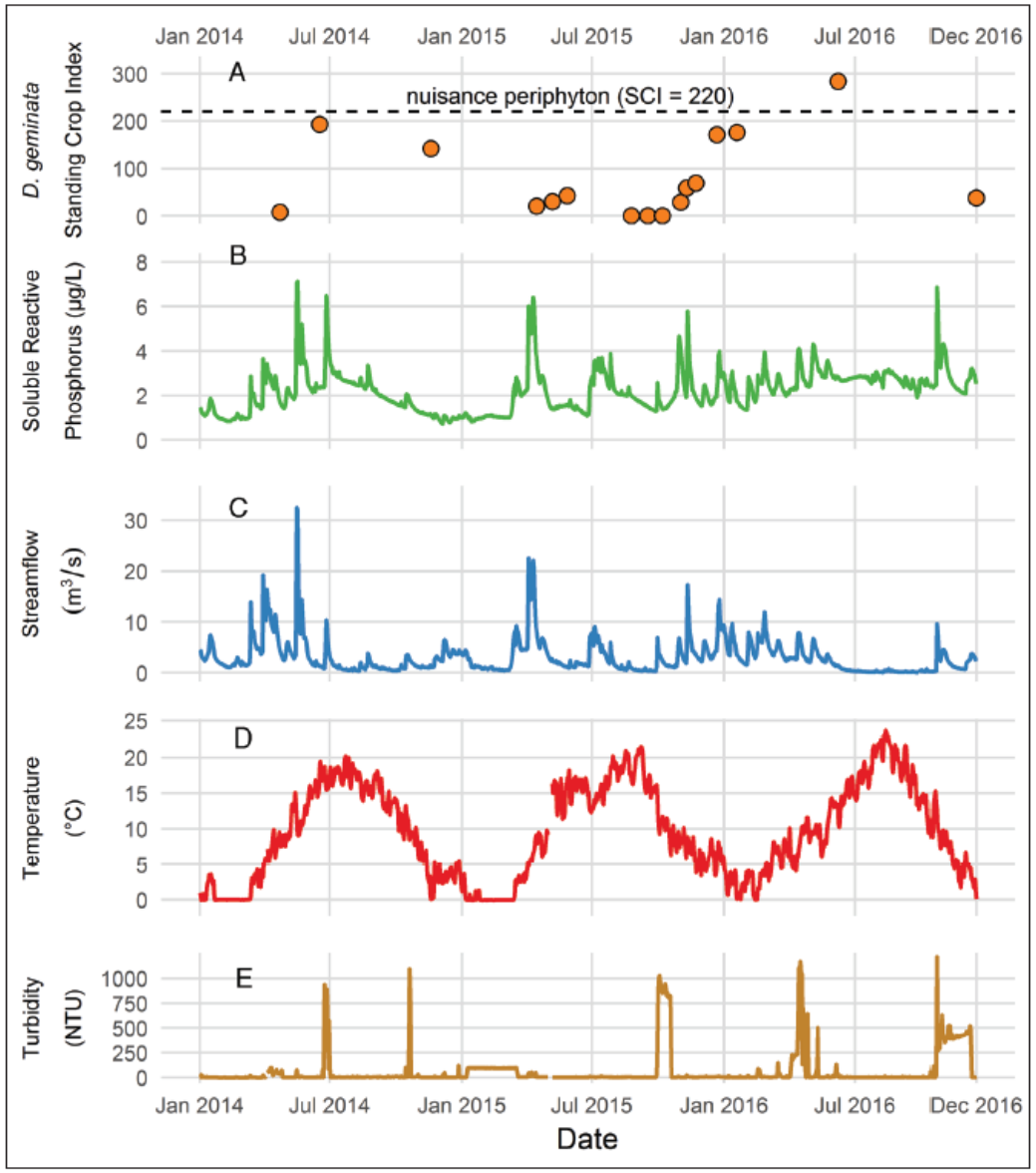


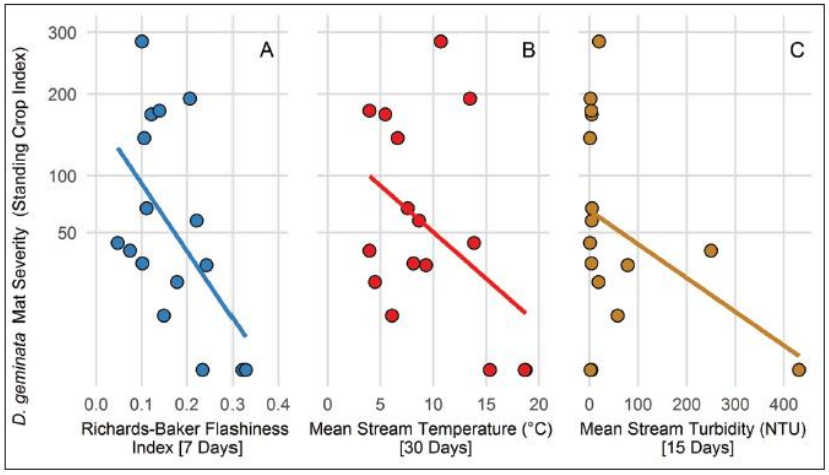


- On a watershed scale, didymo cellular distribution is limited to upper reaches of Pine Creek where median soluble reactive phosphorus (SRP) is 2.7 µg/L; median SRP was 4.8 µg/L at sites where Didymo was absent.

- Didymo cells were detected in the water column up to 101 km downstream from the upstream-most observation, while cells were present on the substrate for 39 km

CIM and water chemistry insights





- At the epicenter of distribution in Pine Creek where SRP was consistently <2 µg/L, increased streamflow flashiness and water temperature were associated with decreased benthic mat severity.

Mid-point recap

- So, after a lot of effort, our understanding of didymo ecology has improved greatly in the mid-Atlantic region

- I still think we do not have a conclusive answer on the native / non-native question
  - This is inherently difficult to determine with a micro-organism, but it's the question that managers want answered
  - So we delved into the world of paleolimnology

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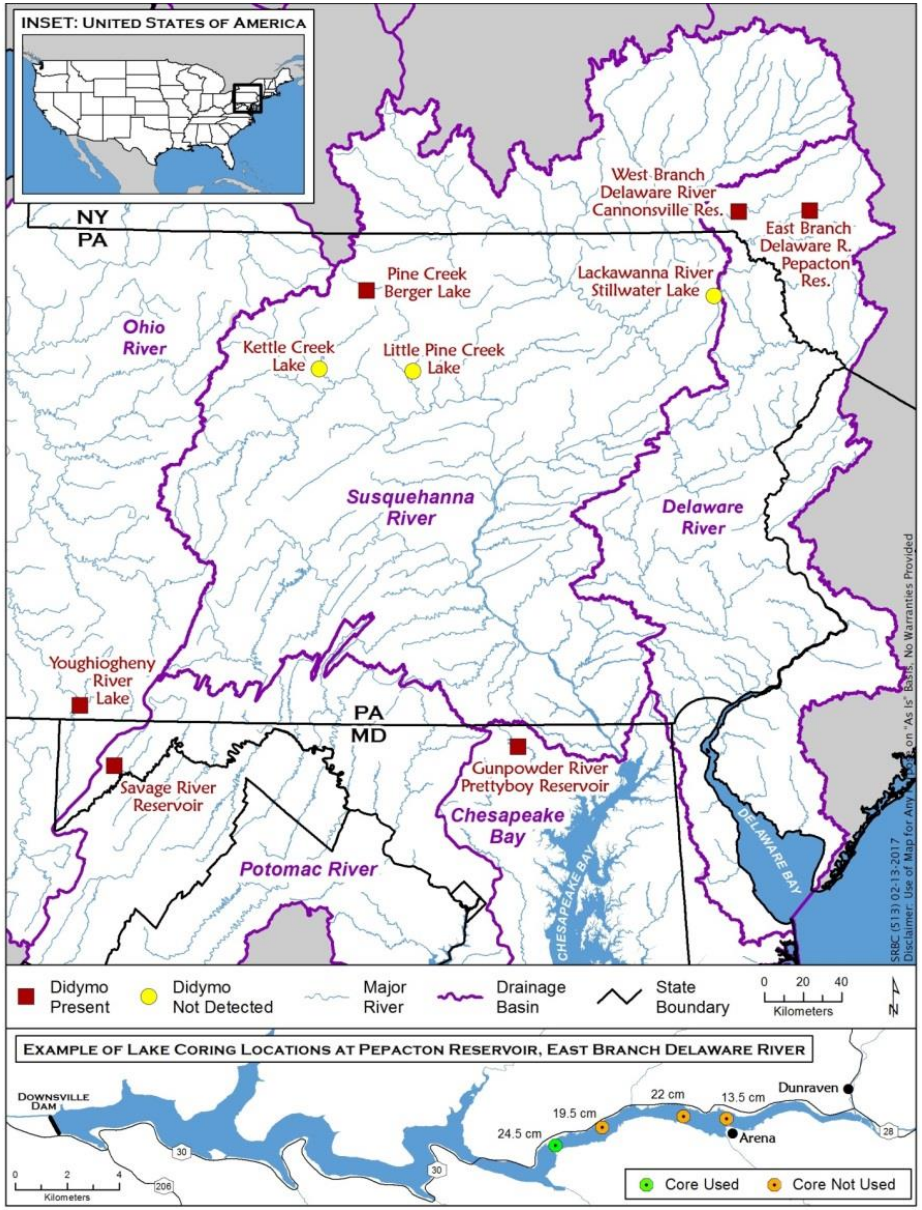
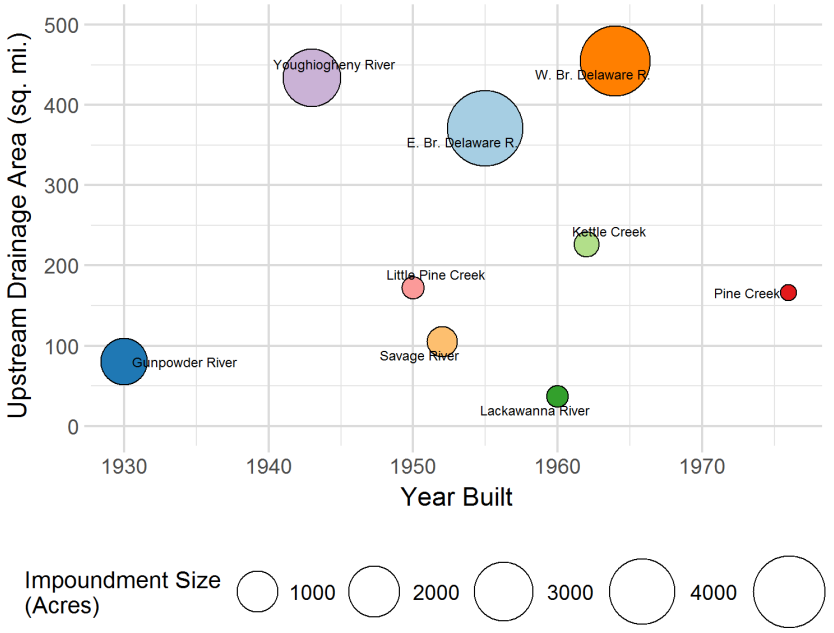
Collaborators: Lisa Kunza (South Dakota School of Mines and Technology) & Dan Spooner (Lock Haven U)

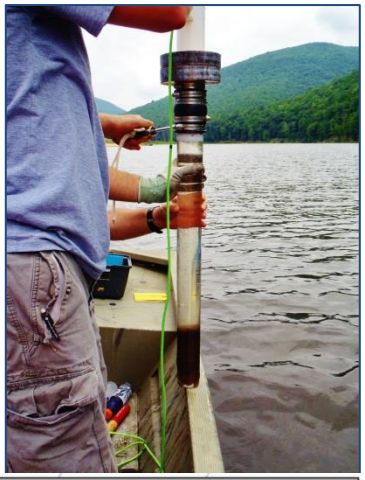
Paleolimnological study





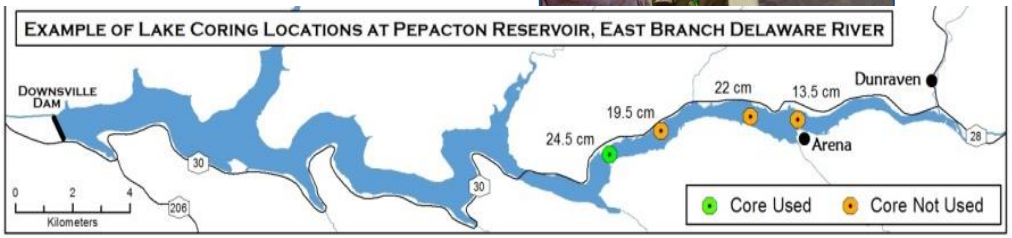
- Nine riverine impoundments were identified throughout Pennsylvania, Maryland, and New York.
- Didymo has been recently (since 2007) observed blooming downstream of six impoundments, while didymo has not been detected in the remaining three watersheds.
- The impoundments were built between 1930–1976
  - range in size from 25–5763 acres
  - impound upstream catchments of 37–455 square miles

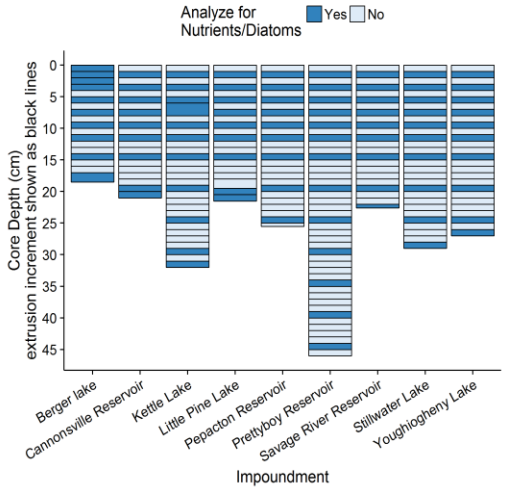
Paleolimnological study

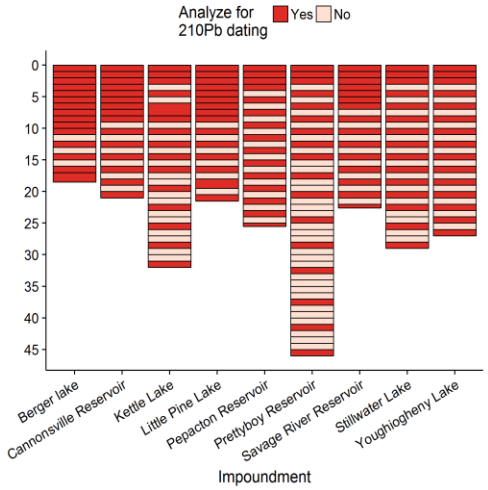


- A messenger operated gravity coring device was used to collect sediment cores from 18.5 – 42.5 cm from the inflowing portion of each reservoir

- Cores were subsampled in 1 cm increments
  - aged (using ^{210}Pb)
  - Examined for diatom presence

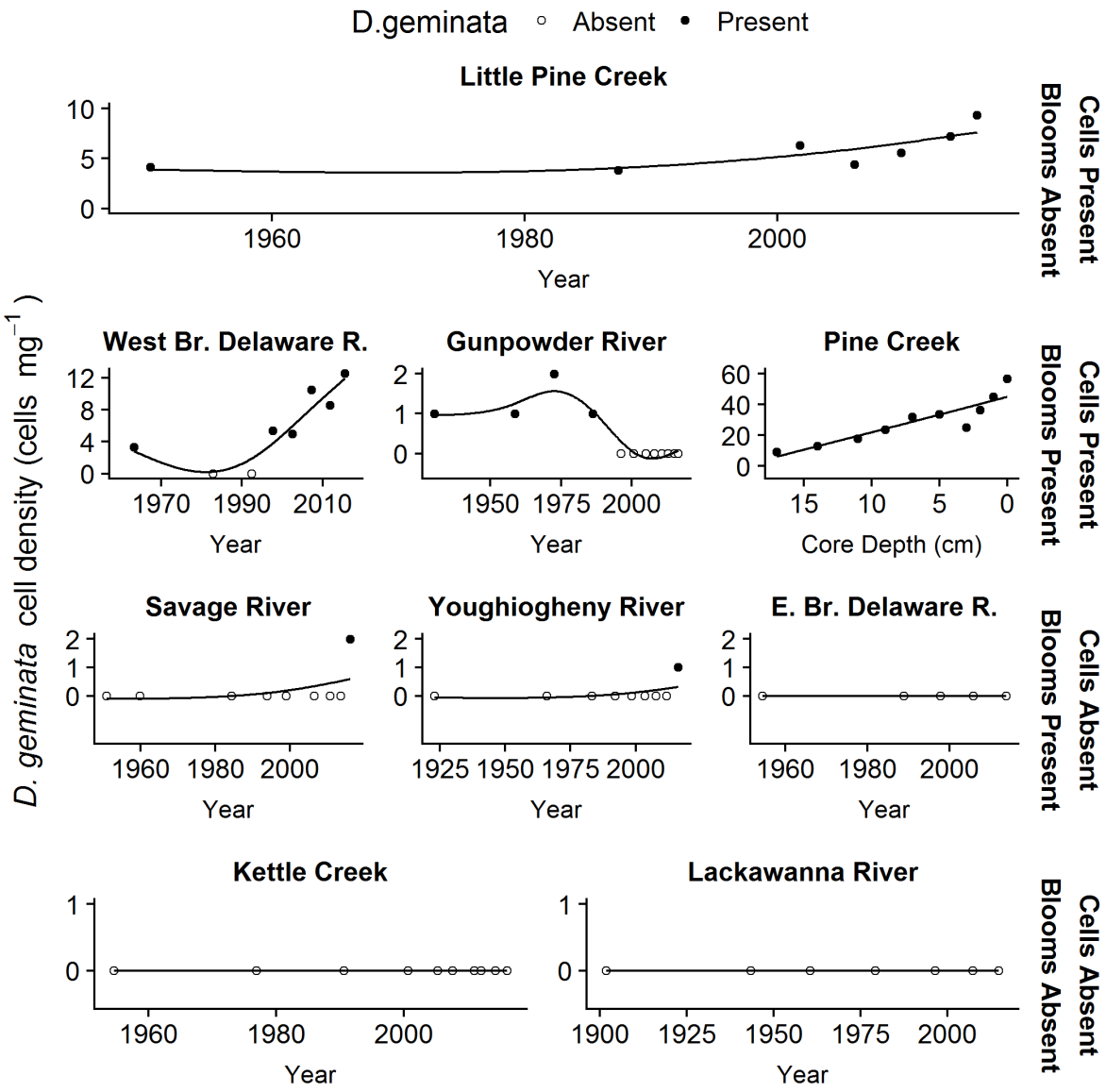






Paleolimnological study

- Results
  - Core material collected back to 1902
  - Didymo found in six lakes; absent in 3
  - Didymo often increasing in abundance through time
  - Sometimes didymo only recently found in sediments (after blooms have been observed DS)

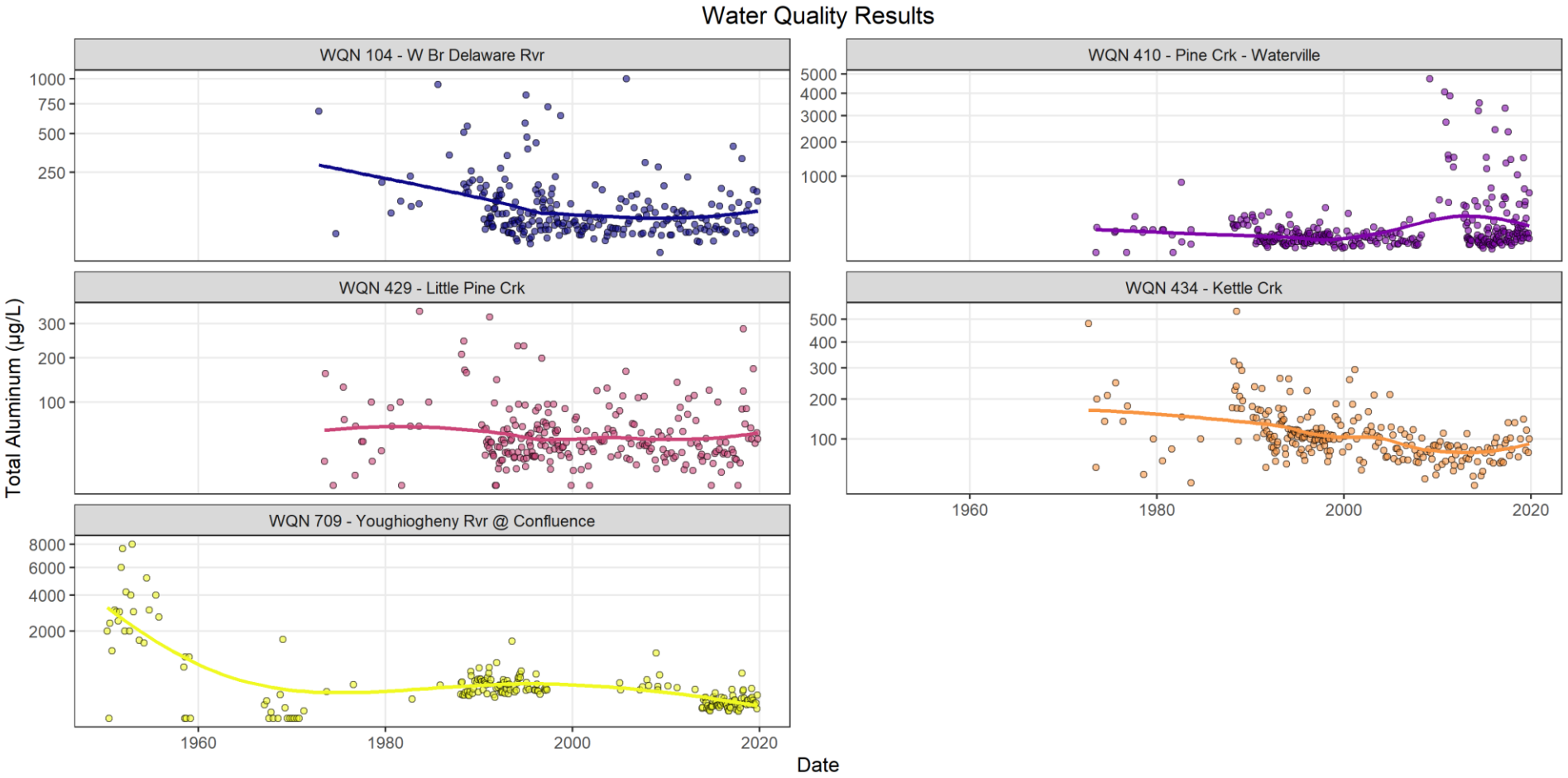


Paleolimnological study

- So, didymo has been in these systems for *nearly a century*.
- WHY HAS IT ONLY BECOME A RECENT ISSUE?
- PA has an extensive water quality monitoring program that has been operating in some locations since the mid 20th century
  - Data available at 5/9 locations with coring data
  - Evidence of changing water quality via flow adjusted Mann-Kendall trend tests

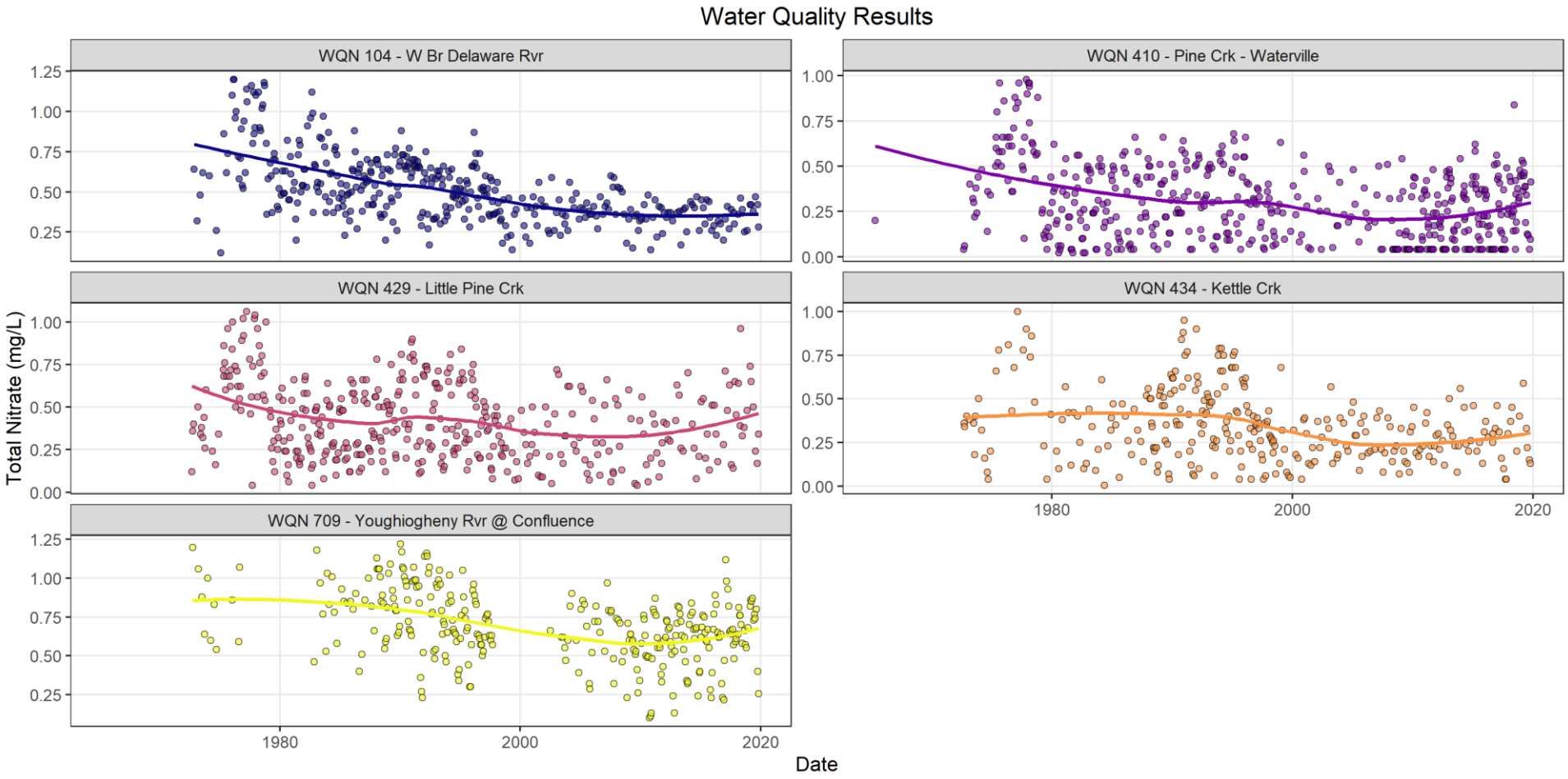
Paleolimnological study

- Consistent reductions in **metals and nutrients** parameters
  - 5/5 sites with significant decreases in Total Aluminum



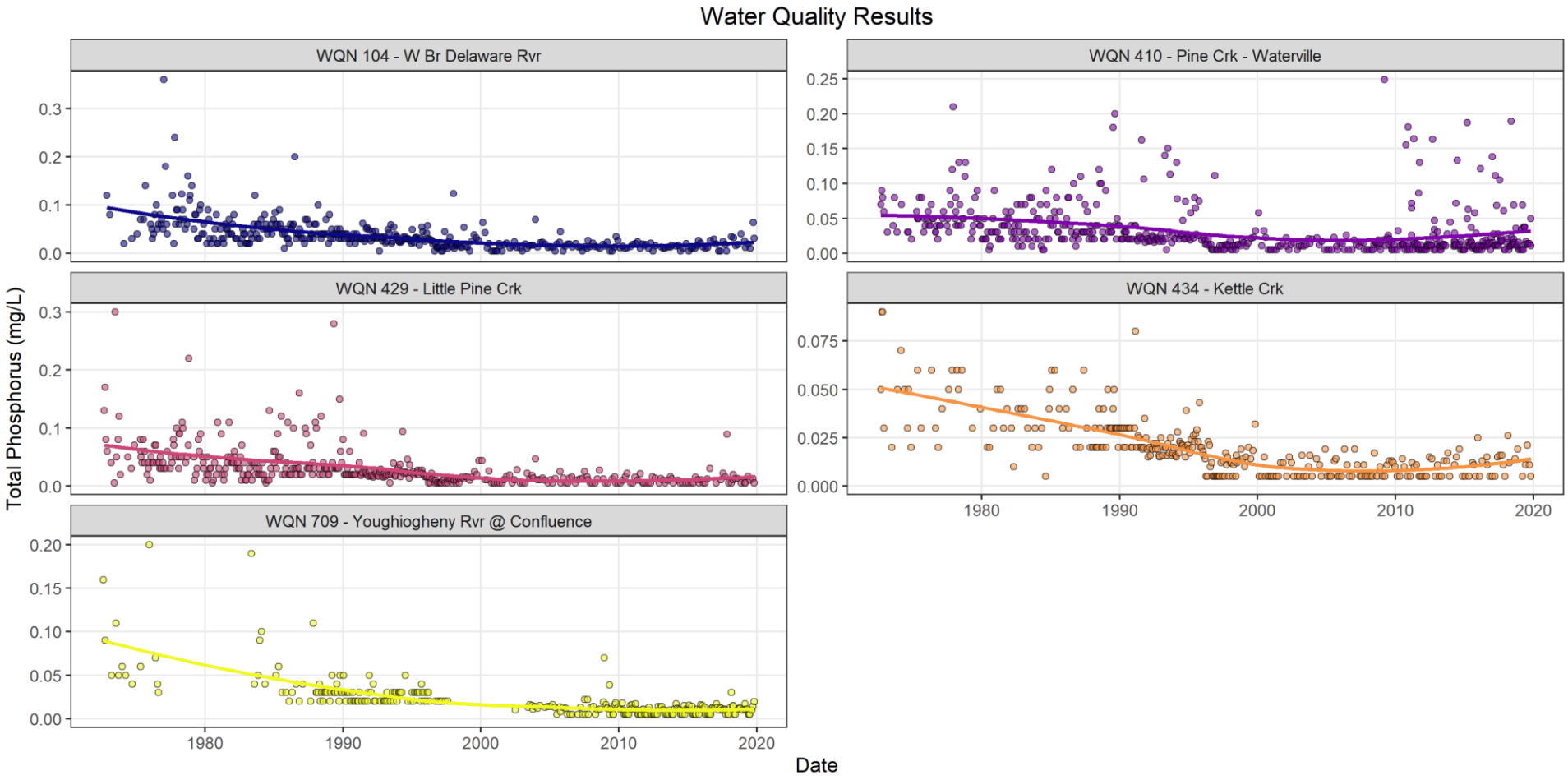
Paleolimnological study

- Consistent reductions in **metals and nutrients** parameters
  - 5/5 sites with significant decreases in Nitrate



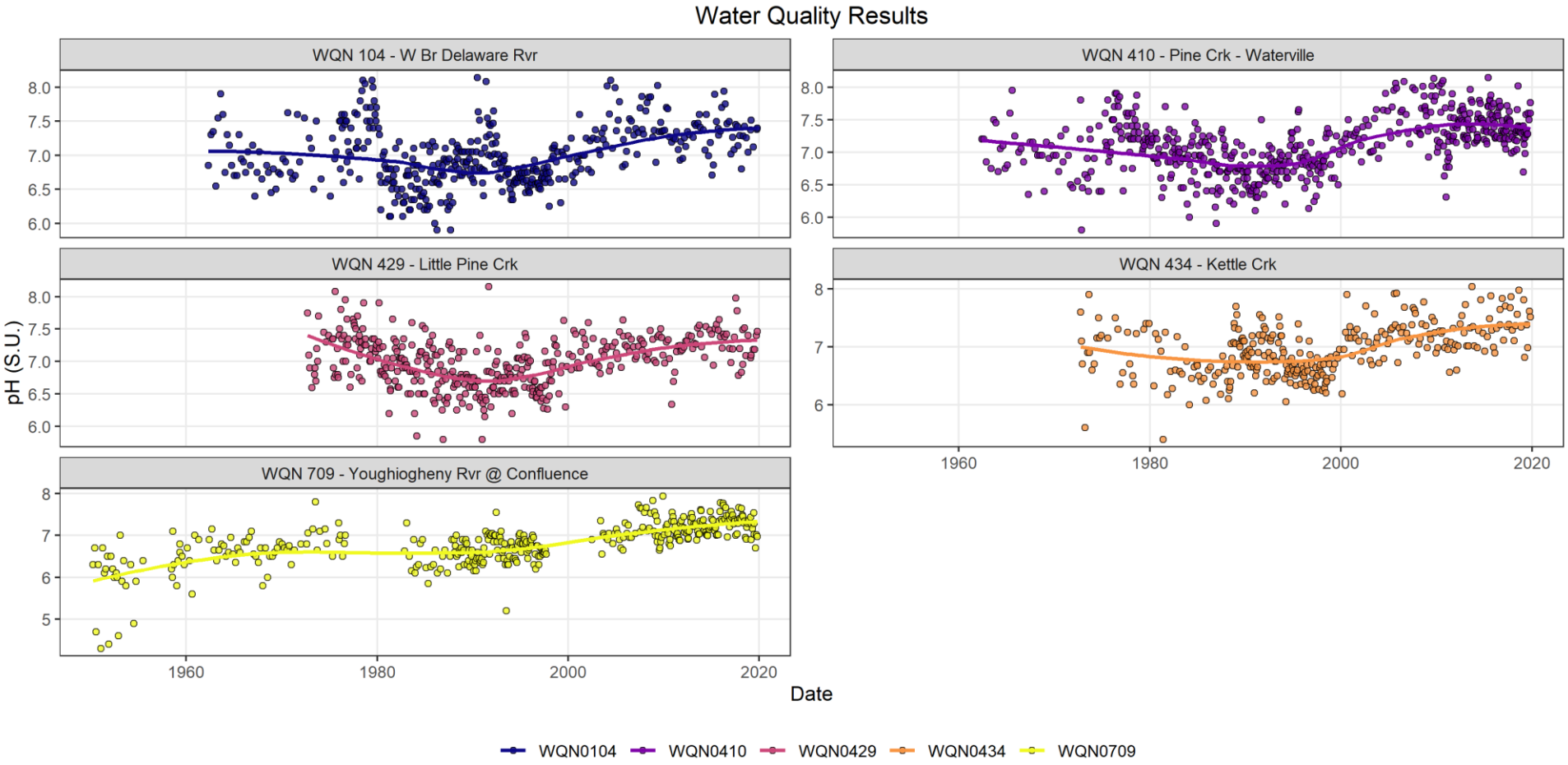
Paleolimnological study

- Consistent reductions in **<u>metals and nutrients</u>** parameters
  - 5/5 sites with significant decreases in Total Phosphorus



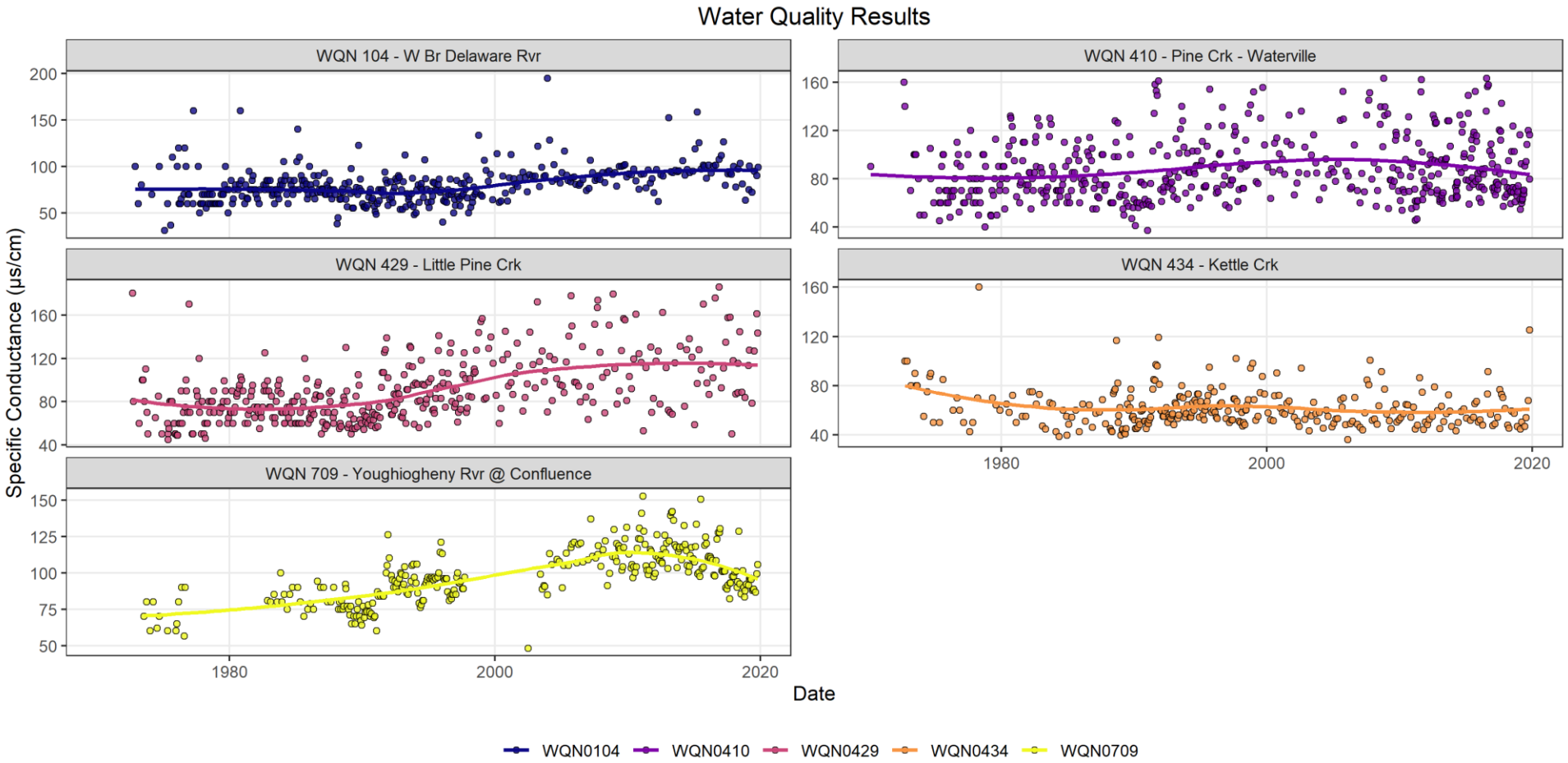
Paleolimnological study

- Consistent increases in **Freshwater Salinization Syndrome** parameters
  - 5/5 sites with significant increases in pH



Paleolimnological study

- Consistent increases in **Freshwater Salinization Syndrome** parameters
  - 4/5 sites with significant increases in specific conductance



Paleolimnological study

- Magnitude of increases/decreases?
  - Example: WQN 104 - W. Br. Delaware R.
  - Dataset: 1972 - 2019

Parameter_units	por	n	mean_sd	Z	S	Tau	P	TrendResult	Sens_slope	Slope_95	SensP	Sens_estimate
Aluminum Total (ug/l)	46.9	246	128.5 ± 201.924	-5.5	-6831.5	-0.23	0	Negative	-0.19	-0.298 - -0.1	0	-46.714
Ammonia as N Total (mg/l)	46.9	398	0.034 ± 0.075	-9.1	-24179.2	-0.31	0	Negative	0	0 - 0	0	-0.017
Nitrate as N Total (mg/l)	46.9	397	0.524 ± 0.221	-12.9	-34008.5	-0.43	0	Negative	-0.001	-0.001 - -0.001	0	-0.425
Phosphorus Total (mg/l)	46.9	395	0.049 ± 0.161	-15.5	-40566.4	-0.52	0	Negative	0	0 - 0	0	-0.052
Sulfate Total (mg/l)	57.5	434	8.546 ± 6.18	-9.6	-28840.4	-0.31	0	Negative	0	0 - 0	0	0
Hardness Total (mg/l)	57.5	425	24.62 ± 11.694	-1.7	-4819.2	-0.05	0.082	No Trend	0	0 - 0	0.005	0
pH (ph units)	57.5	439	7.006 ± 0.455	5	15228.9	0.16	0	Positive	0.001	0.001 - 0.001	0	0.403
Specific Conductance (umhos/cm)	46.9	398	81.924 ± 29.522	9.4	23488.3	0.3	0	Positive	0.058	0.045 - 0.071	0	23.236

Paleolimnological study

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