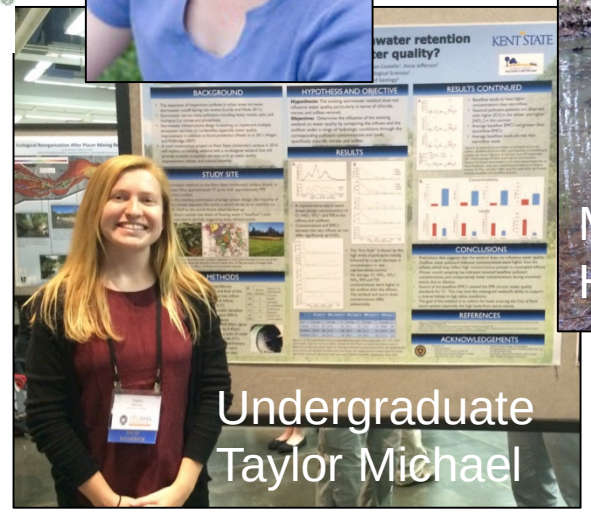
Urban Stormwater Wetlands as Novel Biogeochemical Systems: Elevated Salt and Sulfate

Lauren Kinsman-Costello, Anne Jefferson, Pedro Avellaneda, Hayley Buzulencia, Laura Sugano, and Taylor Michael

12th International Symposium on Biogeochemistry of Wetlands. April 23-26, 2018. Coral Springs, Florida, USA.

Anne Jefferson
KSU Geology



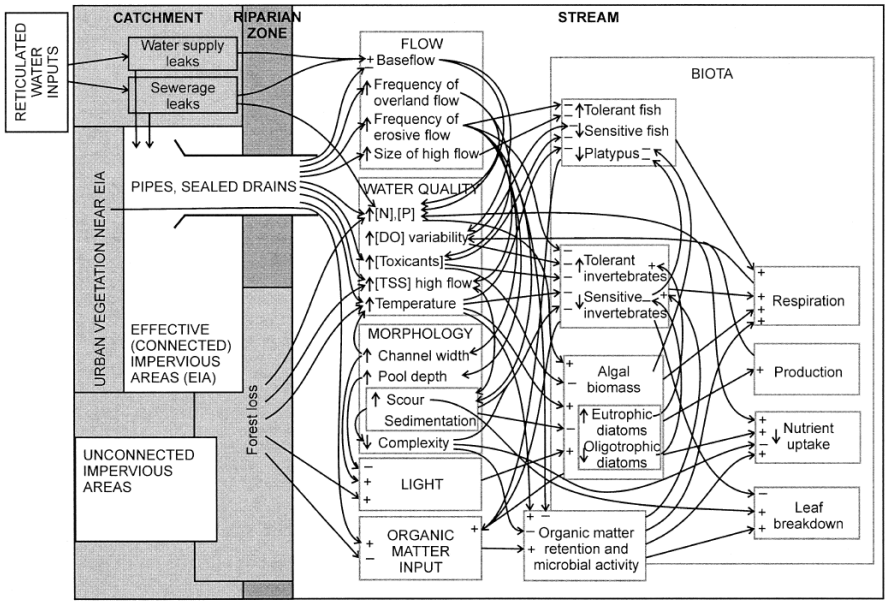
Funding:

-Kent State University
-Cleveland Metroparks Emerald Necklace Endowment Fund

Student Support: Jillian Sarazen, Jaynell Nicholson, Carlyn Mitchell, Olivia Mullen, Riley Weatherholt, Noel Miavez and ALL the Kent State University *Water Quality Quest Volunteer Scientists*!

Urban Aquatic Ecosystems are different

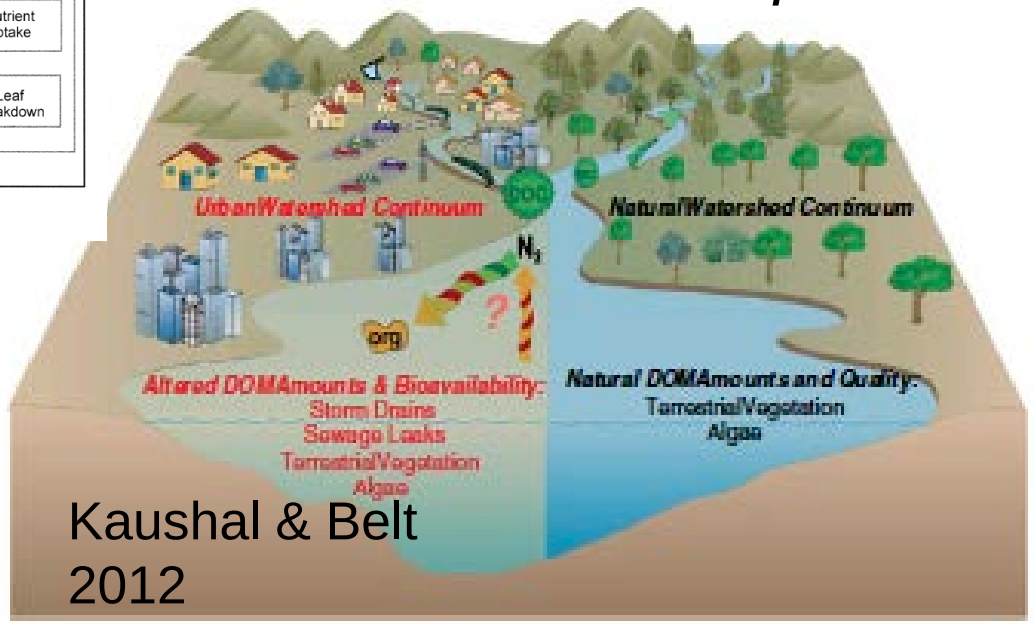
Urban Stream Syndrome



Walsh et al. 2005

Urban Stream Ecology

Urban Watershed Continuum Concept



Kaushal & Belt 2012

What about wetlands?

Urban Wetlands & Water Quality

- Ubiquitous
- Relied on & invested in for water quality
- Understudied

Northeast Ohio Urban Wetlands:

Assessing hydrologic and water quality function

http://www.gcbl.org/explore/water/rivers/cuyahoga-river

Cleveland Metroparks' Watershed Stewardship Center "Working Wetland"

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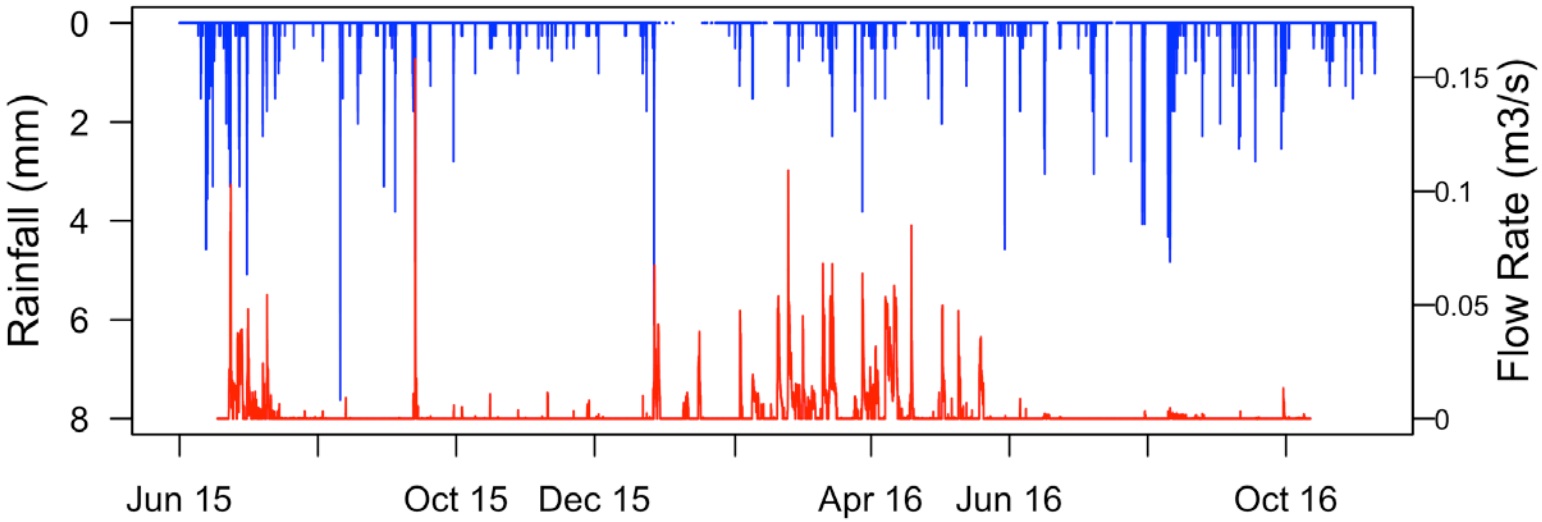
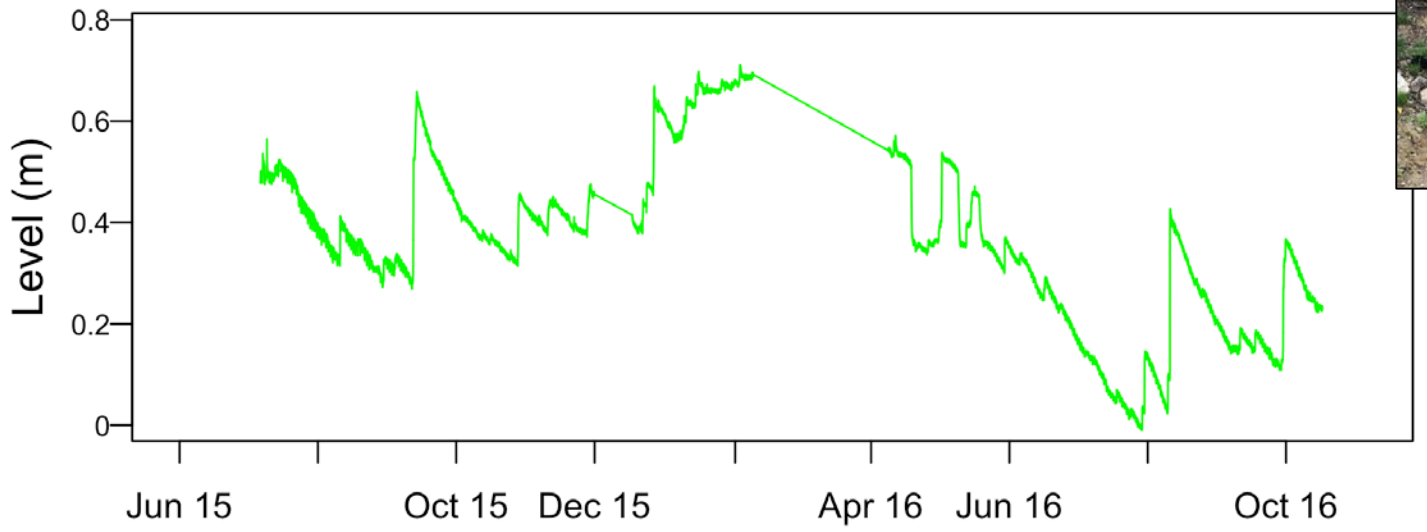
Inflows & Outflows

Monitored Hydrology and Water Quality
June 2015-October 2016

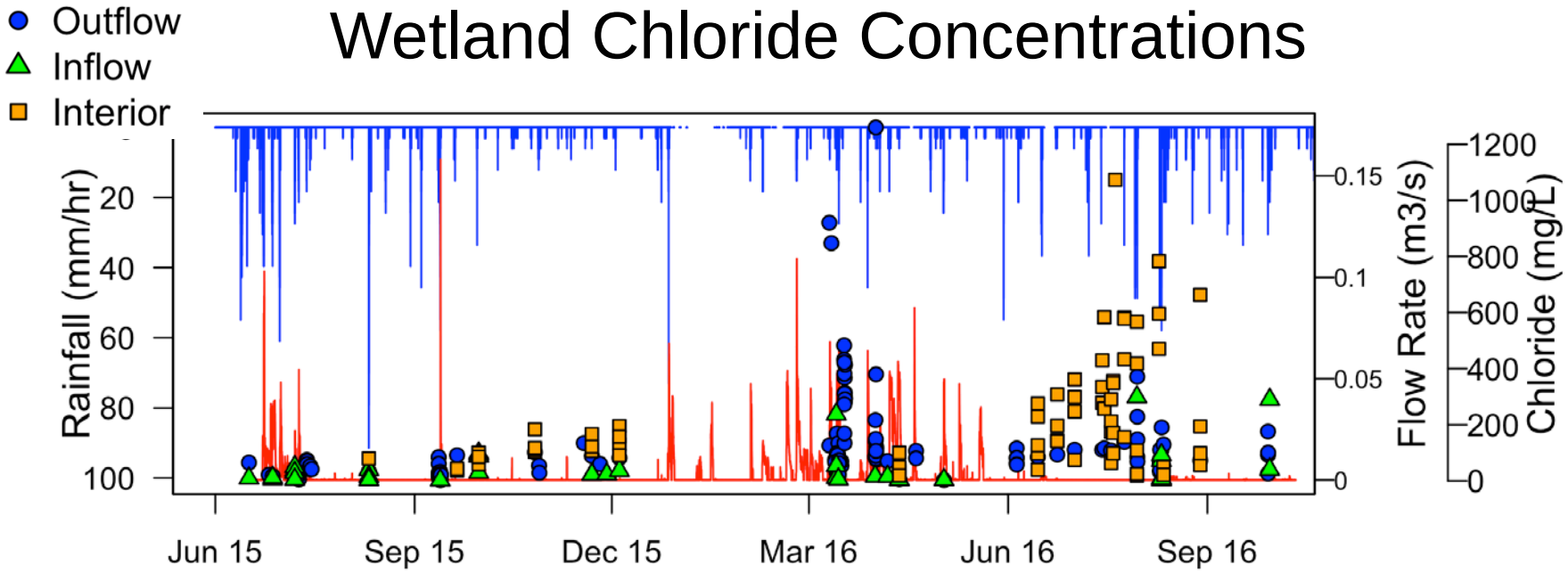
Google earth

“Working Wetland” Water Quality



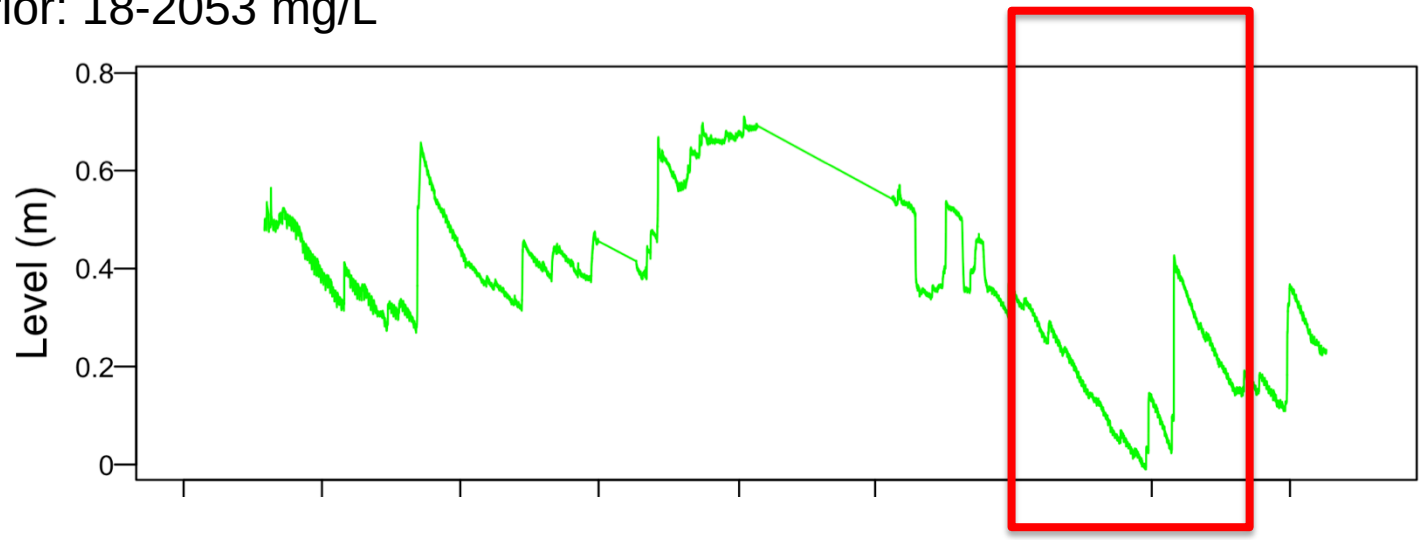


Wetland Chloride Concentrations



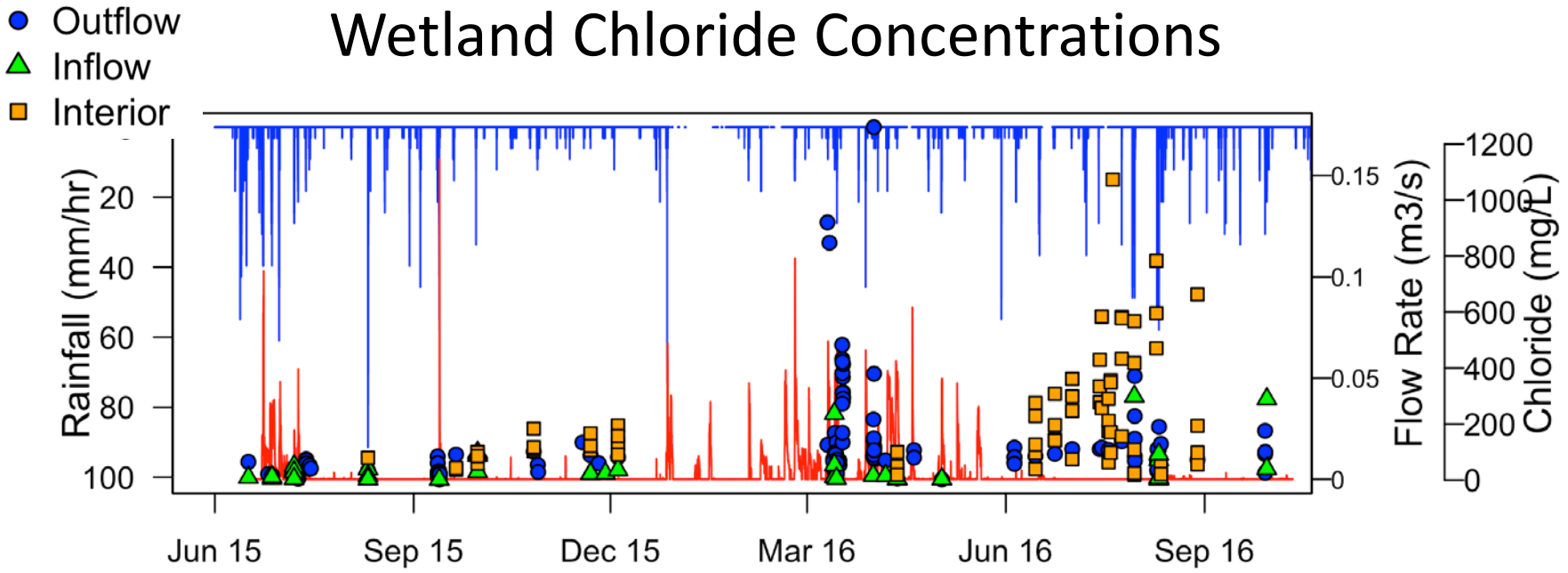
Outflow: 3-1260 mg/L
Inflow: 2-492 mg/L
Interior: 18-2053 mg/L

Evaporative Concentration



Summer 2016: Extreme Drying & Reflooding

Wetland Chloride Concentrations

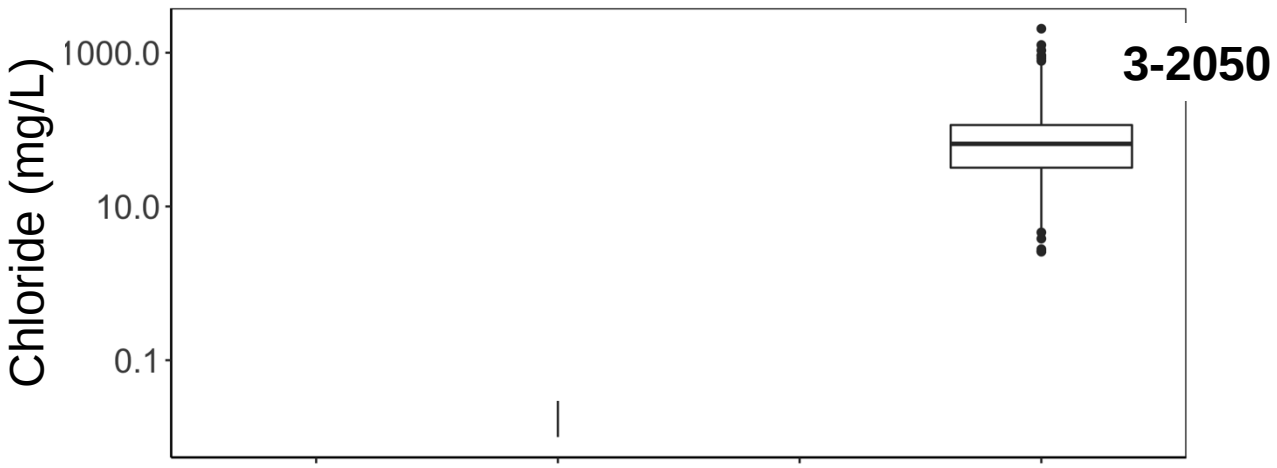


EPA Freshwater toxicity criteria:

chronic = 230 mg/L

acute = 860 mg/L

Chloride (Cl^-): Rural to Urban Comparison



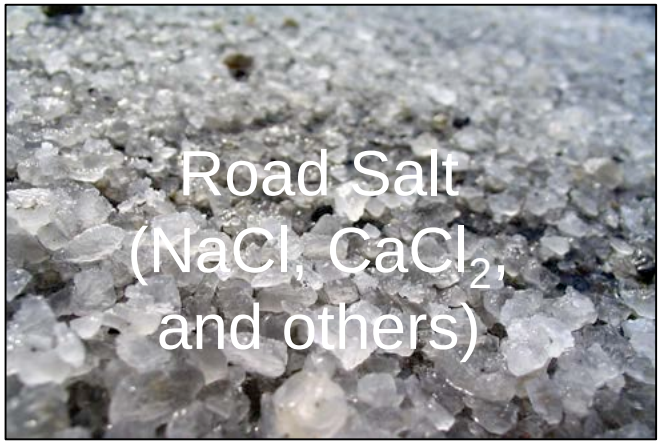
NE Ohio Urban

# of Wetland Sites:

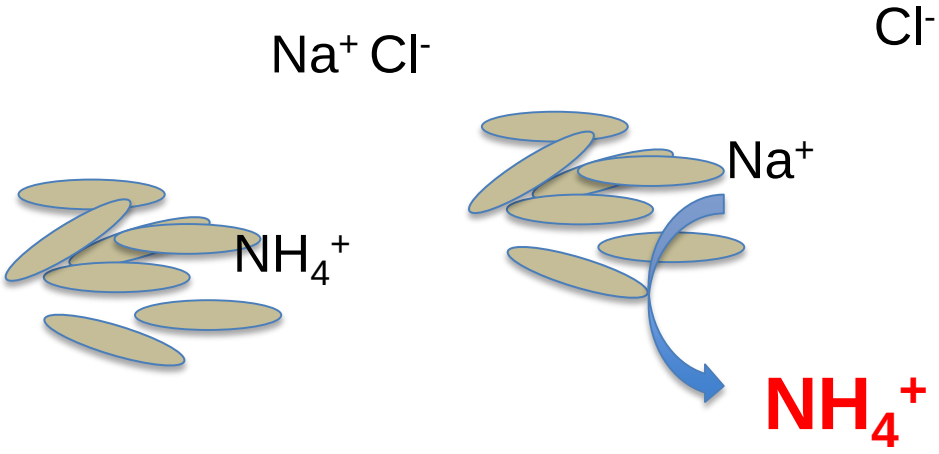
27

N=382

Biogeochemical effects of salt?



Organismal toxicity

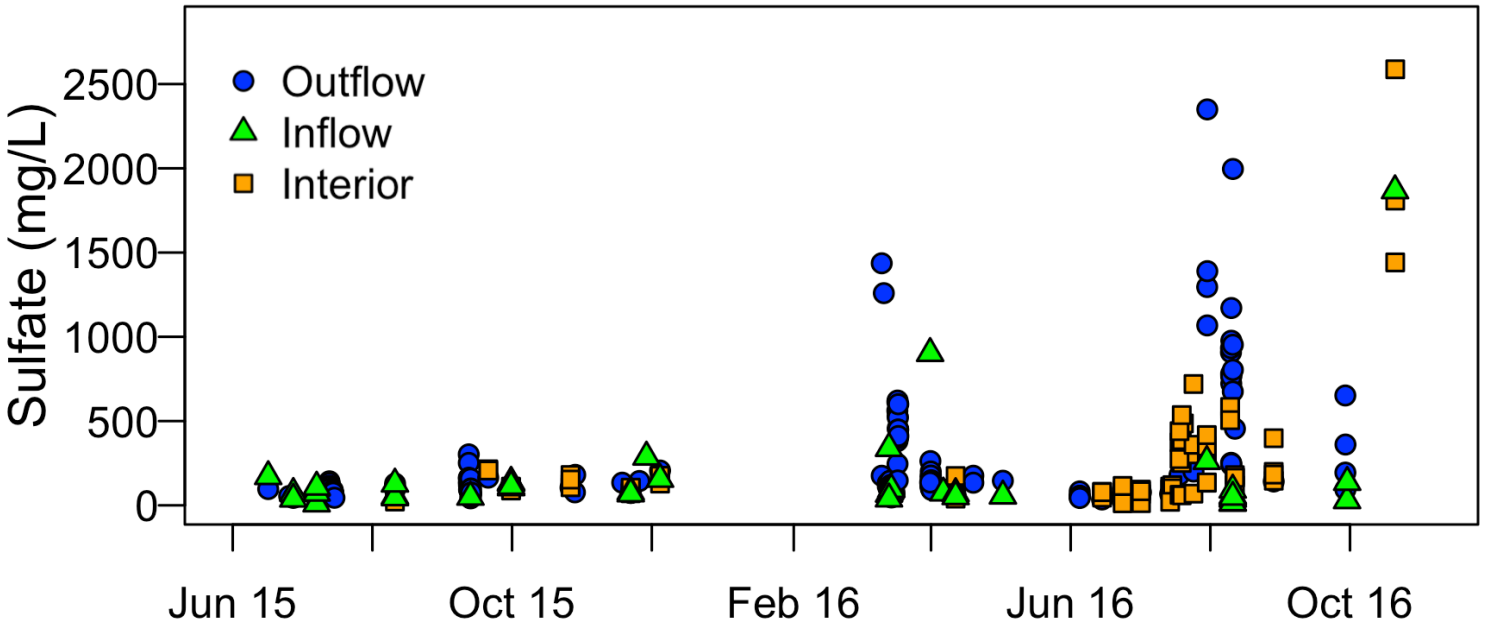


N release due to cationic exchange

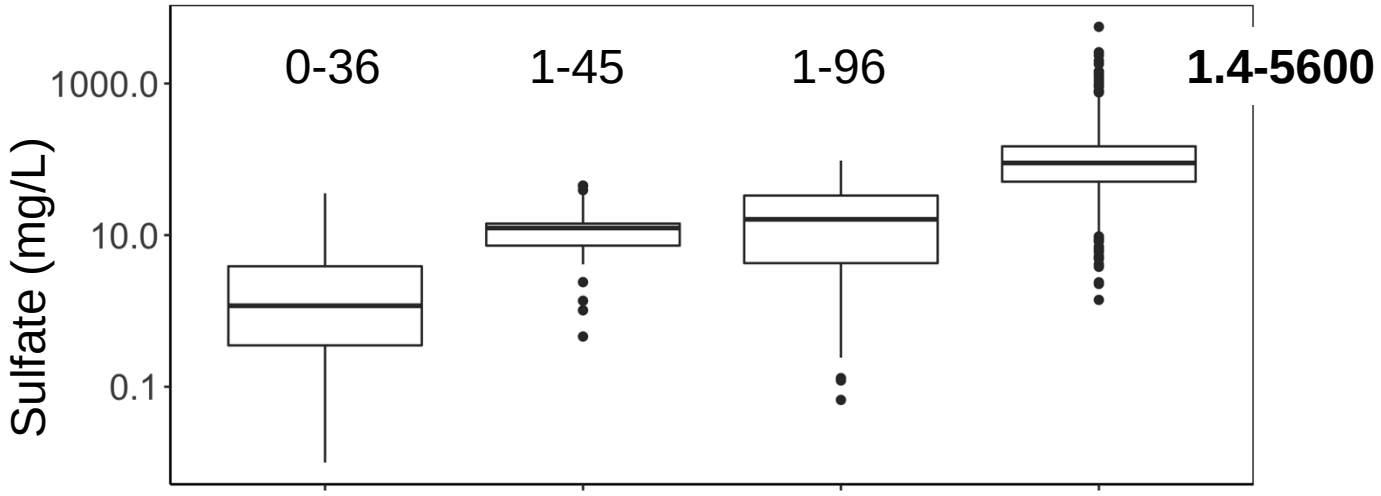
P?

Effects on P retention (e.g., phosphate sorption) are unknown

Wetland Sulfate Concentrations



Sulfate (SO_4^{2-}): Rural to Urban Comparison



# of Wetland Sites:	1	24	46	27
	N=298	N=50	N=98	N=382

Cascading effects of high sulfate?

Toxicity

NO_3^- → N_2O, N_2

Inhibits denitrification

SO_4^{2-} —(*Anoxic conditions*; Sulfate reduction)→ H_2S, HS^-

Sulfate

Sulfide

FeS PO_4^{3-}

Iron binding & P release

CuS NiS

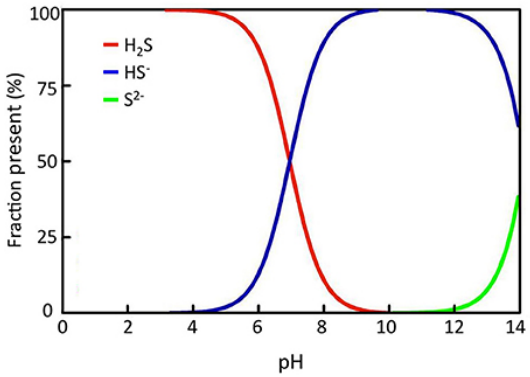
Metal binding & detoxification

$MeHg^+$

Mercury methylation

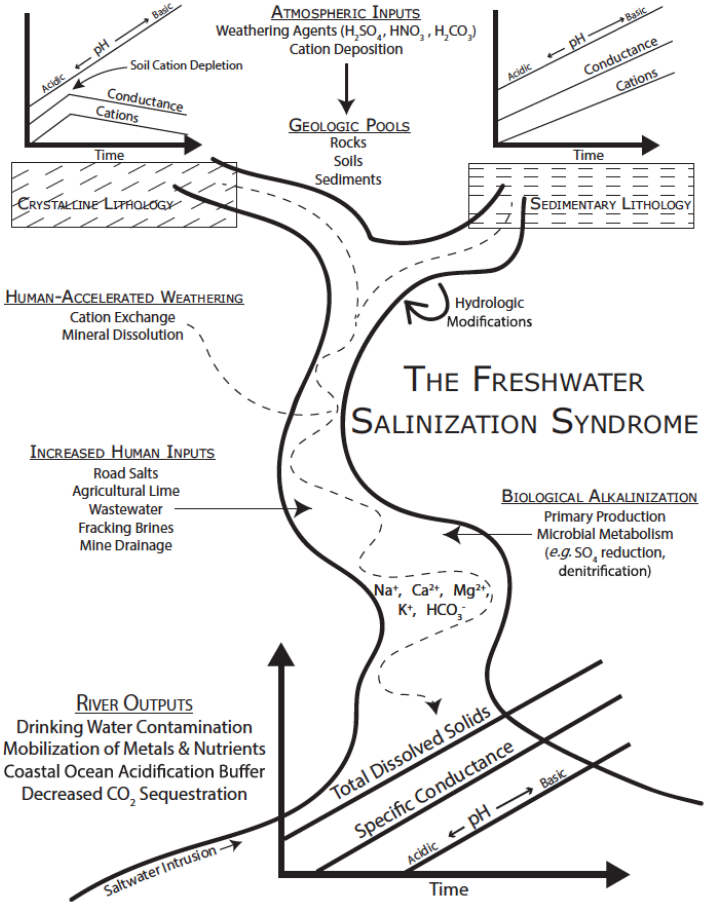
CO_2 → CH_4

Inhibits methanogenesis



Emerging Hypothesis

- In urban wetlands, the biogeochemical rules are the same, but the players are different:
  - "Freshwater Salinization Syndrome"
- Novel urban chemical stressors may *lessen wetlands' nutrient removal capacity*
  - N release due to Na cationic exchange
  - P release due to S binding with Fe



Kaushal et al. 2018

- Better understanding of urban wetland biogeochemistry will help:
  - to quantify services & disservices under management scenarios
  - Set realistic goals

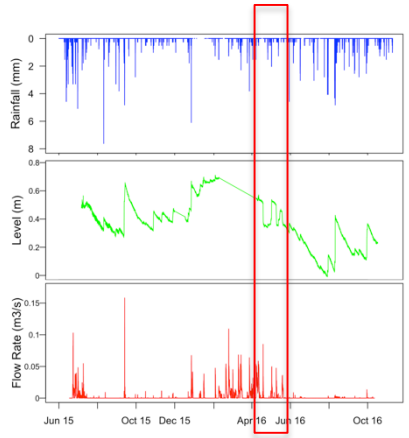

Flooded & Connected
September 16, 2015


Dry & Disconnected
July 15, 2016

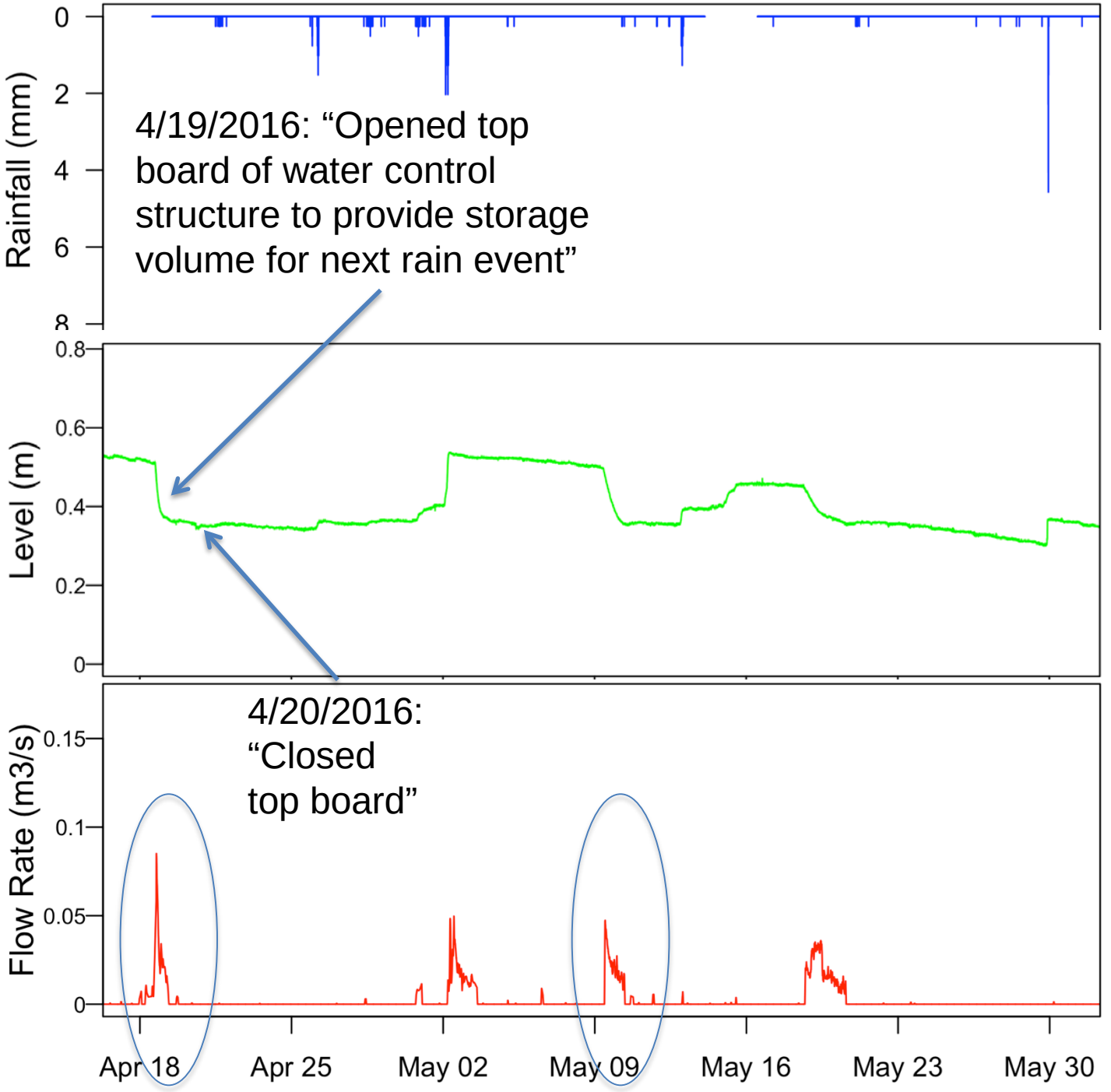

Extreme Drying
September 27, 2017

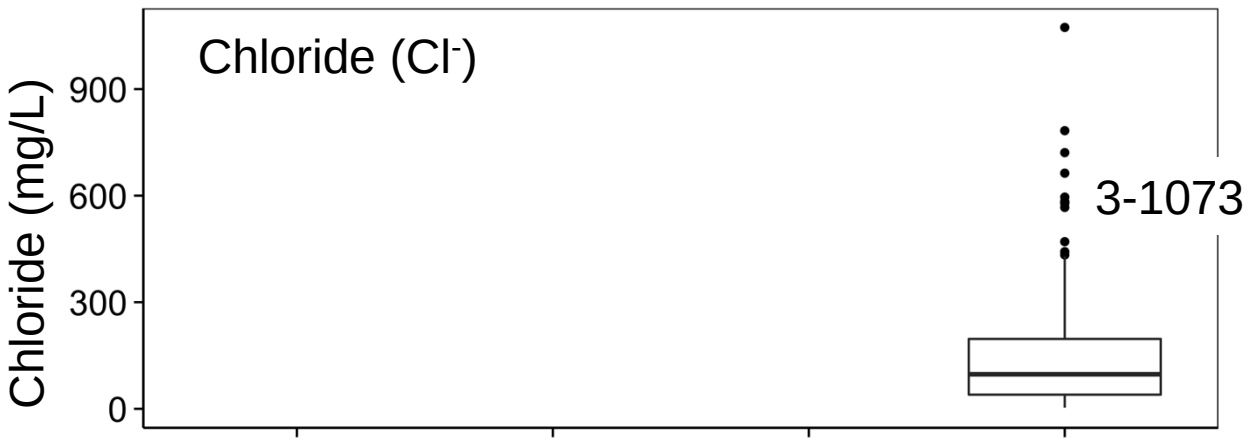
Where are Cl & SO4 coming from?

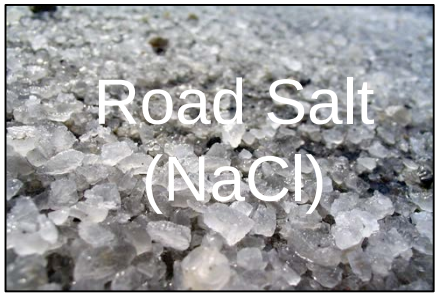
Evidence for S in wetland: CMP high Acid Volatile Sulfides



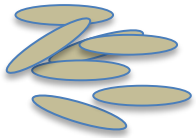
Discharge events w/ no associated rain events







Na^+ Cl^-



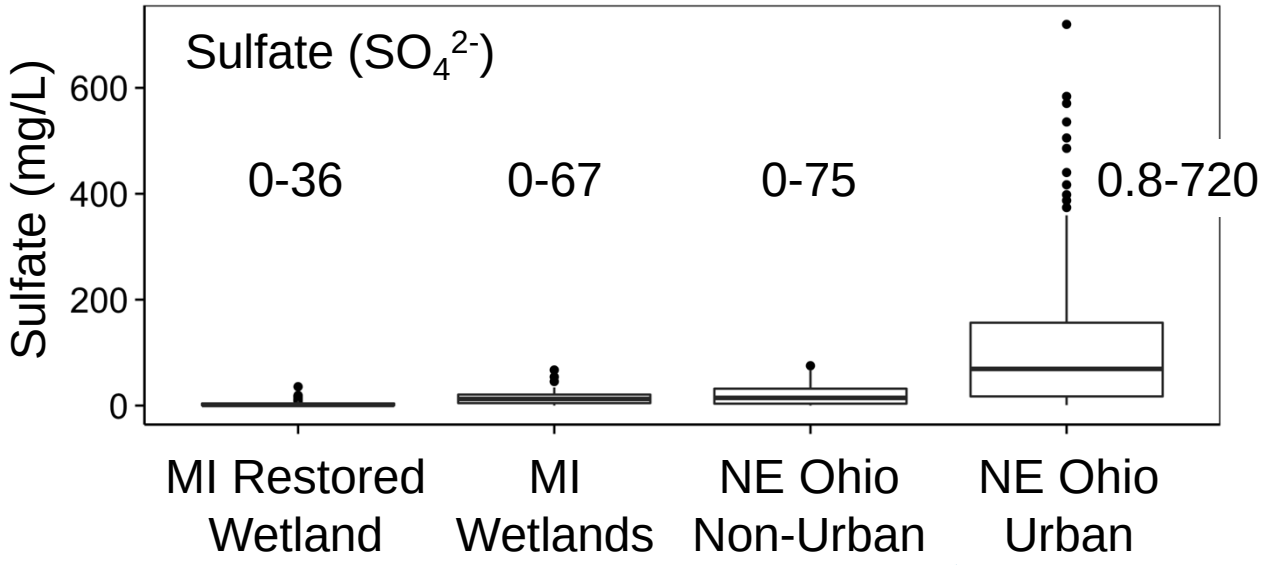
Cl^-

NE Ohio
Urban

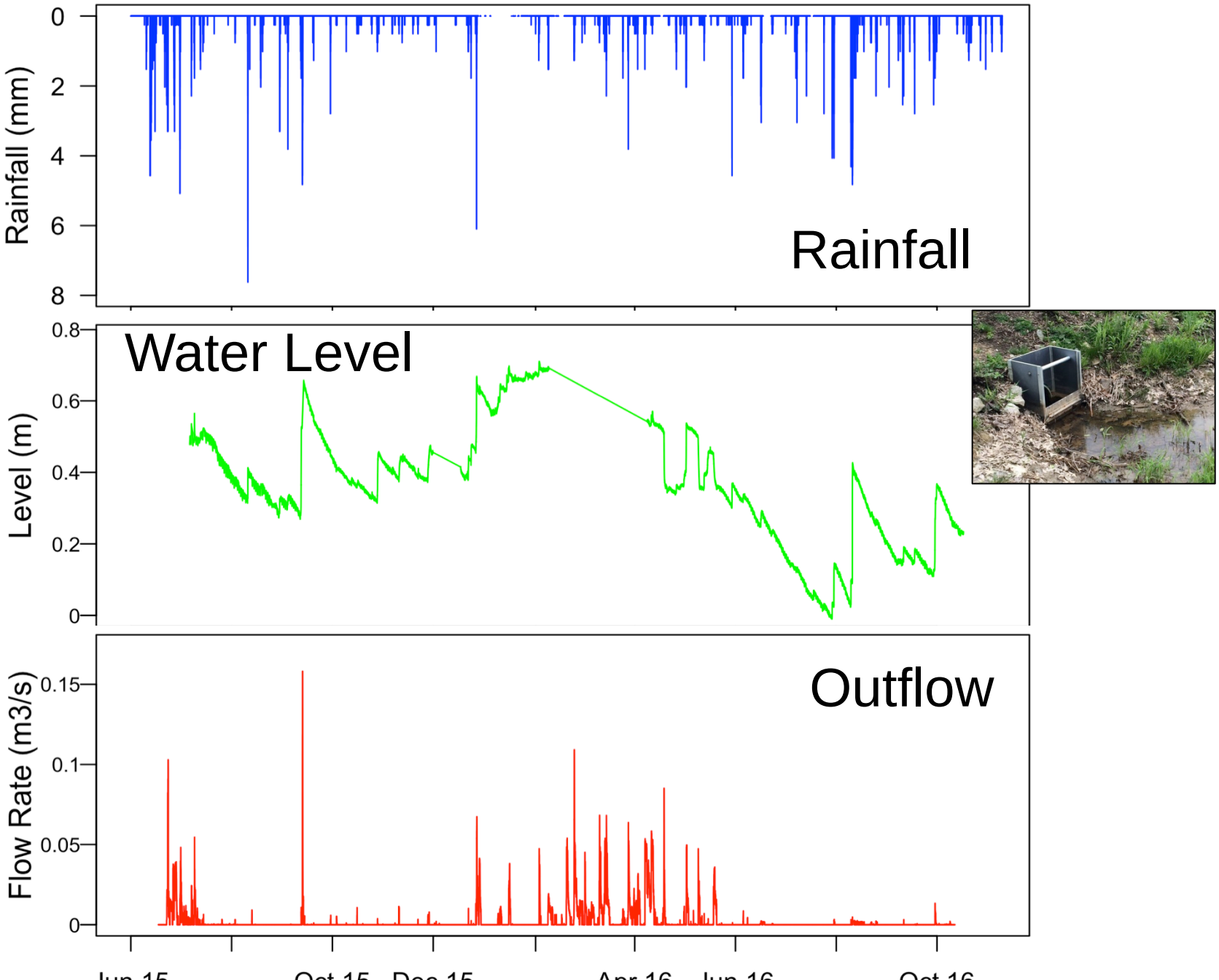
# of Wetland Sites:

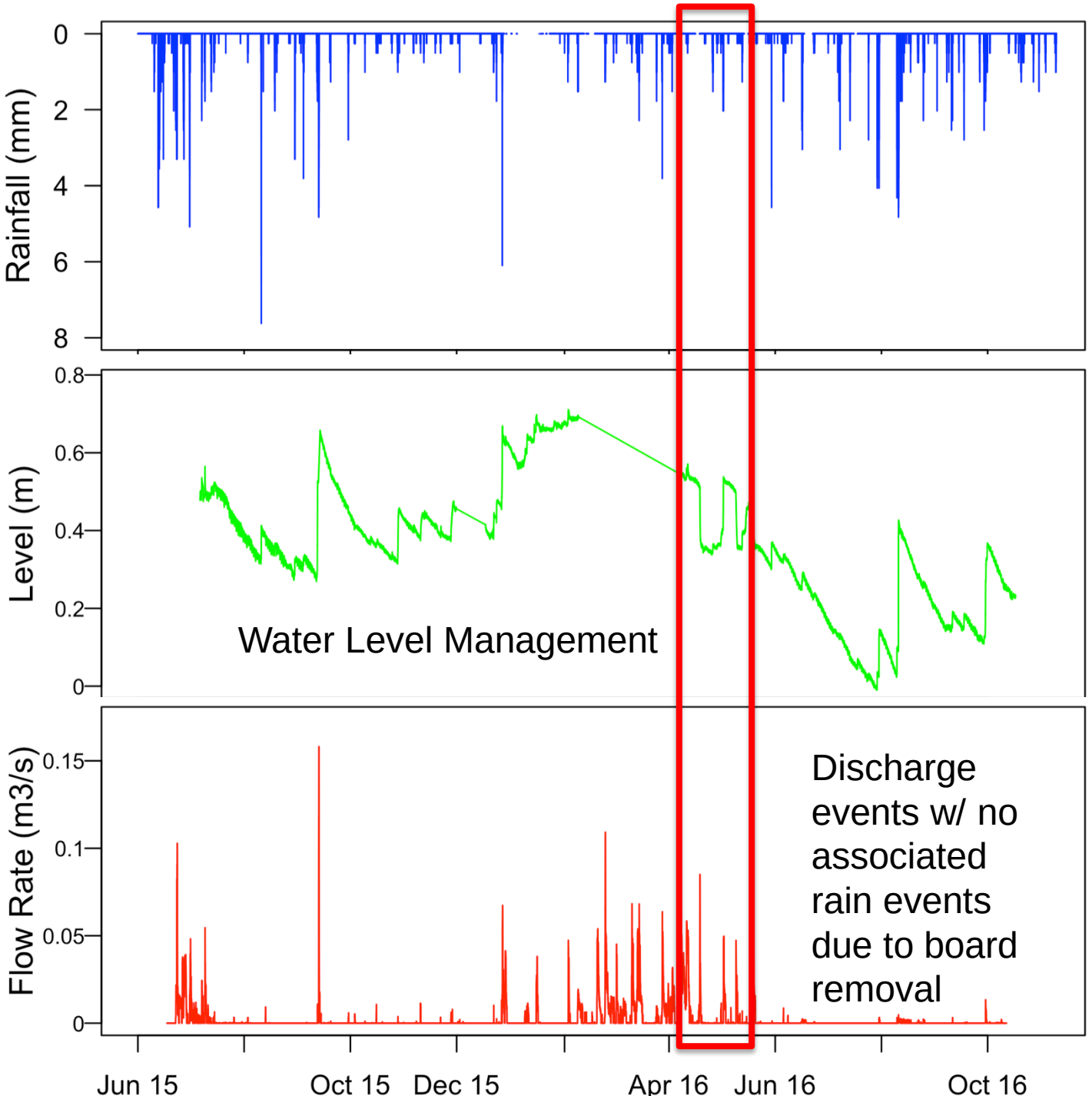
27

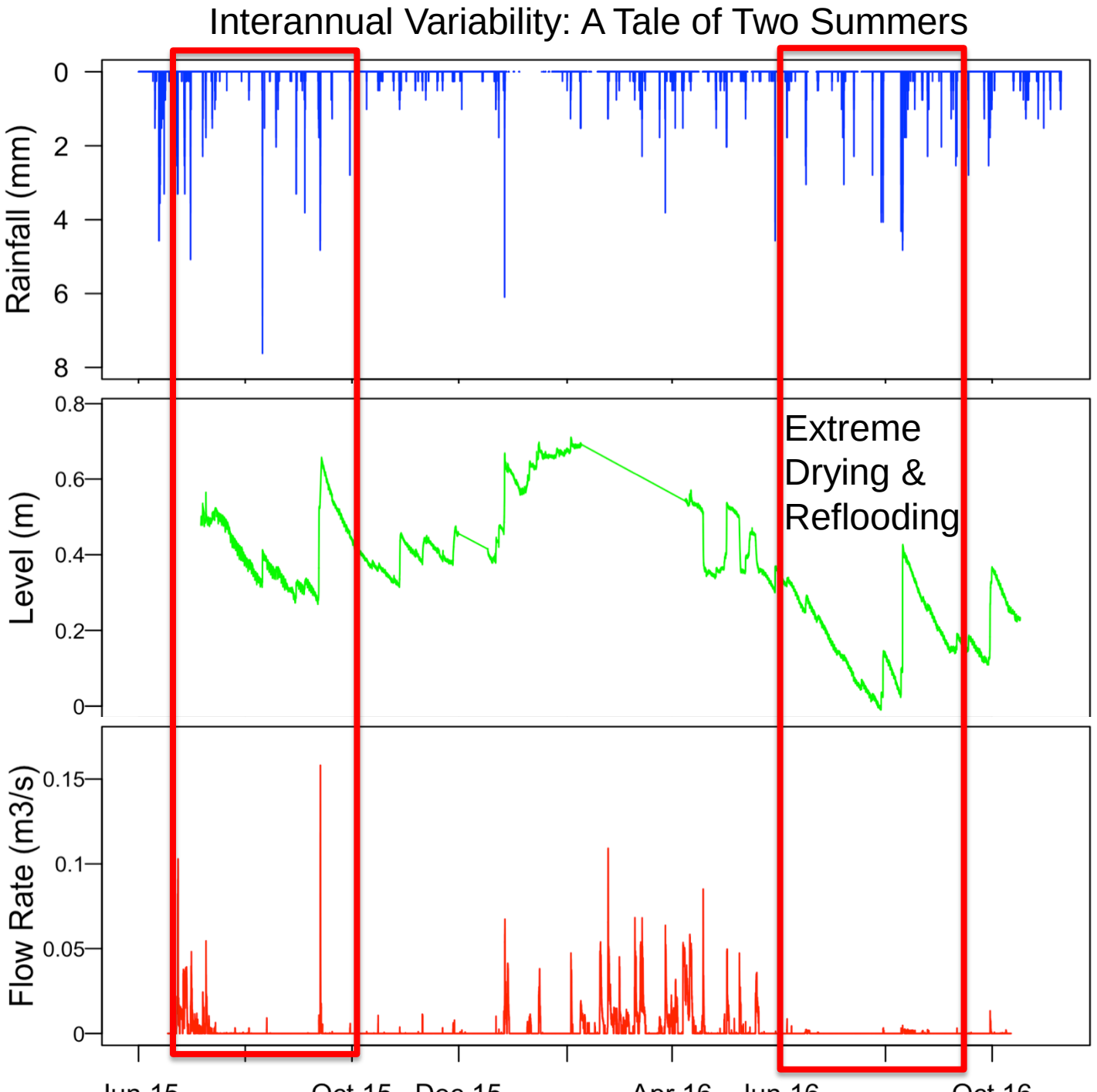
N=141



# of Wetland Sites:	1	24	46	27
	N=357	N=104	N=77	N=141


Rainfall (mm)
0
2
4
6
8
Rainfall
Water Level
Level (m)
0.8
0.6
0.4
0.2
0
Flow Rate (m3/s)
0.15
0.1
0.05
0
Outflow
Jun 15
Oct 15
Dec 15
Apr 16
Jun 16
Oct 16


Rainfall (mm)
0
2
4
6
8
Level (m)
0.8
0.6
0.4
0.2
0
Water Level Management
Flow Rate (m3/s)
0.15
0.1
0.05
0
Discharge events w/ no associated rain events due to board removal
Jun 15
Oct 15
Dec 15
Apr 16
Jun 16
Oct 16


Interannual Variability: A Tale of Two Summers
Rainfall (mm)
0
2
4
6
8
Level (m)
0.8
0.6
0.4
0.2
0
Extreme
Drying &
Reflooding
Flow Rate (m3/s)
0.15
0.1
0.05
0
Jun 15
Oct 15
Dec 15
Apr 16
Jun 16
Oct 16