THE OHIO STATE UNIVERSITY

# Artificial Floating Island System as a Sustainable Solution for Addressing Nutrient Pollution in Ohio: A Pilot Study

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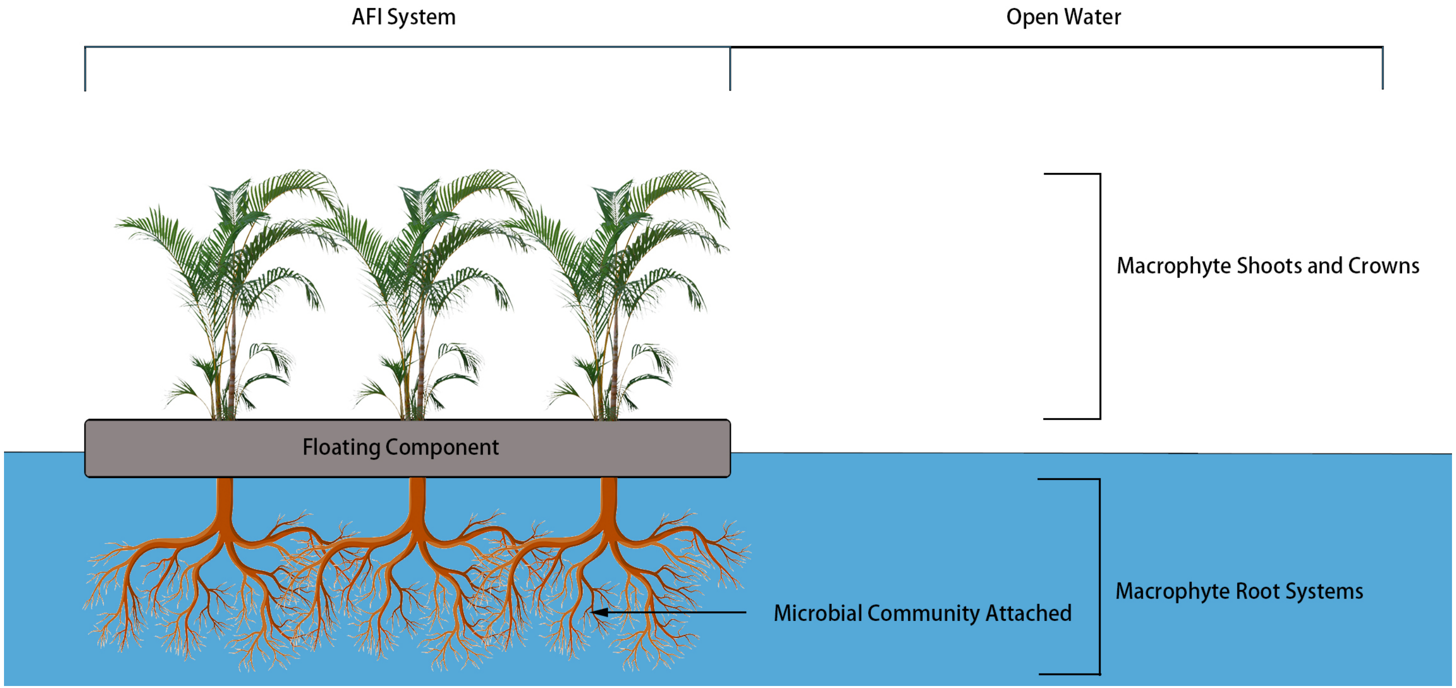
# Introduction

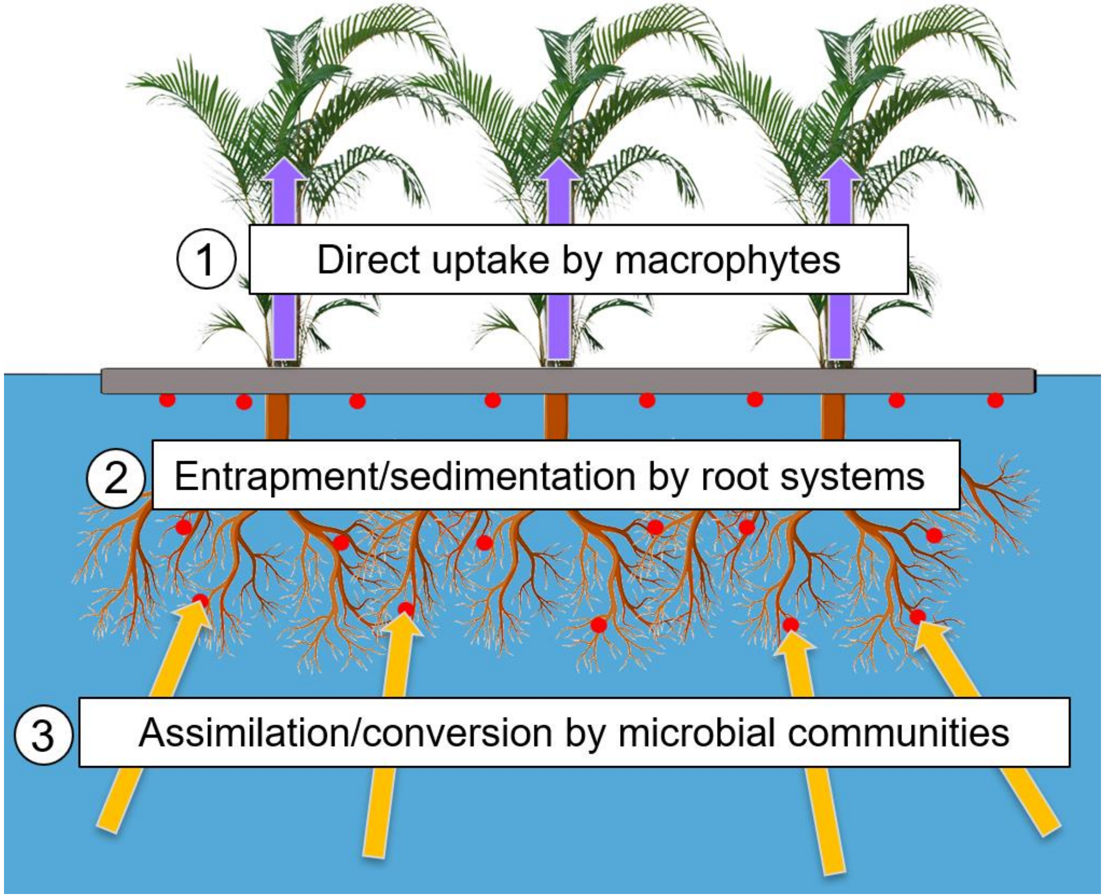
What is Artificial floating island and why is it important?

# What is Artificial Floating Island (AFI)?

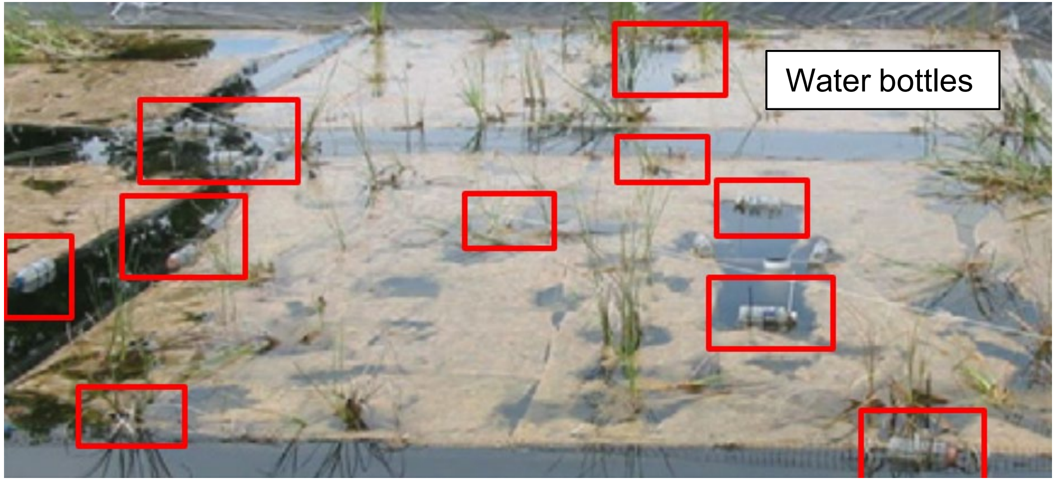
- Phytoremediation strategy
- Tackle water pollution by removing nutrients and other contaminants



# How does AFI work?



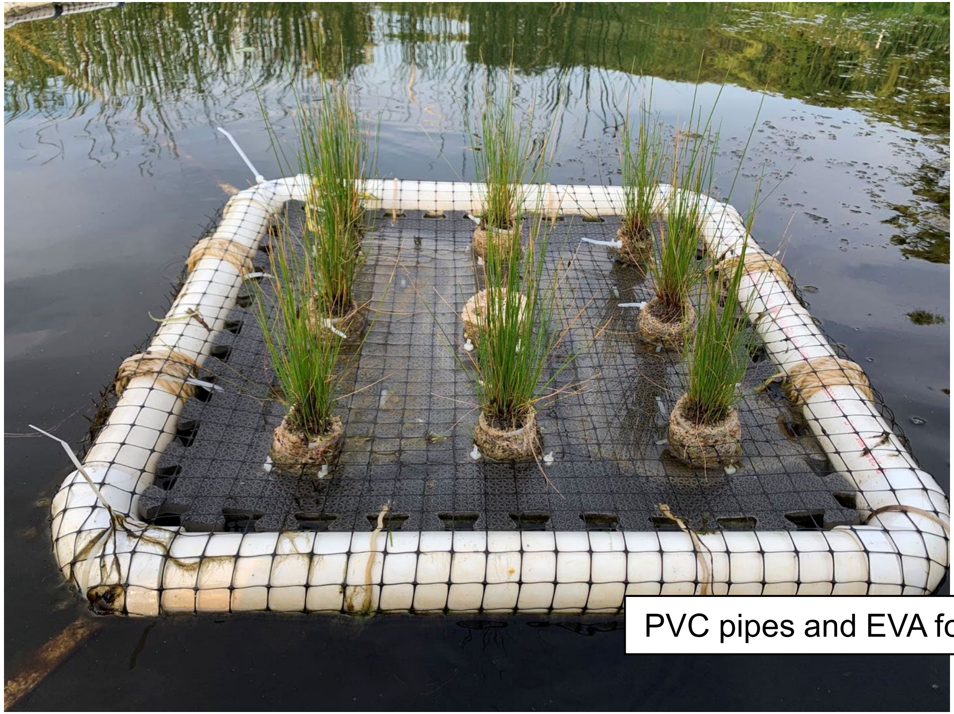
# How are AFIs constructed?






# How are AFIs constructed?

EVA foam



PVC pipes and EVA foam

# Are they efficient?

- Efficiency of AFI systems:
    - Above 90% removal of N and P (Kong et al., 2019; Keizer-Vlek et al., 2014)
    - Up to 85% reduction of TOC (Shahid et al., 2019)
    - Up to 81% removal of Pb and Fe (Kiiskila et al., 2019)
    - Up to 94% removal of caffeine and 89% of ibuprofen (de Oliveira et al., 2019)
    - Up to 93% removal of textile dyes (Chandanshive et al., 2020)
    - Up to 87% reduction of COD; Up to 84% reduction of BOD (Shahid et al., 2019)

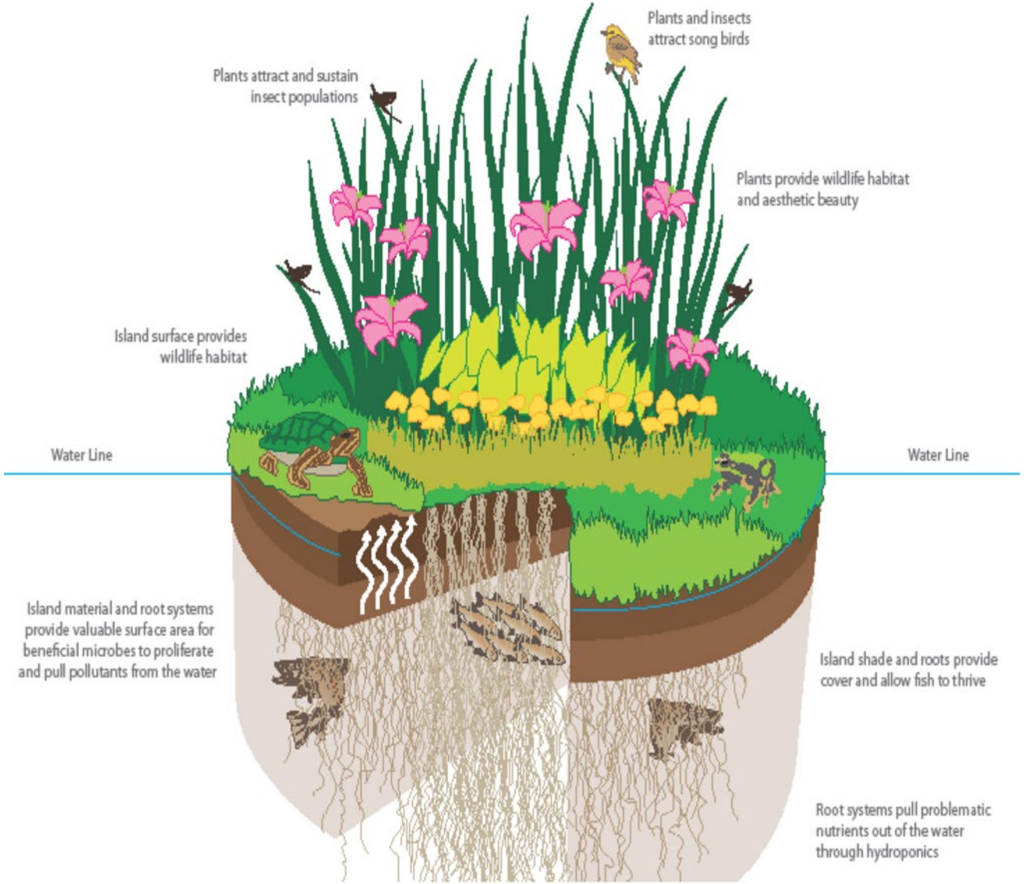
# What else can they do?

- Aesthetic function



# What else can they do?

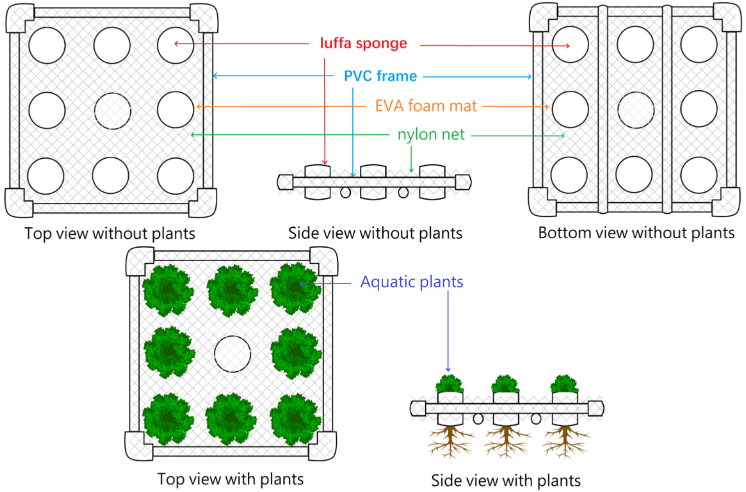
- Improve biodiversity

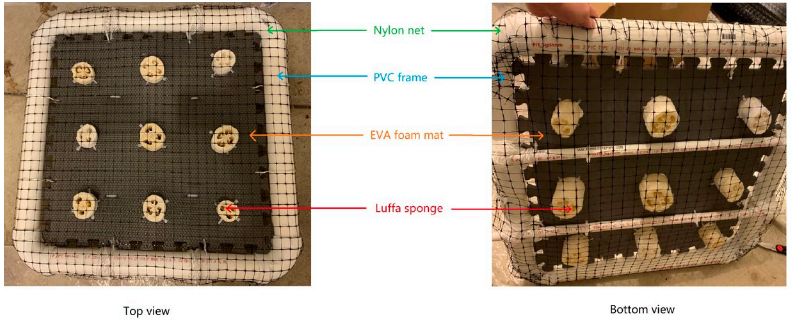


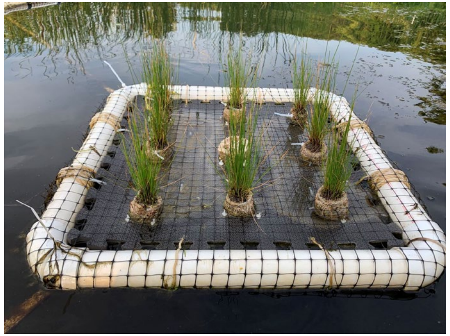
# Methods and Materials

A combination of field experiments and mesocosm experiments

# AFI construction

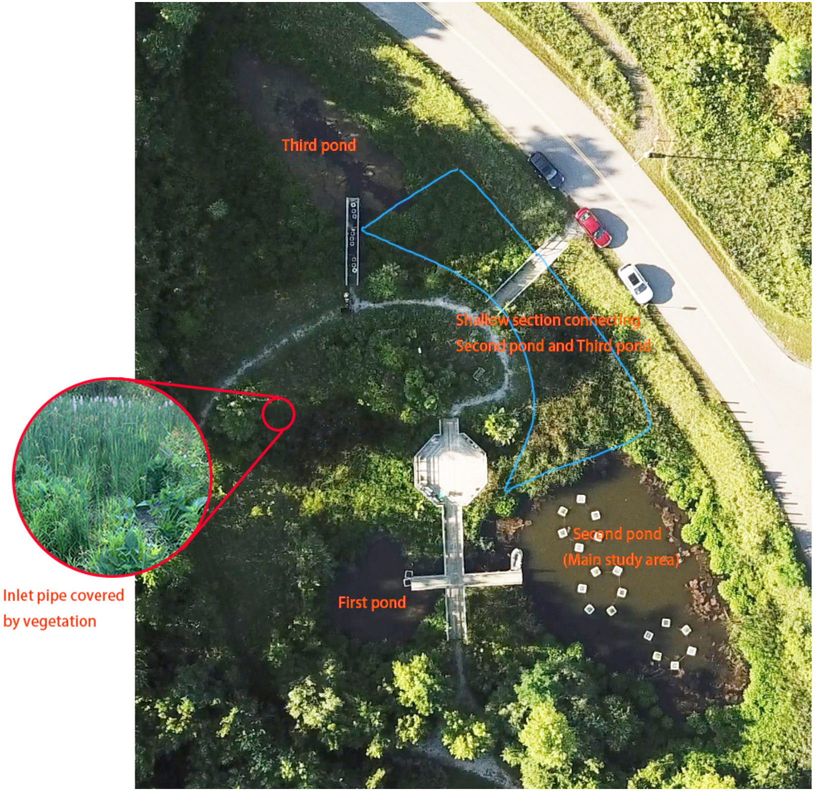


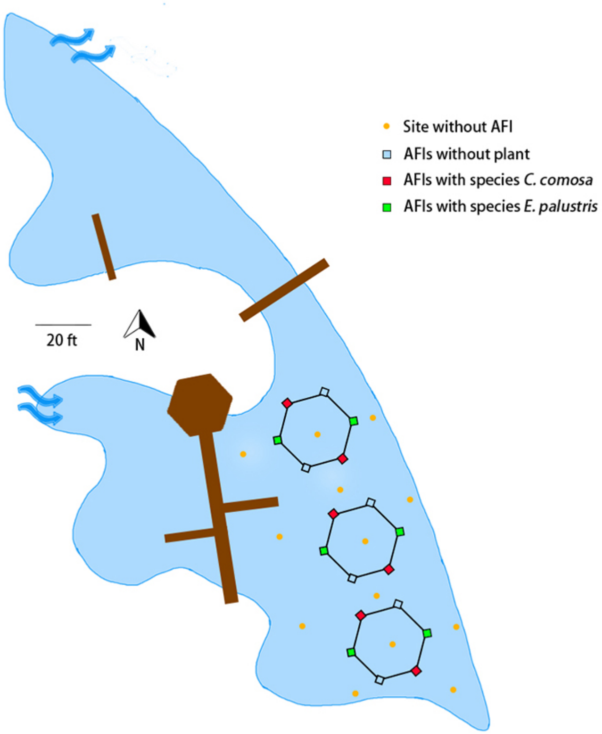



# Study area description

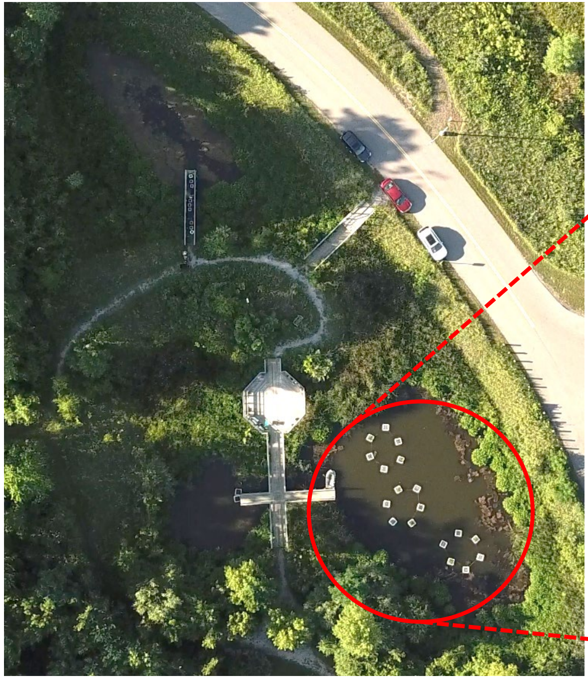
## The Milliron Research Wetland in OSU Mansfield campus

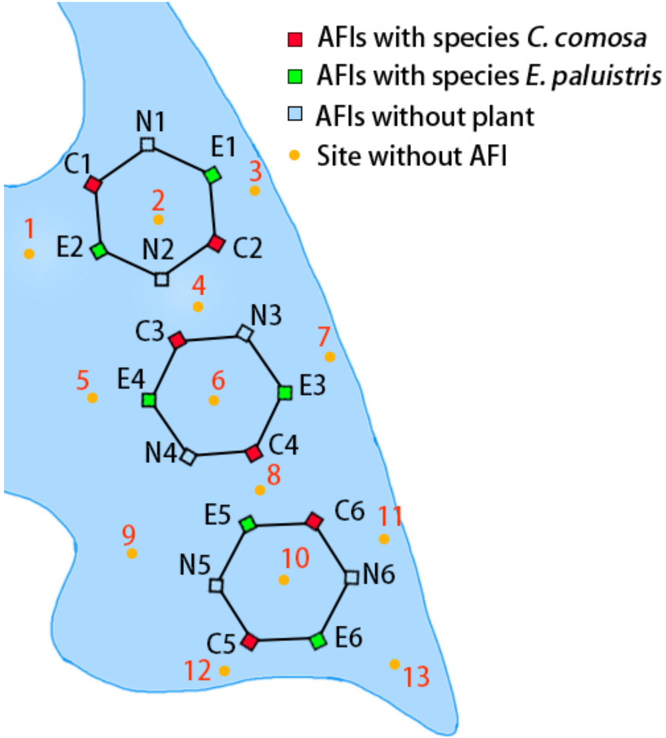


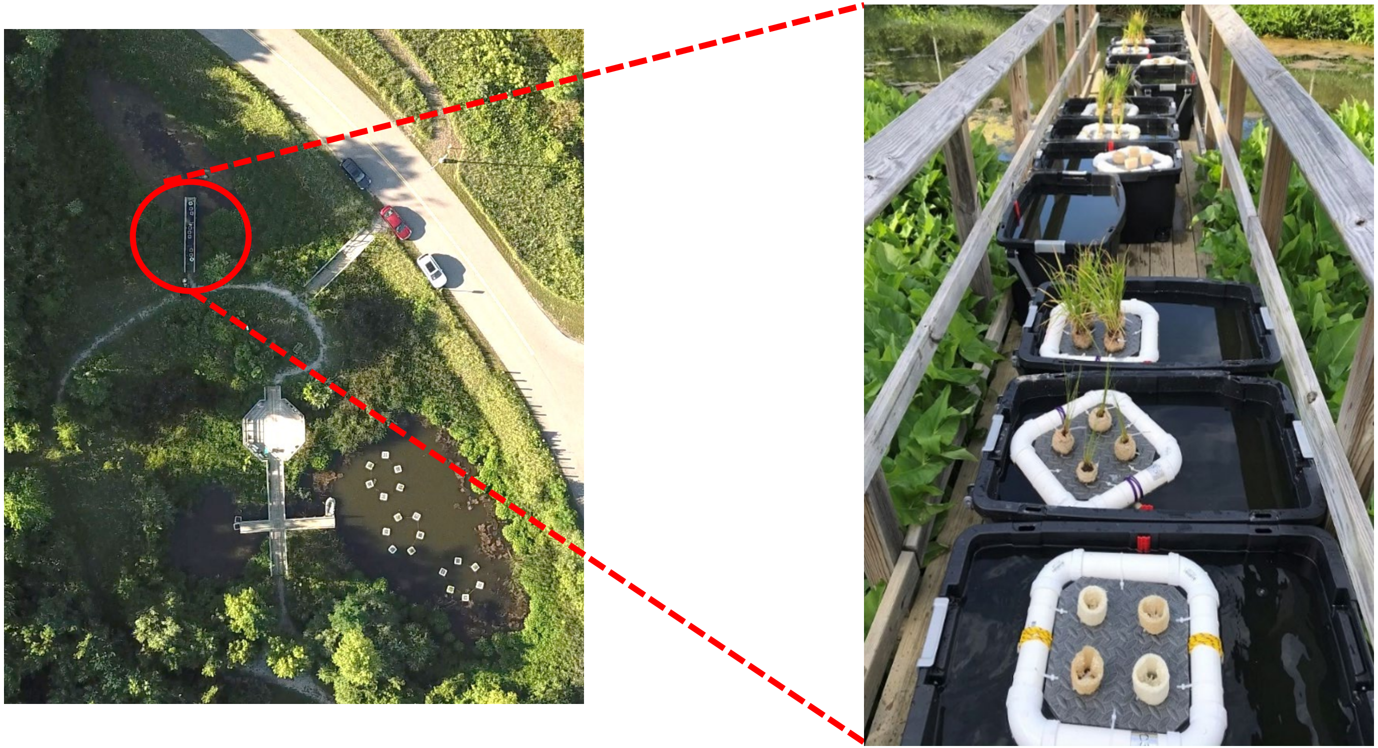
# Experimental design – Field experiments

## Sampling sites

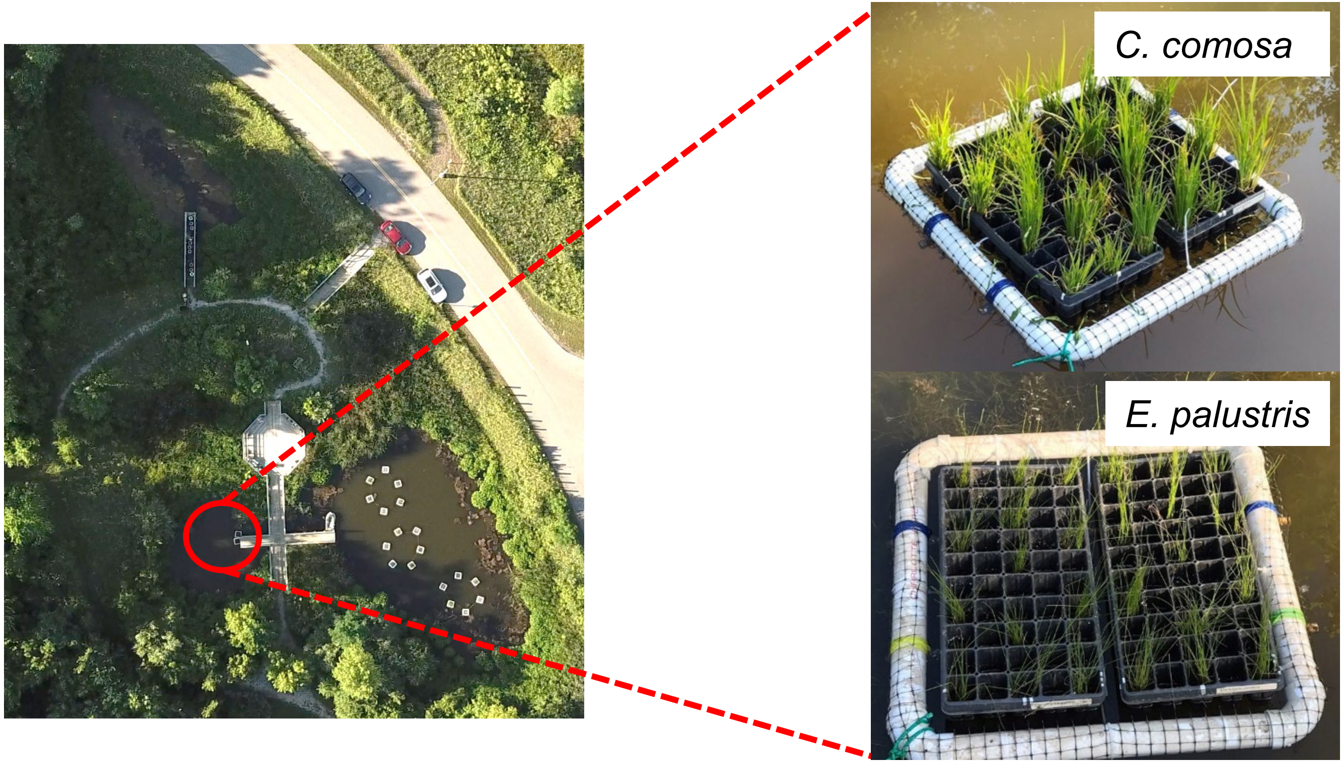




# Experimental design – Mesocosm experiments



# Experimental design – Nursery



# Sampling procedures

- Physico-chemical parameters
  - Biweekly in the field setting (wetland) and weekly in the mesocosm setting (tanks)
  - Measured variables *in situ*:
    - water temperature (℃)
    - pH
    - oxidation-reduction potential – ORP (mV)
    - conductivity (µS)
    - total dissolved solids – TDS (ppm)
    - dissolved oxygen – DO (mg and %)

Oakton® PC 450 portable multiparameter kit (water temperature, pH, ORP, conductivity, TDS)

YSI® ODO/BDO meter kit (dissolved oxygen)

# Sampling procedures

- Physico-chemical parameters
- Water sample collection
    - Biweekly in the field setting (wetland) and weekly in the mesocosm setting (tanks)
    - Measured variables:
        - $PO_4$, $NO_2$+$NO_3$, $NH_4$, and $SiO_2$ concentrations — Skalar SAN++ FIA analyzer

# Sampling procedures

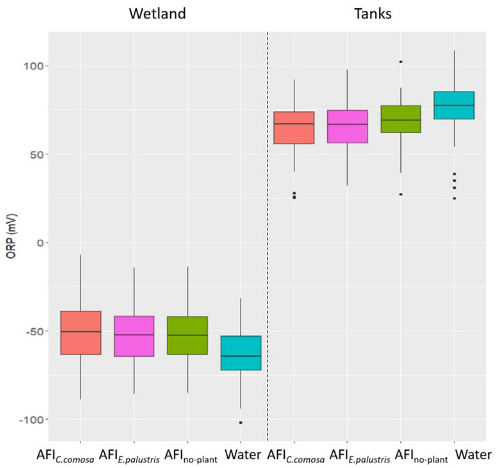
- Physico-chemical parameters
- Water sample collection
- Plant tissues
    - Measured variables:
        - Wet biomass (g)
        - Dry biomass (g) — 80℃ for 48 hours
        - Shoot length (cm)
        - Root length (cm)
    - Calculated variables:
        - Water content (%)
        - Root elongation rate

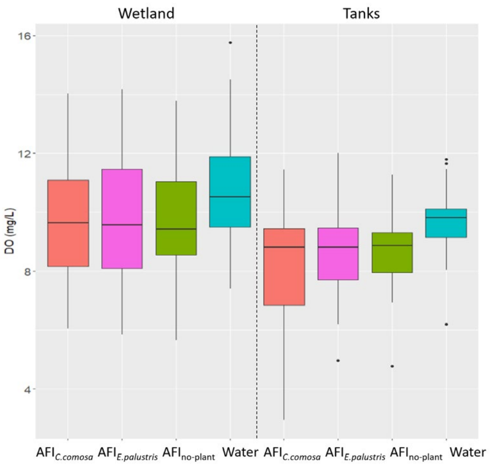
# Results and discussions

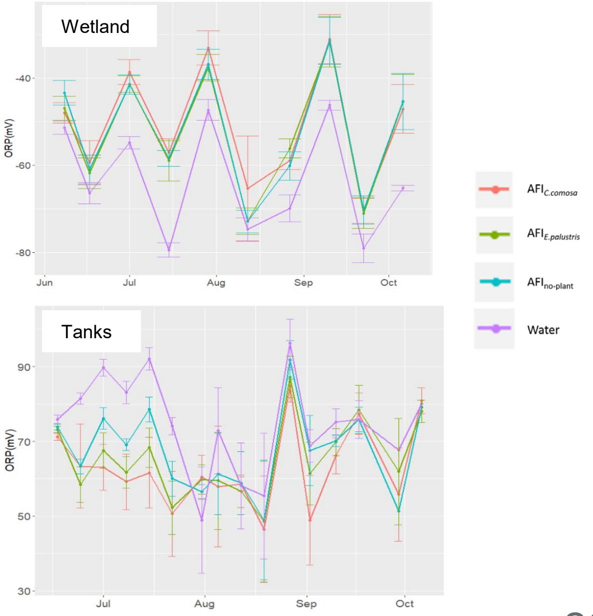
Key findings from the experiments

# Effect of AFIs on physico-chemistry

- The wetland has a more reducing environment compared to the tanks ($p<0.05$)
- AFIs increase ORP in the wetland but decrease ORP in the tanks ($p<0.05$)

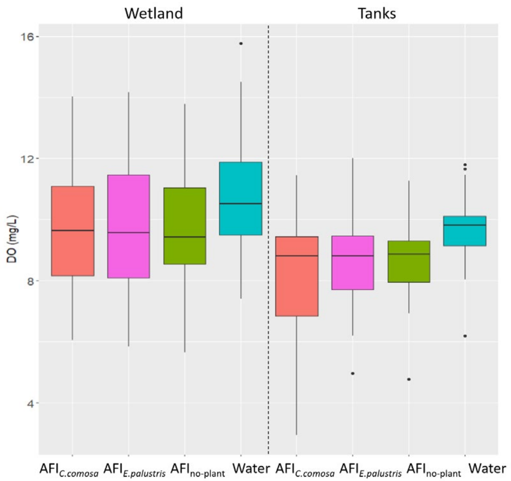


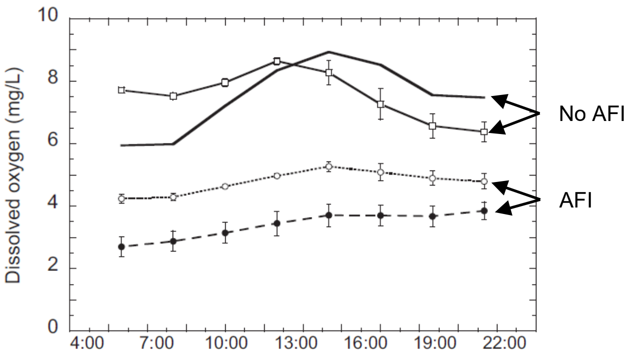



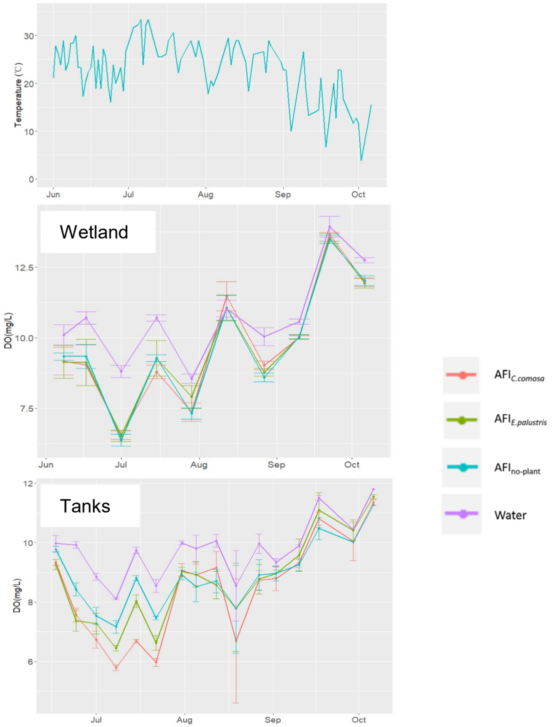
# Effect of AFIs on physico-chemistry

- The wetland has higher DO than the tanks ($p<0.05$)
- AFIs decrease DO ($p<0.05$)



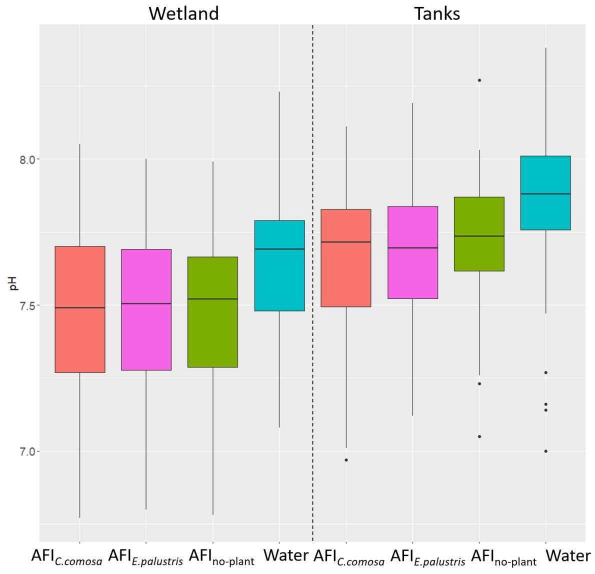



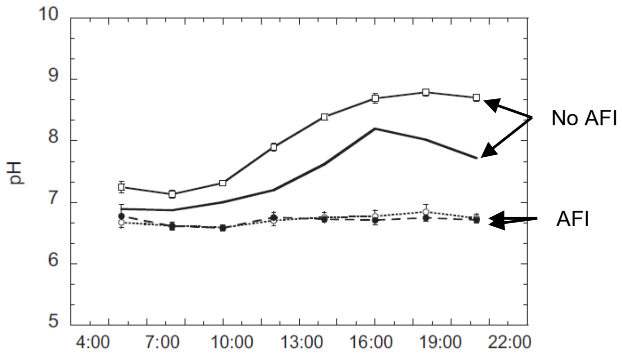

(Lynch et al., 2015)



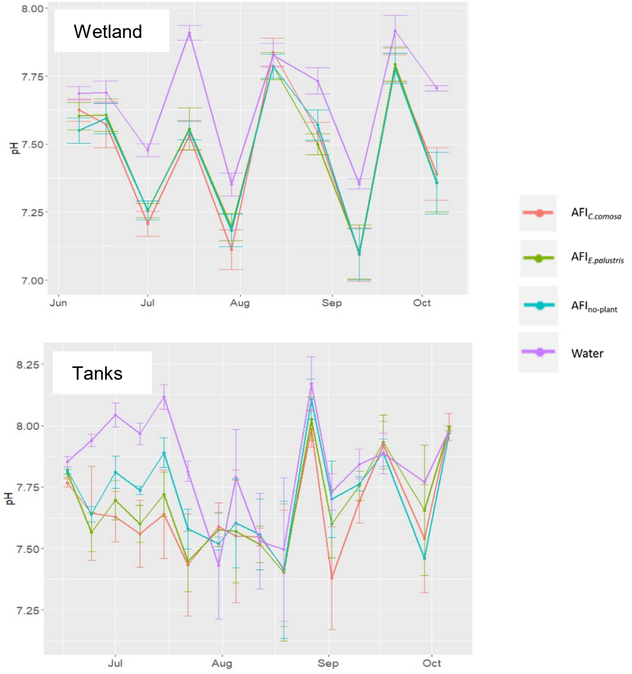
# Effect of AFIs on physico-chemistry

- AFIs decrease pH ($p<0.05$)



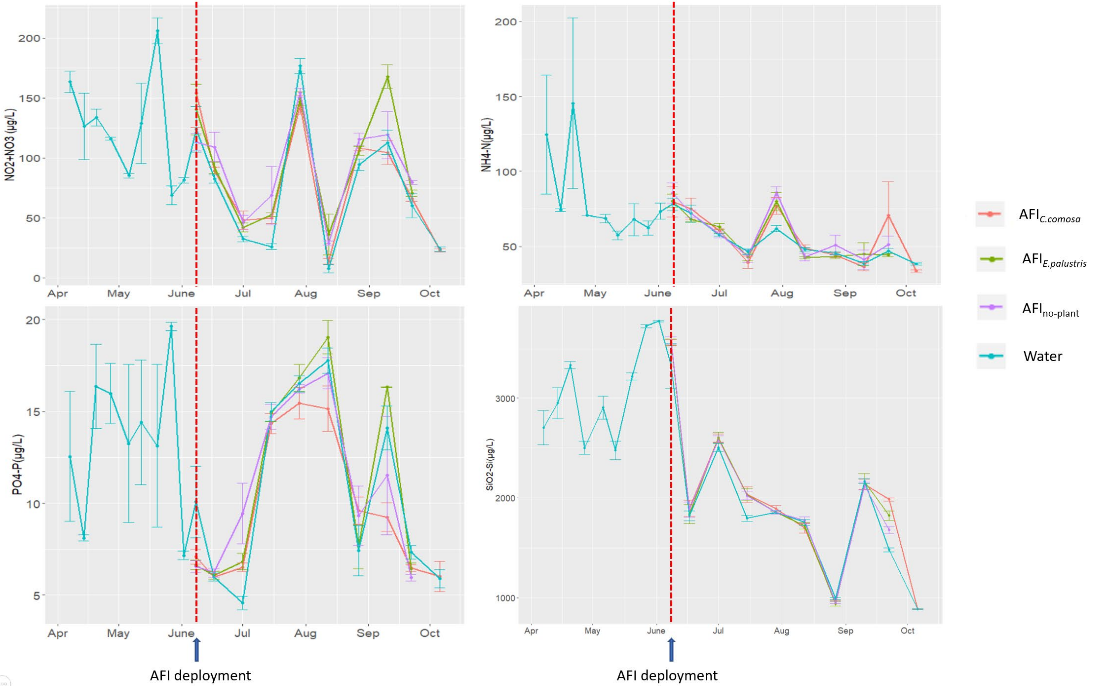



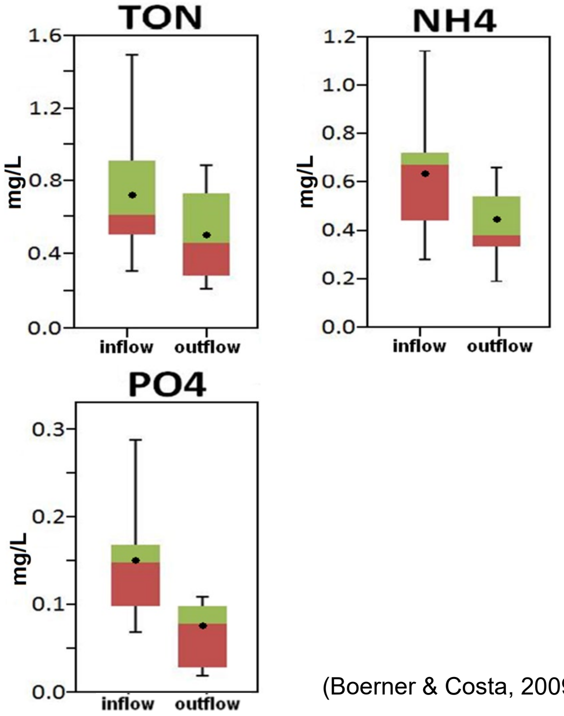

(Lynch et al., 2015)



# Nutrient concentrations

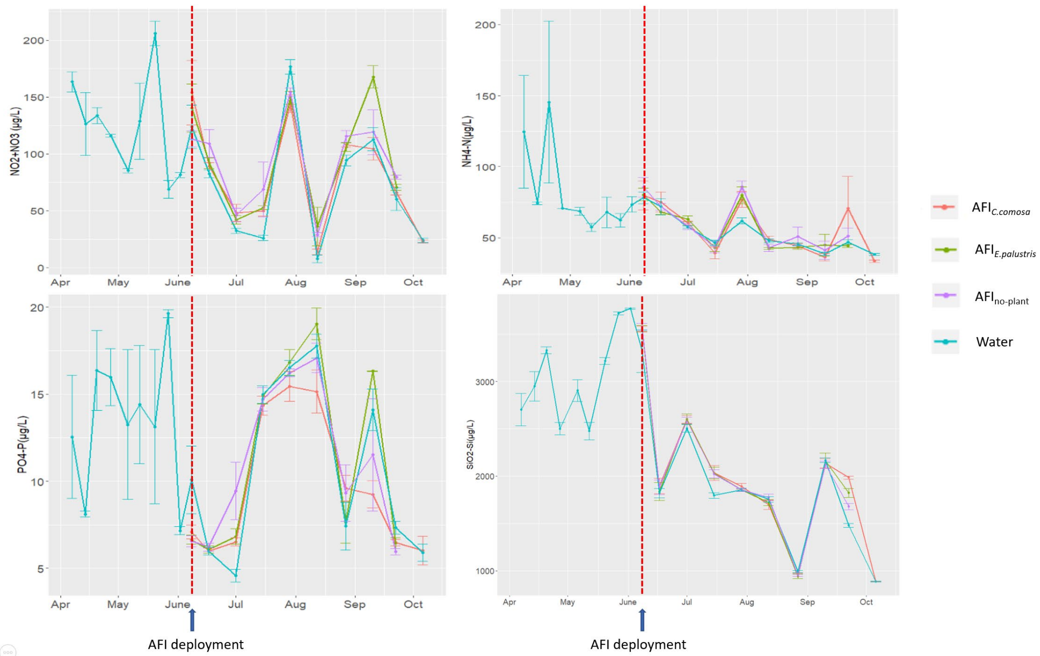
## Historical nutrient data in 2009



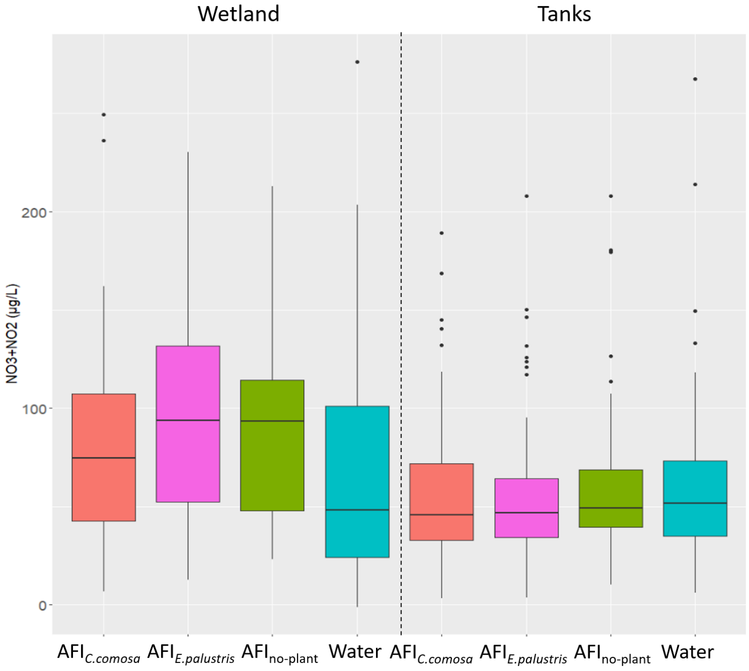

(Boerner & Costa, 2009)

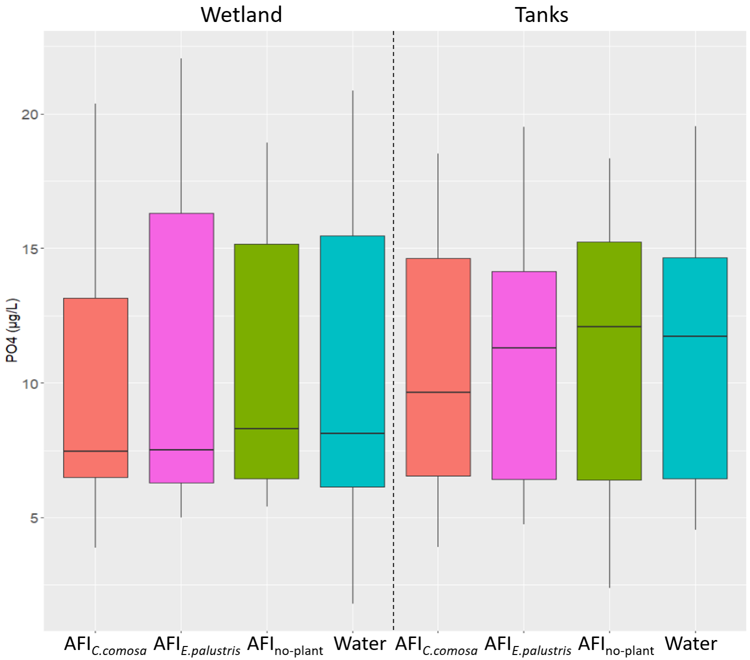
# Nutrient concentrations




# Nutrient concentrations

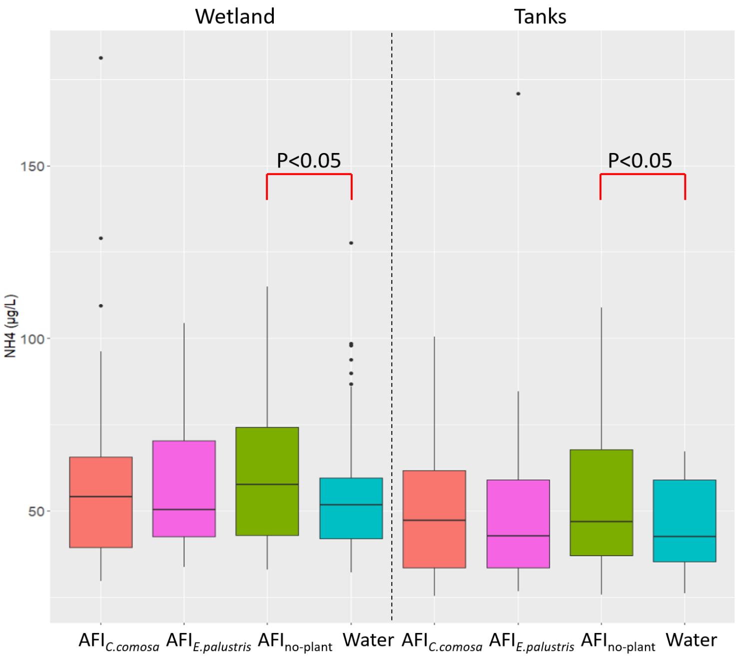
- No significant difference observed among treatments for $PO_4$ and $NO_3+NO_2$ in both settings

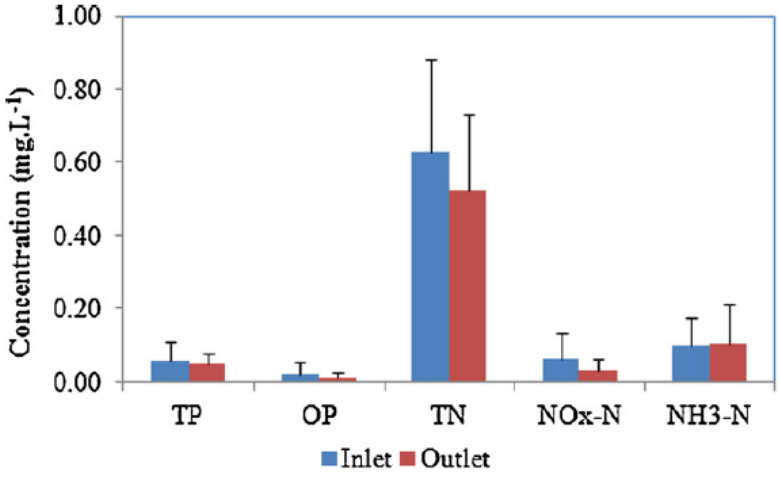


# Nutrient concentrations

- Higher $NH_4$ in AFIs without plant ($p<0.05$)
- But AFIs with plants did not present higher $NH_4$



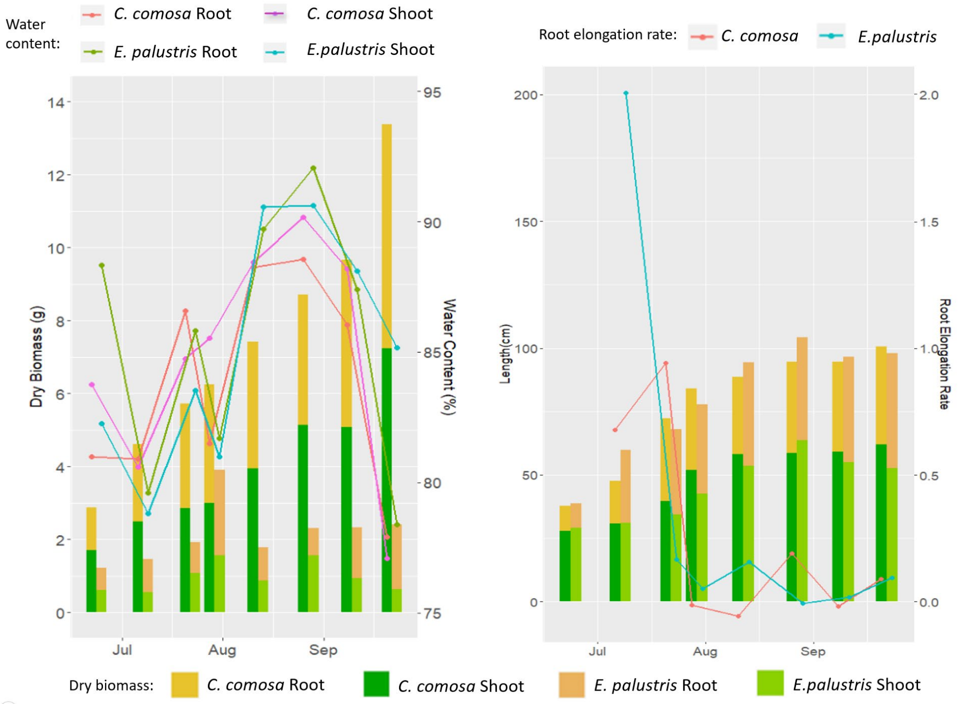




(Chang et al., 2013)

# Biomass accumulation – Nursery

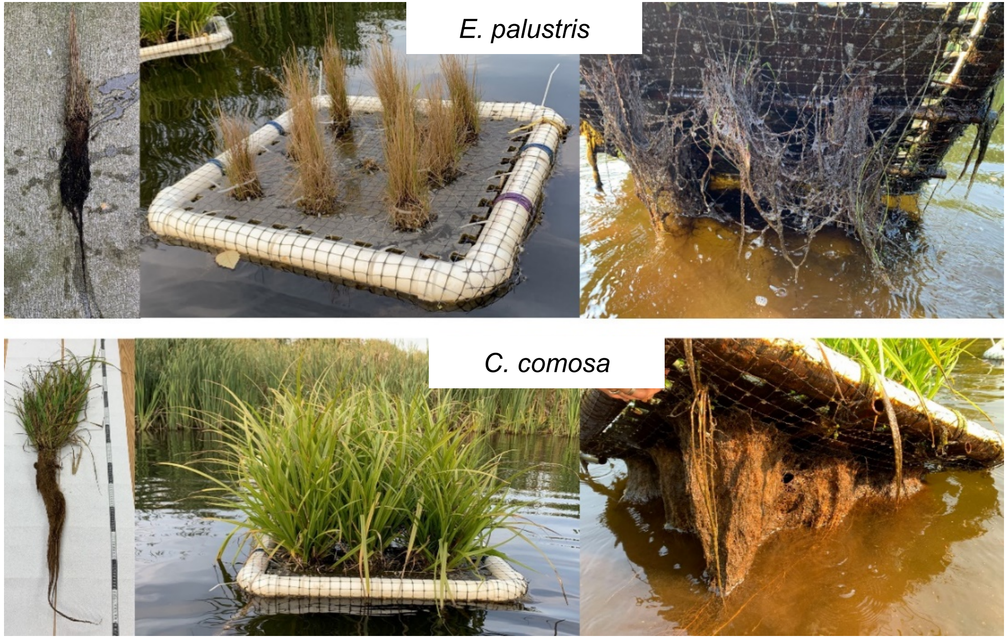
- *C. comosa* continuously increased biomass
- *E. palustris* barely increased biomass
- Both species started to lose water from Sep
- Root elongation rate dropped after a few weeks

- $$\text{Water content} = \frac{Wet\ biomass - dry\ biomass}{Wet\ biomass} \times 100\%$$
- $$Root\ elongation\ rate = \frac{Root\ length_{(i+1)th\ sample} - Root\ length_{ith\ sample}}{Root\ length_{ith\ sample}}$$



# Biomass accumulation – Field experiments

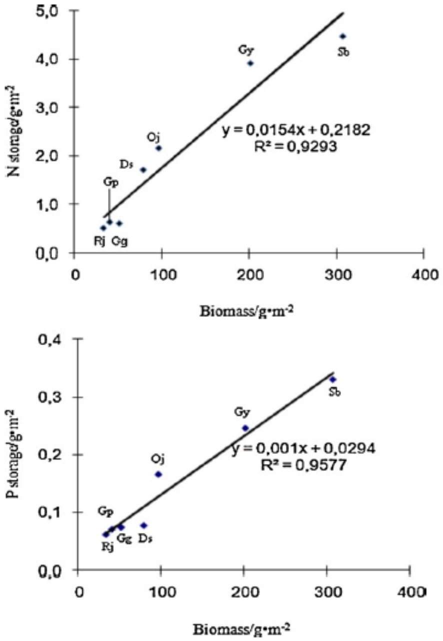
- *C. comosa* dry biomass accumulation
  - Shoot: 33.2 ± 18.8 g/plant (56.8%)
  - Root: 25.3 ± 11.9 g/plant (43.2%)
- *E. palustris* dry biomass accumulation
  - Shoot: 2.0 ± 1.8 g/plant (32.8%)
  - Root: 4.1 ± 2.6 g/plant (67.2%)



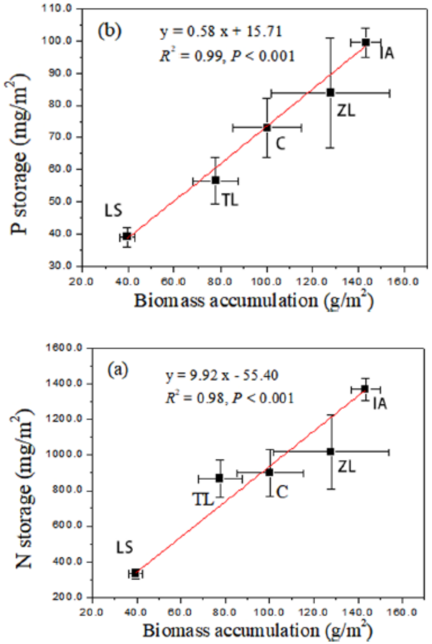

*E. palustris* and *C. comosa* on AFIs in the wetland on Oct 6.

# Biomass accumulation – Field experiments

- Linear relationship exists between nutrient uptake and dry biomass accumulation



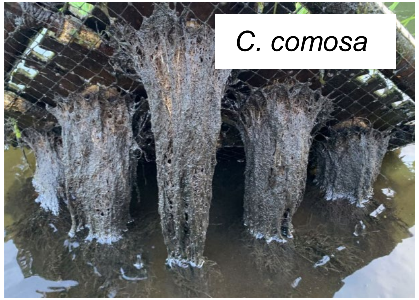

(Zhu et al., 2011)

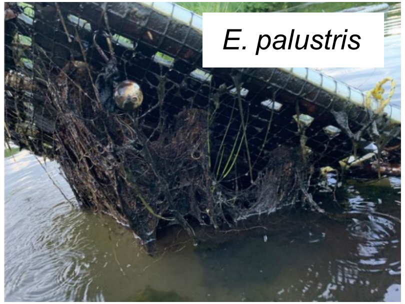



(Chen et al., 2019)

# Biomass accumulation – Field experiments

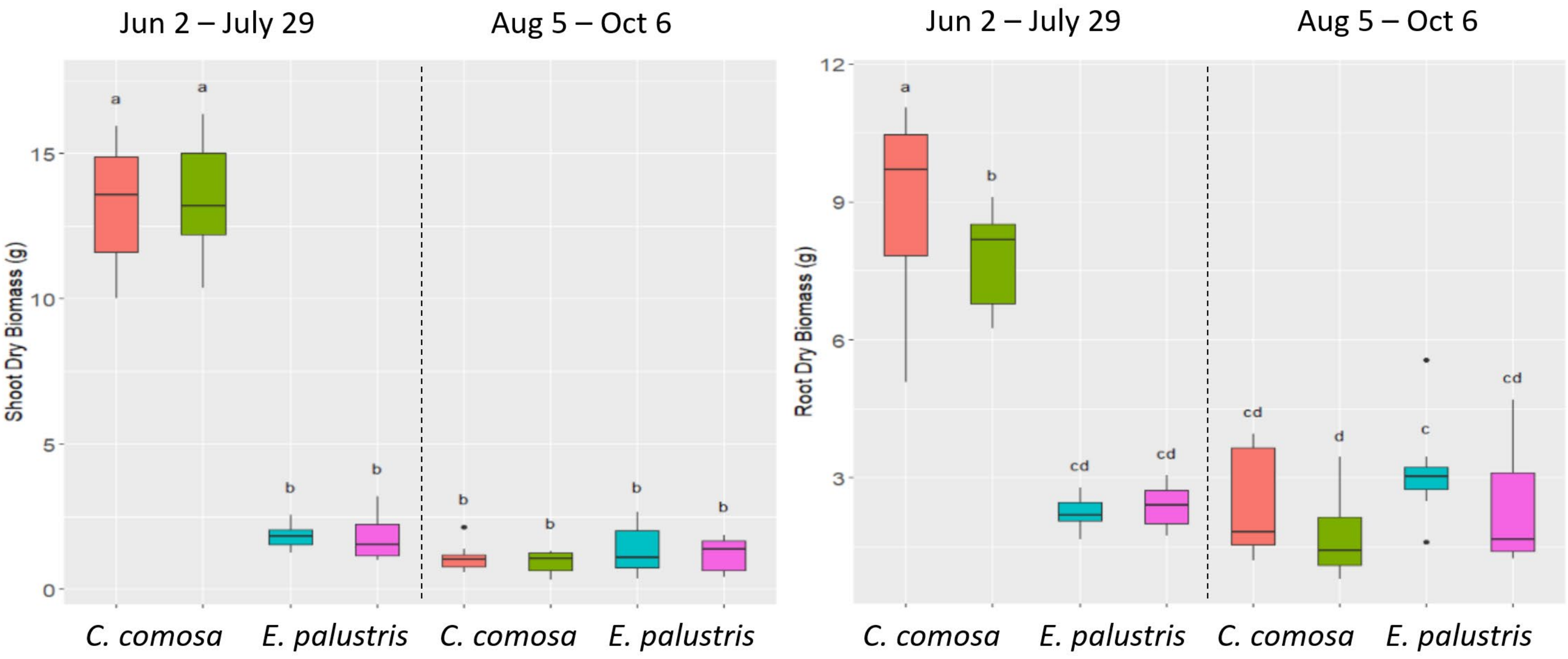
- Major pathways of AFIs removing nutrients:
  - Plant direct uptake
  - Sedimentation and entrapment by root systems
  - Microbial assimilation or conversion by biofilms attaching to the roots
- Ratio of root dry biomass to root length:
  - *C. comosa*: 0.36 g/cm
  - *E. palustris*: 0.09 g/cm



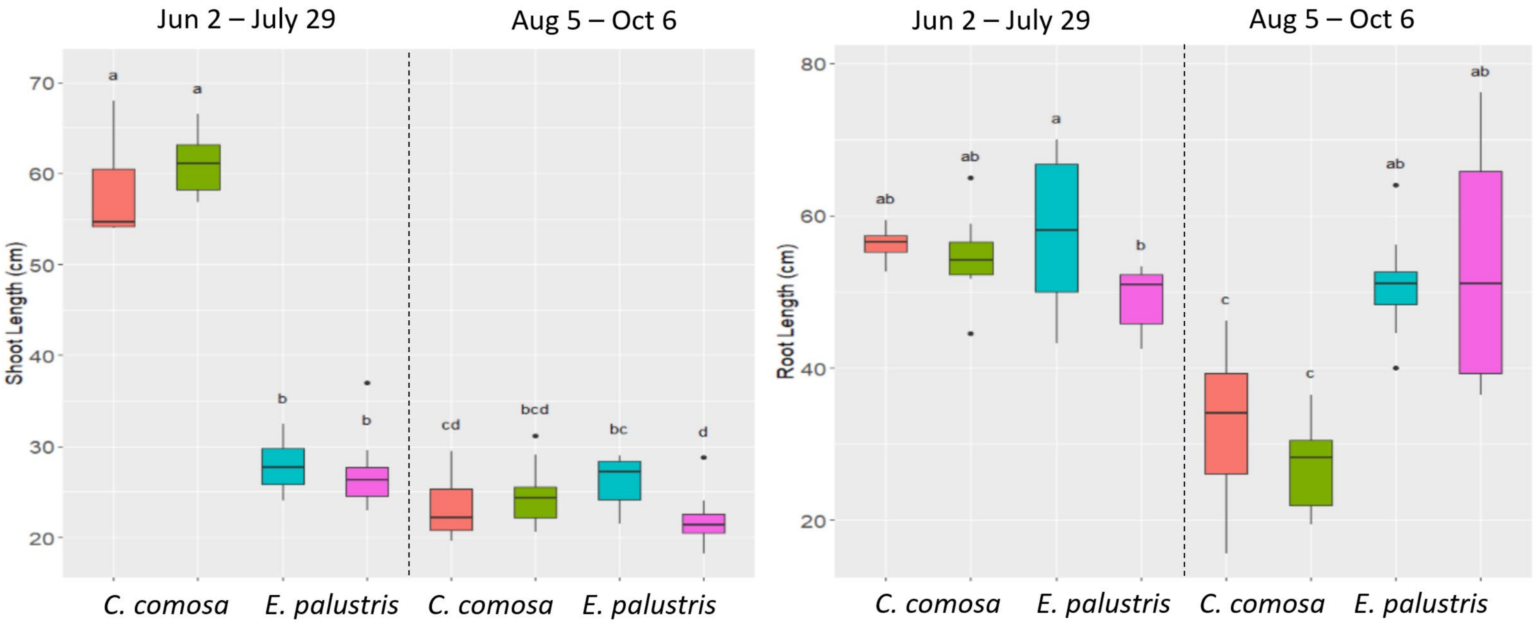
# Biomass accumulation – Seasonal variations

- Biomass accumulation for *C. comosa* slowed down in late summer



# Plant elongation – Seasonal variations

- Root elongation for *C. comosa* slowed down in late summer



# Conclusions

# Conclusions

- More field-scale studies of AFIs are required to understand the complexity of the natural environment
- More long-term studies of AFIs are required to investigate seasonality effect
- AFIs decrease the DO and pH
- AFIs with no plant increase $NH_4$

# Conclusions

- *C. comosa* has better ability in plant direct uptake of nutrients
- AFIs containing *C. comosa* outperformed AFIs containing *E. palustris* in the overall nutrient removal
- Both species were largely affected by seasonal dynamics that their biomass accumulation and elongation rate decreased significantly from mid-summer

# Thank you!

Questions?

# Acknowledgements


- Financial support:
  - Friends of Orton Hall
  - The Ohio State University Sustainability Institute

- Advises, knowledge sharing, and personal support:
  - Dr. Ozeas S. Costa Jr.
  - Dr. Jiyoung Lee, Dr. Audrey Sawyer, and Dr. James Bauer

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  - OSU Mansfield campus: Dr. Norman Jones
  - OSU Columbus campus: Dr. Steven Lower, Angeletha Rogers, Theresa Mooney


School of Earth Sciences Friends of Orton Hall

The Ohio State University Sustainability Institute

The Ohio State University Mansfield Campus

# Outline

- Introduction
- Bibliometric analysis
- Methods and materials
- Results and discussions
- Conclusions

# Why is AFI important?

- No land requirement
- Adjust to water level fluctuation